Greater New Haven Water Pollution Control Authority

New Haven, Connecticut

BIDDING REQUIREMENTS
AND
CONTRACT DOCUMENTS

for the construction of the

Process Air Compressor System for Low Level Nitrogen Removal at the East Shore Water Pollution Abatement Facility

Project No. CWF 2019-04

Volume 2
100% Technical Specifications

JACOBS

Wethersfield, CT

July 2023

Project No. E2X90000

Copy No._____

SECTION 01 11 00
SUMMARY OF WORK

PART 1 GENERAL

1.01 WORK COVERED BY CONTRACT DOCUMENTS

A. The completed Work will provide Owner with a new process air compressor facility including, site civil work, relocation of underground utilities, abandonment of existing utilities, installing micropiles, construction of a new process air compressor building with an electrical room, installation of 6 process air compressor units, installation of process air piping and controls, demolition of existing process air piping and controls, construction of walk ways and sidewalks, repair to existing building masonry, repair to aeration basin construction joints, installation of site drainage, and paving of a new road.

1.02 WORK NOT COVERED BY CONTRACT DOCUMENTS

A. The following construction work is necessary for the completion of the project, but is not included in the contract documents:

1. Control System Integration: The Owner will select and contract through Engineer with a system integrator for the application software.

1.03 PRESELECTED PROCESS AIR COMPRESS EQUIPMENT

A. The Process Air Compressor Equipment Manufacturer has been preselected by the Owner and the price for the preselected Equipment is listed on the bid form. This price should be included in the Contractors Bid. The Contractor shall be responsible for the installation cost of this Equipment in their Base Bid.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01 26 00
CONTRACT MODIFICATION PROCEDURES

PART 1 GENERAL

1.01 PROPOSAL REQUESTS

A. Owner may, in anticipation of ordering an addition, deletion, or revision to the Work, request Contractor to prepare a detailed proposal of cost and times to perform contemplated change.

B. Proposal request will include reference number for tracking purposes and detailed description of and reason for proposed change, and such additional information as appropriate and as may be required for Contractor to accurately estimate cost and time impact on Project.

C. Proposal request is for information only; Contractor is neither authorized to execute proposed change nor to stop Work in progress as result of such request.

D. Contractor's written proposal shall be transmitted to Engineer promptly, but not later than 14 days after Contractor's receipt of Owner's written request. Proposal shall remain firm for a maximum period of 60 days after receipt by Engineer, unless extended.

E. Owner's request for proposal or Contractor's failure to submit such proposal within the required time period will not justify a Claim for an adjustment in Contract Price or Contract Times (or Milestones).

1.02 CLAIMS

A. Include, at a minimum:

1. Specific references including (i) Drawing numbers, (ii) Specification section and article/paragraph number, and (iii) Submittal type, Submittal number, date reviewed, Engineer's comment, as applicable, with appropriate attachments.
2. Stipulated facts and pertinent documents, including photographs and statements.
3. Interpretations relied upon.
4. Description of (i) nature and extent of Claim, (ii) who or what caused the situation, (iii) impact to the Work and work of others, and (iv) discussion of claimant's justification for requesting a change to price or times or both.
5. Estimated adjustment in price claimant believes it is entitled to with full documentation and justification.

6. Requested Change in Contract Times: Include at least (i) Progress Schedule documentation showing logic diagram for request, (ii) documentation that float times available for Work have been used, and (iii) revised activity logic with durations including sub-network logic revisions, duration changes, and other interrelated schedule impacts, as appropriate.
7. Documentation as may be necessary as set forth below for Work Change Directive, and as Engineer may otherwise require.

1.03 WORK CHANGE DIRECTIVES

A. Procedures:

1. Engineer will:
   a. Initiate, including a description of the Work involved and any attachments.
   b. Affix signature, demonstrating Engineer's recommendation.
   c. Transmit Electronic copies to Owner for authorization.
2. Owner will:
   a. Affix signature, demonstrating approval of the changes involved.
   b. Return Electronic copies to Engineer, who will retain one copy, send one copy to the Resident Project Representative or other field representative, and forward electronic copies to Contractor.
3. Upon completion of Work covered by the Work Change Directive or when final Contract Times and Contract Price are determined, Contractor shall submit documentation for inclusion in a Change Order.
4. Contractor's documentation shall include but not be limited to:
   a. Appropriately detailed records of Work performed to enable determination of value of the Work.
   b. Full information required to substantiate resulting change in Contract Times and Contract Price for Work. On request of Engineer, provide additional data necessary to support documentation.
   c. Support data for Work performed on a unit price or Cost of the Work basis with additional information such as:
      1) Dates Work was performed, and by whom.
      2) Time records, wage rates paid, and equipment rental rates.
      3) Invoices and receipts for materials, equipment, and subcontracts, all similarly documented.

B. Effective Date of Work Change Directive: Date of signature by Owner, unless otherwise indicated thereon.

1.04 CHANGE ORDERS

A. Procedure:

1. Engineer will prepare electronic copies of proposed Change Order and transmit such with Engineer's written recommendation and request to Contractor for signature.
2. Contractor shall, upon receipt, either: (i) promptly sign copies, retaining one for its file, and return remaining electronic copies to Engineer for Owner's signature, or (ii) return unsigned electronic copies with written justification for not executing Change Order.
3. Engineer will, upon receipt of Contractor signed copies, promptly forward Engineer's written recommendation and partially executed electronic copies for Owner's signature, or if Contractor fails to execute the Change Order, Engineer will promptly so notify Owner and transmit Contractor's justification to Owner.
4. Upon receipt of Contractor-executed Change Order, Owner will promptly either:
    a. Execute Change Order, retaining electronic copy for its file and returning electronic copies to Engineer; or
    b. Return to Engineer unsigned copies with written justification for not executing Change Order.
5. Upon receipt of Owner-executed Change Order, Engineer will transmit electronic copies to Contractor, one copy to Resident Project Representative or other field representative, and retain one copy, or if Owner fails to execute the Change Order, Engineer will promptly so notify Contractor and transmit Owner's justification to Contractor.
6. Upon receipt of Owner-executed Change Order, Contractor shall:
    a. Perform Work covered by Change Order.
    b. Revise Schedule of Values to adjust Contract Price and submit with next Application for Payment.
    c. Revise Progress Schedule to reflect changes in Contract Times, if any, and to adjust times for other items of Work affected by change.
    d. Enter changes in Project record documents after completion of change related Work.

B. In signing a Change Order, Owner and Contractor acknowledge and agree that:

1. Stipulated compensation (Contract Price or Contract Times, or both) set forth includes payment for (i) the Cost of the Work covered by the Change Order, (ii) Contractor's fee for overhead and profit, (iii) interruption of Progress Schedule, (iv) delay and impact, including cumulative impact, on other Work under the Contract Documents, and (v) extended overheads.

2. Change Order constitutes full mutual accord and satisfaction for the change to the Work.
3. Unless otherwise stated in the Change Order, all requirements of the original Contract Documents apply to the Work covered by the Change Order.

1.05 COST OF THE WORK

A. In determining the supplemental costs allowed in Paragraph 13.01.B.5 of the General Conditions for rental equipment and machinery, the following will apply.

B. Rental of construction equipment and machinery and the parts thereof having a replacement value in excess of $1,000, whether owned by Contractor or rented or leased from others, shall meet the following requirements:

1. Full rental costs for leased equipment shall not exceed rates listed in the Rental Rate Blue Book published by Equipment Watch, as adjusted to the regional area of the Project. Owned equipment costs shall not exceed the single shift rates established in the Cost Reference Guide (CRG) published by Equipment Watch. The most recent published edition in effect at commencement of actual equipment use shall be used.
2. Rates shall apply to equipment in good working condition. Equipment not in good condition, or larger than required, may be rejected by Engineer or accepted at reduced rates.
3. Leased Equipment: For equipment leased or rented in arm's length transactions from outside vendors, maximum rates shall be determined by the following actual usage/Payment Category:
   a. Less than 8 hours: Hourly rate.
   b. 8 or more hours but less than 7 days: Daily rate.
   c. 7 or more days but less than 30 days: Weekly rate.
   d. 30 days or more: Monthly rate.
4. Arm's length rental and lease transactions are those in which the firm involved in the rental or lease of equipment is not associated with, owned by, have common management, directorship, facilities and/or stockholders with the firm renting the equipment.
5. Financial arrangements associated with rental and lease transactions that provide Contractor remuneration or discounts not visible to the Owner must be disclosed and integrated with charged rates.
6. Leased Equipment in Use: Actual equipment use time documented by Engineer shall be the basis that equipment was on and utilized at the Project Site. In addition to the leasing rate above, equipment operational costs shall be paid at the estimated hourly operating cost rate set forth in the Rental Rate Blue Book if not already included in the lease rate. Hours

of operation shall be based upon actual equipment usage to the nearest quarter hour, as recorded by Engineer.

7. Leased Equipment, When Idle (Standby): Idle or standby equipment is equipment onsite or in transit to and from the Work Site and necessary to perform the Work under the modification, but not in actual use. Idle equipment time, as documented by Engineer, shall be paid at the leasing rate determined above, excluding operational costs.
8. Owned and Other Equipment in Use: Equipment rates for owned equipment or equipment provided in other than arm's length transaction shall not exceed the single shift total hourly costs rate developed in accordance with the CRG and as modified herein for multiple shifts. This total hourly rate will be paid for each hour the equipment actually performs work. Hours of operation shall be based upon actual equipment usage as recorded by Engineer. This rate shall represent payment in full for Contractor's direct costs.
9. Owned and Other Equipment, When Idle (Standby): Equipment necessary to be onsite to perform the Work on single shift operations, but not utilized, shall be paid for at the ownership hourly expense rate developed in accordance with the CRG, provided its presence and necessity onsite has been documented by Engineer. Payment for idle time of portions of a normal workday, in conjunction with original contract Work, will not be allowed. In no event shall idle time claimed in a day for a particular piece of equipment exceed the normal Work or shift schedule established for the Project. It is agreed that this rate shall represent payment in full for Contractor's direct costs. When Engineer determines that the equipment is not needed to continuously remain at the Work Site, payment will be limited to actual hours in use.
10. Owned and Other Equipment, Multiple Shifts: For multiple shift operations, the CRG single shift total hourly costs rate shall apply to the operating equipment during the first shift. For subsequent shifts, up to two in a 24-hour day, operating rate shall be the sum of the total hourly CRG operating cost and 60 percent of the CRG ownership and overhaul expense. Payment for idle or standby time for second and third shifts shall be 20 percent of the CRG ownership and overhaul expense.
11. When necessary to obtain owned equipment from sources beyond the Project limits, the actual cost to transfer equipment to the Site and return it to its original location will be allowed as an additional item of expense. Move-in and move-out allowances will not be made for equipment brought to the Project if the equipment is also used on original Contract or related Work.
12. If the move-out destination is not to the original location, payment for move-out will not exceed payment for move-in.
13. If move is made by common carrier, the allowance will be the amount paid for the freight. If equipment is hauled with Contractor's own forces, rental will be allowed for the hauling unit plus the hauling unit operator's wage. If equipment is transferred under its own power, the rental will be

75 percent of the appropriate total hourly costs for the equipment, without attachments, plus the equipment operator's wage.

14. Charges for time utilized in servicing equipment to ready it for use prior to moving and similar charges will not be allowed.
15. When a breakdown occurs on any piece of owned equipment, payment shall cease for that equipment and any other owned equipment idled by the breakdown.
16. If any part of the Work is shut down by Owner, standby time will be paid during nonoperating hours if diversion of equipment to other Work is not practicable. Engineer reserves the right to cease standby time payment when an extended shutdown is anticipated.
17. If a rate has not been established in the CRG for owned equipment, Contractor may:
    a. If approved by Engineer, use the rate of the most similar model found, considering such characteristics as manufacturer, capacity, horsepower, age, and fuel type, or
    b. Request Equipment Watch to furnish a written response for a rate on the equipment, which shall be presented to Engineer for approval; or
    c. Request Engineer to establish a rate.

1.06 FIELD ORDER

A. Engineer will issue Field Orders, with electronic copies to Contractor.

B. Effective date of the Field Order shall be the date of signature by Engineer, unless otherwise indicated thereon.

C. Contractor shall acknowledge receipt by signing and returning an electronic copy to Engineer.

D. Field Orders will be incorporated into subsequent Change Orders, as a no-cost change to the Contract.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01 29 00
PAYMENT PROCEDURES

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Schedule of Values: Submit on Contractor's standard form.
2. Schedule of Estimated Progress Payments:
   a. Submit with initially acceptable Schedule of Values.
   b. Submit adjustments thereto with Application for Payment.
3. Application for Payment.
4. Final Application for Payment.

1.02 CASH ALLOWANCES

A. Consult with Engineer in selection of products or services. Obtain proposals from Suppliers and installers and offer recommendations.

B. Cash allowances will be administered in accordance with Paragraph 13.02 of General Conditions.

C. Submit, with application for payment, invoice showing date of purchase, from whom the purchase was made, the date of delivery of the product or service, and the price, including delivery to the Site and applicable taxes.

1.03 SCHEDULE OF VALUES

A. Prepare a separate Schedule of Values for each schedule of the Work under the Agreement.

B. Upon request of Engineer, provide documentation to support the accuracy of the Schedule of Values.

C. Unit Price Work: Reflect unit price quantity and price breakdown from conformed Bid Form.

D. Lump Sum Work:

1. Reflect specified cash allowances and alternates, as applicable.
2. List bonds and insurance premiums, mobilization, demobilization, preliminary and detailed progress schedule preparation, equipment testing, facility startup, and contract closeout separately.
   a. Mobilization includes, at minimum, items identified in Section 01 50 00, Temporary Facilities and Controls.

b. Include item(s) for monthly progress schedule update and maintenance of Engineer's trailer.

3. Break down by Division 02 through 49 with appropriate subdivision of each specification.

E. An unbalanced or front-end loaded schedule will not be acceptable.

F. Summation of the complete Schedule of Values representing all the Work shall equal the Contract Price.

G. Submit Schedule of Values in a spreadsheet format compatible with latest version of MSExcel.

1.04 SCHEDULE OF ESTIMATED PROGRESS PAYMENTS

A. Show estimated payment requests throughout Contract Times aggregating initial Contract Price.

B. Base estimated progress payments on initially acceptable progress schedule. Adjust to reflect subsequent adjustments in progress schedule and Contract Price as reflected by modifications to the Contract Documents.

1.05 APPLICATION FOR PAYMENT

A. Transmittal Summary Form: Attach one Summary Form with each detailed Application for Payment for each schedule and include Request for Payment of Materials and Equipment on Hand as applicable. Execute certification by authorized officer of Contractor.

B. Use detailed Application for Payment Form provided by Owner, following "End of Section."

C. Provide separate form for each schedule as applicable.

D. Include accepted Schedule of Values for each schedule or portion of lump sum Work and the unit price breakdown for the Work to be paid on a unit priced basis.

E. Include separate line item for each Change Order and Work Change Directive executed prior to date of submission. Provide further breakdown of such as requested by Engineer.

F. Preparation:

1. Round values to nearest dollar.
2. Submit Application for Payment, including a Transmittal Summary Form and detailed Application for Payment Form(s) for each schedule

as applicable, a listing of materials on hand for each schedule as applicable, and such supporting data as may be requested by Engineer.

1.06 MEASUREMENT—GENERAL

A. Weighing, measuring, and metering devices used to measure quantity of materials for Work shall be suitable for purpose intended and conform to tolerances and specifications as specified in National Institute of Standards and Technology, Handbook 44.

B. Whenever pay quantities of material are determined by weight, weigh material on scales furnished by Contractor and certified accurate by state agency responsible. Obtain weight or load slip from weigher and deliver to Owner's representative at point of delivery of material.

C. If material is shipped by rail, car weights will be accepted provided that actual weight of material only will be paid for and not minimum car weight used for assessing freight tariff and provided further that car weights will not be acceptable for material to be passed through mixing plants.

D. Vehicles used to haul material being paid for by weight shall be weighed empty daily and at such additional times as required by Engineer. Each vehicle shall bear a plainly legible identification mark.

E. Haul materials that are specified for measurement by the cubic yard measured in the vehicle in transport vehicles of such type and size that actual contents may be readily and accurately determined. Unless all vehicles are of uniform capacity, each vehicle must bear a plainly legible identification mark indicating its water level capacity. Load vehicles to at least their water level capacity. Loads hauled in vehicles not meeting above requirements or loads of a quantity less than the capacity of the vehicle, measured after being leveled off as above provided, will be subject to rejection, and no compensation will be allowed for such material.

F. Quantities Based on Profile Elevations: Existing ground profiles shown on Drawings were taken from a topographic map drawn with contour intervals of 2 feet with supplementary spot elevations to nearest foot.

G. Quantities will be based on ground profiles shown. Field surveys will not be made to confirm accuracy of elevations shown.

H. Where measurement of quantities depends on elevation of existing ground, elevations obtained during construction will be compared with those shown on Drawings. Variations of 1 foot or less will be ignored, and profiles shown on Drawings will be used for determining quantities.

I. Units of measure shown on Bid Form shall be as follows, unless specified otherwise.

Item	Method of Measurement
AC	Acre—Field Measure by Engineer
CY	Cubic Yard—Field Measure by Engineer within limits specified or shown
CY-VM	Cubic Yard—Measured in Vehicle by Volume
EA	Each—Field Count by Engineer
GAL	Gallon—Field Measure by Engineer
HR	Hour
LB	Pound(s)—Weight Measure by Scale
LF	Linear Foot—Field Measure by Engineer
MFBM	Thousand Foot Board Measure -Delivery Invoice
SF	Square Foot
SY	Square Yard
TON	Ton—Weight Measure by Scale (2,000 pounds)

J. Measurement of Linear Items: Where payment will be made based on linear quantities and on parameters other than length, those parameters shall be as follows:

Item	Measurement Parameters
Trench Safety System	Depth of Trench: 0 foot to 4 feet; 4 feet to 10 feet; over 10 feet in 2-foot increments. The depth of trench will be measured at intervals of 25 feet along the centerline of the trench. The depth of each measuring point will be the depth from existing at grade surface to bottom of pipe base, 12 inches below pipe invert and will used for computing the depth of trench for a distance of 25 feet ahead of the point of measurement. The depth figures indicated in Bid Form are inclusive to nearest 0.1 foot; that is, a trench depth measured as 11.9 feet will be paid for at the unit price for excavation 10 feet to 12 feet deep. A trench depth measured as 12 feet will be paid for at the unit price for excavation 12 feet to 14 feet deep.

Item	Measurement Parameters
Unclassified Trench Excavation	Depth of Trench: Same as Trench Safety System above.
Trench Backfill and Compaction	Depth of Trench: Same as Unclassified Trench Excavation above.
Rock Excavation	Depth: Same as for Unclassified Trench Excavation above except that depth will be measured from surface of rock to bottom of pipe base 12 inches below pipe invert.

1.07 PAYMENT

A. Payment for all Lump Sum Work shown or specified in Contract Documents is included in the Contract Price. Payment will be based on a percentage complete basis for each line item of the accepted Schedule of Values.

B. Payment for Lump Sum Work covers all Work specified or shown within the limits or Specification sections as follows:

1. Limits of Work are as shown on the Drawings.
2. Limits of Work are as defined in Section 01 11 00, Summary of Work.

C. Payment for unit price items covers all the labor, materials, and services necessary to furnish and install the following items.

Item	Description
Rock Excavation	Pipe Lines: Maximum Width for Payment Purposes: 24 inches greater than the outside diameter of the barrel of the proposed pipeline. No payment will be made for rock excavated below the required grade or outside the widths mentioned above. No payment will be made for rock removed by any method other than systematic drilling. Manholes: Limits: 21 inches greater than outside diameter of manhole walls for manholes on 36 inches and smaller pipe. 12 inches outside actual dimensions of the base for manholes on 42 inches and larger pipe.

Item	Description
Highway Under Crossing(s)	Includes all Work between pay limits shown. Should limits of any crossing be increased or decreased for any reason during construction, lump sum payment for crossing will be adjusted by negotiated Change Order.
Removal and Disposal of Underground Tanks	Includes excavation, removal of tanks, piping and associated materials, transportation and disposal of contaminated earth, tanks and piping in a landfill licensed for hazardous waste, backfill of excavation with Imported Backfill, surface restoration and associated Work within pay limits shown.
Imported Pipe Bedding	Includes providing imported pipe bedding where required by Engineer.
Imported Pipe Zone	Includes providing imported pipe zone where required by Engineer.
12-Inch Ductile Iron Pipe	Includes providing pipe, fittings, valves, thrust protection, pipe bedding, pipe zone, and associated Work.
12-Inch Ductile Iron Water Line	Includes excavation, placement of pipe bedding, providing pipe, fittings, valves, thrust protection, pipe zone material, and all associated Work.
Trench Excavation and Backfill-Class D	Includes excavation, disposal of excavated material and providing imported backfill, backfill compaction, surface restoration, and associated Work as specified.

1.08 NONPAYMENT FOR REJECTED OR UNUSED PRODUCTS

A. Payment will not be made for following:

1. Loading, hauling, and disposing of rejected material.
2. Quantities of material wasted or disposed of in manner not called for under Contract Documents.
3. Rejected loads of material, including material rejected after it has been placed by reason of failure of Contractor to conform to provisions of Contract Documents.
4. Material not unloaded from transporting vehicle.
5. Defective Work not accepted by Owner.
6. Material remaining on hand after completion of Work.

1.09 PARTIAL PAYMENT FOR STORED MATERIALS AND EQUIPMENT

A. Partial Payment: No partial payments will be made for materials and equipment delivered or stored unless Shop Drawings and preliminary operation and maintenance data is acceptable to Engineer.

B. Final Payment: Will be made only for products incorporated in Work; remaining products, for which partial payments have been made, shall revert to Contractor unless otherwise agreed, and partial payments made for those items will be deducted from final payment.

1.10 PARTIAL PAYMENT FOR UNDELIVERED, PROJECT-SPECIFIC MANUFACTURED OR FABRICATED EQUIPMENT

A. Partial payment shall be made per the Process Air Compressor Equipment Request for Proposal for the Process Air Compression Equipment.

1.11 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this specification.

1. Application and Certification for Payment Form.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

GREATER NEW HAVEN WATER POLLUTION CONTROL AUTHORITY
APPLICATION AND CERTIFICATE FOR PAYMENT

TO (OWNER): **Greater New Haven WPCA**
260 East Street
New Haven, CT 06511

FROM (CONTRACTOR): [contractor name]

PROJECT: [name]

ENGINEER: [firm name]

Requisition No : 1
PERIOD TO: [date]
PROJECT NO: xxxxxxxx
CONTRACT DATE: [date]

Distribution to:
■ OWNER
☐ ENGINEER/ARCHITECT
☐ CONTRACTOR
☐ OTHER:
☐ OTHER:

CONTRACTOR'S APPLICATION FOR PAYMENT

Application is made for Payment, as shown below, in accordance with the Greater New Haven Water Pollution Control Authority's (Authority) Standard Specifications

1. ORIGINAL CONTRACT SUM		
2. Net change by Change Orders	$	-
3. CONTRACT SUM TO DATE (Line 1+2)	$	-
4. TOTAL COMPLETED & STORED TO DATE		$0.00
5. RETAINAGE:		
a. 0 % of Completed Work	$	-
b. 0 % of Stored Material	$	
Total Retainage (Line 5a + 5b)	$	-
6. TOTAL EARNED LESS RETAINAGE (Line 4 less Line 5 Total)	$	-
7. LESS PREVIOUS CERTIFICATES FOR (Line 6 from prior certificate)	$	-
8. CURRENT PAYMENT DUE	$	-
9. BALANCE TO FINISH, PLUS RETAINAGE (Line 3 Less Line 6)	$	-

CHANGE ORDER SUMMARY	ADDITIONS	DEDUCTIONS
Change orders approved in previous months by Owner:		
Change orders approved this month:		
TOTALS	**$0.00**	**$0.00**
NET CHANGES by Change Order		

The undersigned Contractor certifies that to the best of the Contractor's knowledge, information and belief the Work covered by this Application for payment has been completed in accordance with the Authority's Standard Specifications, that all amounts have been paid by the Contractor for Work for which previous Certificates for Payment were issued and payments received from the Owner, and that current payment shown herein is now due.

CONTRACTOR: _____

By: _____ Date: _____

State of: _____ County of: _____

Subscribed and sworn to before me this _____ day of _____

Notary Public: _____

My Commission expires: _____

AUTHORITY'S CERTIFICATE FOR PAYMENT

In accordance with the Authority's Standard Specification, based on on-site observations and the data comprising the above application, the Engineer certifies to the owner that to the best knowledge, information and belief the Work has progressed as indicated, the quality of the Work is in accordance with the Standard Specification, and the Contractor is entitled to payment of the AMOUNT CERTIFIED.

AMOUNT CERTIFIED $ _____

Project Engineer Name/Firm: _____

By: _____ Date: _____

(Attach explanation if amount certified differs from the amount applied for. Initial all figures on this Application and on the Continuation Sheet that are changed to conform to the amount certified.)

GNHWPCA USE ONLY:
GNHWPCA Project Manager:

By: _____ Date: _____

Director of Engineering: Thomas V. Sgroi, P.E.

By: _____ Date: _____

This certificate is not negotiable. The AMOUNT CERTIFIED is payable only to the Contractor named herein. Issuance, payment and acceptance of payment are without prejudice to any rights of the Owner or Contractor under this Contract.

SECTION 01 31 13
PROJECT COORDINATION

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational:

1. Statement of Qualification (SOQ) for land surveyor or civil engineer.
2. Photographs:
   a. Digital Images: Submit Electronic copies of images within 5 days of being taken. Each image is to have a minimum file size of 1.4 Mb (1,400 Kb) so viewed resolution is high quality. The production of larger file sizes with higher resolution is encouraged.
   b. Color Prints: Submit two copies, accompanied by negatives, within 5 days of being taken.
3. Video Recordings: Submit electronic copies, including updated copy of project video log, within 5 days of being taken.

1.02 RELATED WORK AT SITE

A. General:

1. Other work that is either directly or indirectly related to scheduled performance of the Work under these Contract Documents, listed henceforth, is anticipated to be performed at Site by others.
2. Coordinate the Work of these Contract Documents with work of others as specified in General Conditions.
3. Include sequencing constraints specified herein as a part of Progress Schedule.

B. Applications Software Development:

1. NIC Systems Corporation will perform programming of applications software for certain portions of Process Instrumentation and Control Subsystem (PICS). Refer to Section 40 90 01, Instrumentation and Control for Process Systems, for detailed information pertaining to Engineer programming.
   a. Coordinate and deliver to staging site hardware and standard software components, as specified for PICS.
   b. Sequencing: Include sequencing constraints specified herein as part of Progress Schedule.
   c. Engineer will confirm delivery date with Contractor 10 days prior to scheduled delivery, and within 24 hours of expected delivery time.

2. Engineer will be responsible for coordinating delivery of hardware specified in Sections 40 90 01.01 Component Specifications, 40 90 01.02 Instrument List, and 40 90 01.03 IO List to NIC Systems Corporation within constraints detailed in Section 40 90 01, Instrumentation and Control for Process Systems.
3. Allowance for interruptions to the Work because of testing by Engineer of NIC Systems Corporation-developed applications software:
    a. During Functional Testing and Demonstration Testing, Contractor shall plan for interruption of testing of the Work to allow Engineer to investigate software problems, make software configuration changes, and conduct additional testing.
    b. Allowance for Interruptions: 10 days total.
    c. When applications software testing is delayed because of altered equipment interfaces or receipt of incorrect Shop Drawing information, duration of delay will be excluded from interruption allowance, unless notified otherwise by Engineer.

1.03 MILESTONES

A. General:

1. This contract is divided up into a series of milestones.
2. The constraints within a milestone are arranged in a logical order but are not intended to be executed consecutively.
3. The Construction Sequence Drawings in the Drawings define significant items of temporary work required to sequence construction activities in order to maintain the necessary level of treatment capacity
4. The Owner will not make final inspection of substantially completed work until all milestones are substantially complete.

B. Milestones:

1. Milestone 1 – Time period for Contract Administration and Start of Procurement (90 days).
2. Milestone 2 – New PAC Building Substantial Completion (427 days).
3. Milestone 3 – Aeration Basin Piping System Substantial Completion (125 days).
4. Milestone 4 – PAC Demonstration Testing (28 days).

1.04 WORK SEQUENCING AND CONSTRAINTS

A. Include the following work sequences and constraints in the Progress Schedule:

1. Milestone 1 – 90-day time period for Milestone 1 is time for Contractor to start administration work and procurement. No field work is permitted during Milestone 1.

2. Milestone 2 – New PAC Building Substantial Completion:
    a. Underground Piping Relocation:
        1) A maximum of 4 hour shut down will be allowed during the relocation of the Scum Discharge, Activated Sludge, Plant Water and Fire Water Process pipes.
        2) New Scum Discharge, Activated Sludge, Plant Water and Fire Water Process pipes shall be in place and pressure tested prior to the shut down and tie in of the existing pipes.
    b. Existing Aeration Basin Joint Repair:
        1) Repair structural concrete joints in existing anoxic zone exterior walls as shown on the drawings.
    c. PAC Building Construction:
        1) Construct New PAC Building complete with all equipment and exterior features.
        2) Construct New PAC Facility Main ALP Header.
    d. Electrical Service to New PAC Building:
        1) New Pad Mounted Transformers for Process Air Compressor Building:
            a) Note: The new transformers for the Process Air Compressor Building will functionally replace the two existing pad mounted transformers presently feeding the existing 4,160 volts Substation 4 MCC A7, A8, and A9 when the new process air compressors are tested and verified operational.
            b) Transfer power to MCC A7, A8, and A9 to be fed only from existing transformer XFMR-A7.
            c) At 13,800 volts Service Entrance Switchgear located in Electrical Building, open circuit breaker feeding existing transformer XMR-A9. Provide lockout-tagout of breaker with Contractor's lock and with Owner's lock.
            d) At existing transformer XMR-A9, disconnect all primary and secondary conductors. Pull secondary conductors to be demolished back to main switch located on Substation 4 located in the Substation 2 building. See drawings for demolition of exposed secondary conduits.
            e) In Manhole E10, locate primary feeders conductors to existing transformer XMR-A9 and pull back into manhole. Note that these conductors will be re-used.
            f) Completely demolish concrete pad for existing transformer XMR-A9. Install new manhole at same location and extend existing transformer XMR-A9 primary conduits routed from Manhole E10 into new manhole. Note: The purpose of the new manholes is to provide a better location to splice high voltage

conductors than in the existing Manhole E-10 which contains feeders for Substations 2, 3, and 4.

g) Install new primary conduits from new manhole to new Transformer TR4 concrete pad.

h) Install secondary conduits from new Transformer TR4 pad to new Substation 4. Complete pad installation.

i) Install transformer and install and connect primary feeder conductors from new manhole to Transformer TR4. In existing Manhole E-10, pull XMR-A9 primary feeder conductors and make 13,800 volts splices in manhole to connect existing primary feeder conductors with new primary feeder conductors. Install and connect new secondary conductors from transformer to new Substation 4. Secondary Substation 4 should be already installed and ready to be energized.

j) When it has been determined by Engineer that the new process air compressors can be tested, remove lockout-tagout of breaker with Contractor's lock and with Owner's lock and energize Transformer TR4 and Substation 4.

k) The result of this is while the new air compressors are being tested, the existing aeration basins air blower are still providing air to the process through the other existing transformer. Note that though the process air compressors may not be operational all the time, the Process Air Compressor Building will have lighting and ventilation because the 480V to the building is powered from new transfer switch located in Substation 2 Building which is adjacent to the new Process Air Compressor Building.

l) When it has been agreed with the Owner that the new process air compressors are tested and verified operational, repeat above steps for existing Transformer XMR-A7 and new Transformer TL4.

m) Demolish the existing 4,160 volts MCC-A7, A8, and A9. Remove all overhead conduits routed to existing Control Panel CP-50 located in small control panel room in building. Cap all conduits penetrating the floor slab under the MCCs. See drawings for additional demolition.

e. Replacement of existing 13.8KV/480V transformers feeding Substation 2:

1) Remove existing transformers one at a time and replace with new transformer. Coordinate with new transformer manufacturer the required number of secondary conductor

lugs required due to the fact the new transformer is reduced total KVA.

3. Milestone 3 – Aeration Basin Piping System Substantial Completion:
   a. Contractor shall not put any lifts, scaffolding or other equipment on the floor of the aeration basins to perform any demolition or installation work on the basins. All Contractor work shall be performed from existing walkways or new temporary construction walkways provided by the Contractor.
   b. Main ALP Header Cross and Isolation Valve Installation:
      1) A 30-inch fabricated cross and isolation valve shall be installed on the FRP blower discharge crossover pipe as shown on the Drawings. The maximum 6-hour shut down will be allowed.
      2) A section of the 30-inch FRP blower suction crossover pipe shall be demolished south of the 30-inch isolation valve to permit installation of the new ALP header as shown on the Drawings. The cut section of FRP shall be capped. A maximum 6-hour shut down will be allowed.
   c. 15-day Functional Test of PAC System:
      1) After each PAC has passed Functional Testing, the new ALP header is installed on the basin, including crossover piping isolation valves, and connected to the PACs, the PAC System shall operate successfully for 15 days.
      2) The PAC manufacturer shall prepare functional testing procedures and provide assistance as needed during Functional Testing. The 15-day Functional Test must demonstrate the PAC System will operate as specified.
      3) After 15 consecutive days of trouble-free operation approved by the Owner, the Contractor may proceed to Basin Piping Installation.
   d. Basin Piping Installation:
      1) Basin Piping Installation consists of 4 stages.
         a) Stage 1 - Basin 4 Piping Installation:
            (1) Owner will drain basin. Contractor will allow Owner 7 days to drain basin. Owner may leave basin empty or refill with plant water during Contractor activities.
            (2) Basin 4 can be taken offline for up to 30 days for completion of this work.
            (3) Demolish two existing Blowers on north side of Aeration Basins including the north side filters, suction piping, suction crossover piping up to 30-inch isolation valve and discharge piping up to blower isolation valves.
            (4) Demolish Basin 4 FRP piping downstream of 20-inch discharge piping isolation valve and supports no longer required.

(5) Install new ALP piping to Zones 2A/2B, 2, 3 and 4/5.
(6) Install new control valves and instrumentation.
(7) Owner will refill Basin 4 with mixed liquor and Contractor shall complete startup of new piping system for Basin 4.
(8) Provide 5 days of trouble-free operation and Owner approval to proceed to next Basin.

b) Stage 2 – Basin 3 Piping Installation:
(1) All demolition and new installation of piping and valves will be accomplished with Basin 3 remaining in service.
(2) All remaining FRP piping and supports north of crossover isolation valves can be demolished. Existing blowers and FRP piping shall remain operational to provide aeration for Basins 1 and 2.
(3) Install new ALP piping to Zones 2A/2B, 2, 3 and 4/5.
(4) Install new control valves and instrumentation.
(5) Provide 5 days of trouble-free operation and Owner approval to proceed to next Basin.

c) Stage 3 –Basin 2 Piping Installation:
(1) All demolition and new installation of piping and valves will be accomplished with Basin 3 remaining in service.
(2) Install new ALP piping to Zones 2A/2B, 2, 3 and 4/5.

d) Install new control valves and instrumentation.

e) Provide 5 days of trouble-free operation and Owner approval to proceed to next Basin.

f) Stage 4 – Basin 1 Piping Installation:
(1) Owner will drain basin. Contractor will allow Owner 7 days to drain basin. Owner may leave basin empty or refill with plant water during Contractor activities.
(2) Basin 1 can be taken offline for up to 30 days for completion of this work.
(3) Demolish three Blowers on south side of Aeration Basins including the south side filters, suction piping, suction crossover piping up to 30-inch cross isolation valve.
(4) Install new ALP piping to Zones 2A/2B, 2, 3 and 4/5.
(5) Install new control valves and instrumentation.

(6) Owner will refill Basin 1 with mixed liquor and Contractor shall complete startup of new piping system for Basin 1.
(7) Provide 5 days of trouble-free operation and Owner approval to proceed to next Basin.

4. Milestone 4 – PAC Demonstration Testing:
   a. Perform PAC Demonstration Testing per PAC Section 44 42 19.05, High Speed Turbo Air Compressors.

1.05 FACILITY OPERATIONS

A. Continuous operation of Owner's facilities is of critical importance. Schedule and conduct activities to enable existing facilities to operate continuously, unless otherwise specified.

B. Perform Work continuously during critical connections and changeovers, and as required to prevent interruption of Owner's operations.

C. When necessary, plan, design, and provide various temporary services, utilities, connections, temporary piping and heating, access, and similar items to maintain continuous operations of Owner's facility.

D. Do not close lines, open or close valves, or take other action which would affect the operation of existing systems, except as specifically required by the Contract Documents and after authorization by Owner and Engineer. Such authorization will be considered within 48 hours after receipt of Contractor's written request.

E. Process or Facility Shutdown:

1. Provide 7 days advance written request for approval of need to shut down a process or facility to Owner and Engineer.
2. Power outages will be considered upon 48 hours written request to Owner and Engineer. Describe the reason, anticipated length of time, and areas affected by the outage. Provide temporary provisions for continuous power supply to critical facility components.

F. Do not proceed with Work affecting a facility's operation without obtaining Owner's and Engineer's advance approval of the need for and duration of such Work.

G. Relocation of Existing Facilities:

1. During construction, it is expected that minor relocations of Work will be necessary.
2. Provide complete relocation of existing structures and Underground Facilities, including piping, utilities, equipment, structures, electrical conduit wiring, electrical duct bank, and other necessary items.
3. Use only new materials for relocated facility. Match materials of existing facility, unless otherwise shown or specified.
4. Perform relocations to minimize downtime of existing facilities.
5. Install new portions of existing facilities in their relocated position prior to removal of existing facilities, unless otherwise accepted by Engineer.

1.06 ADJACENT FACILITIES AND PROPERTIES

A. Examination:

1. After Effective Date of the Agreement and before Work at Site is started, Contractor, Engineer, and Owner shall make a thorough examination of pre-existing conditions including existing buildings, structures, and other improvements in vicinity of Work, as applicable, which could be damaged by construction operations.
2. Periodic reexamination shall be jointly performed to include, but not limited to, cracks in structures, settlement, leakage, and similar conditions.

B. Documentation:

1. Record and submit documentation of observations made on examination inspections in accordance with Article Construction Photographs.
2. Upon receipt, Engineer will review, sign, and return a record copy of documentation to Contractor to be kept on file in field office.
3. Such documentation shall be used as indisputable evidence in ascertaining whether and to what extent damage occurred as a result of Contractor's operations, and is for the protection of adjacent property owners, Contractor, and Owner.

1.07 CONSTRUCTION PHOTOGRAPHS

A. General:

1. Photographically document all phases of the Project including preconstruction, construction progress, and post-construction.
2. Photography shall be by a professional commercial photographer, experienced in shooting interior/exterior construction photos, in daylight and nighttime conditions, and in good and inclement weather.
3. Engineer shall have right to select subject matter and vantage point from which photographs are to be taken.

4. Digital Images: No post-session electronic editing of images is allowed. Stored image shall be actual image as captured without cropping or other edits. Film Images: Handling and development shall be done by a commercial laboratory.

B. Preconstruction and Post-Construction:

1. After Effective Date of the Agreement and before Work at Site is started, and again upon issuance of Substantial Completion, take a minimum of 48 photographs of Site and property adjacent to perimeter of Site.
2. Particular emphasis shall be directed to structures both inside and outside the Site.
3. Format: Digital, minimum resolution of 1832 by 3264.

C. Construction Progress Photos:

1. Photographically demonstrate progress of construction, showing every aspect of Site and adjacent properties as well as interior and exterior of new or impacted structures.
2. Monthly: Take 50 photographs using digital, minimum resolution of 1832 by 3264.

D. Documentation:

1. Digital Images:
   a. Electronic image shall have date taken embedded into image.
   b. Archive using a commercially available photo management system that provides listing of photographs including date, keyword description, and direction of photograph.
   c. Label file folders or database records with Project and Owner's name, and month and year images were produced.
   d. Label photos with the following information:
      1) Project Number (CWF 2019-04).
      2) Date Taken.
      3) View Provided.
      4) Subject Matter of Photo.

1.08 AUDIO-VIDEO RECORDINGS

A. Prior to beginning the Work on Site or of a particular area of the Work, videograph Site and property adjacent to Site.

B. In the case of preconstruction recording, no work shall begin in the area prior to Engineer's review and approval of content and quality of video for that area.

C. Particular emphasis shall be directed to physical condition of existing vegetation, structures, and pavements within areas adjacent to and within the right-of-way or easement, and on Contractor storage and staging areas.

D. Engineer shall have right to select subject matter and vantage point from which videos are to be taken.

E. Video recording shall be by a professional commercial videographer, experienced in shooting exterior and interior.

F. Video Format and Quality:

1. DVD format, with sound.
2. Video:
   a. Produce bright, sharp, and clear images with accurate colors, free of distortion and other forms of picture imperfections.
   b. Electronically, and accurately display the month, day, year, and time of day of the recording.
3. Audio:
   a. Audio documentation shall be done clearly, precisely, and at a moderate pace.
   b. Indicate date, project name, and a brief description of the location of recording, including:
      1) Facility name.
      2) Street names or easements.
      3) Addresses of private property.
      4) Direction of coverage, including engineering stationing, if applicable.

G. Documentation:

1. DVD Label:
   a. DVD number (numbered sequentially, beginning with 001).
   b. Project name.
   c. Date and time of coverage.
2. Project Video Log: Maintain an ongoing log that incorporates above noted label information for DVDs on Project.

1.09 REFERENCE POINTS AND SURVEYS

A. Location and elevation of benchmarks are shown on Drawings.

B. Contractor's Responsibilities:

1. Provide additional survey and layout required to layout the Work.
2. Check and establish exact location of existing facilities prior to construction of new facilities and any connections thereto.

3. In event of discrepancy in data or staking provided by Owner, request clarification before proceeding with Work.
4. Retain professional land surveyor or civil engineer registered in Connecticut who shall perform or supervise engineering surveying necessary for additional construction staking and layout.
5. Maintain complete accurate log of survey work as it progresses as a Record Document.
6. On request of Engineer, submit documentation.
7. Provide competent employee(s), tools, stakes, and other equipment and materials as Engineer may require to:
    a. Establish control points, lines, and easement boundaries.
    b. Check layout, survey, and measurement work performed by others.
    c. Measure quantities for payment purposes.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 SALVAGE OF MATERIALS

A. Materials to be salvaged are identified on the drawings. Salvage requirements are detailed in the demolition specification.:

B. Salvage materials for Owner's use where shown.

1. Remove material with extreme care so as not to damage for future use.
2. Promptly remove salvaged materials from Work area.
3. Store materials where instructed by Owner onsite.

C. Meet with Engineer prior to starting to dismantle equipment or piping designated to be salvaged. Engineer will indicate locations where equipment is to be disconnected.

D. Provide new or repair damaged equipment or material specified or indicated to be salvaged. Clean and protect equipment from dust, dirt, natural elements, and store as directed.

3.02 CUTTING, FITTING, AND PATCHING

A. Cut, fit, adjust, or patch Work and work of others, including excavation and backfill as required, to make Work complete.

B. Obtain prior written authorization of Engineer before commencing Work to cut or otherwise alter:

1. Structural or reinforcing steel, structural column or beam, elevated slab, trusses, or other structural member.

2. Weather-resistant or moisture-resistant elements.
3. Efficiency, maintenance, or safety of element.
4. Work of others.

C. Refinish surfaces to provide an even finish.

1. Refinish continuous surfaces to nearest intersection.
2. Refinish entire assemblies.
3. Finish restored surfaces to such planes, shapes, and textures that no transition between existing work and the Work is evident in finished surfaces.

D. Restore existing work, Underground Facilities, and surfaces that are to remain in completed Work including concrete-embedded piping, conduit, and other utilities as specified and as shown on Drawings.

E. Make restorations with new materials and appropriate methods as specified for new Work of similar nature; if not specified, use recommended practice of manufacturer or appropriate trade association.

F. Fit Work airtight to pipes, sleeves, ducts, conduit, and other penetrations through surfaces and fill voids.

G. Remove specimens of installed Work for testing when requested by Engineer.

END OF SECTION

SECTION 01 31 19
PROJECT MEETINGS

PART 1 GENERAL

1.01 GENERAL

A. Engineer will schedule physical arrangements for meetings throughout progress of the Work, prepare meeting agenda with regular participant input and distribute with written notice of each meeting, preside at meetings, record minutes to include significant proceedings and decisions, and reproduce and distribute copies of minutes within 5 days after each meeting to participants and parties affected by meeting decisions.

1.02 PRECONSTRUCTION CONFERENCE

A. Contractor shall be prepared to discuss the following subjects, as a minimum:

1. Required schedules.
2. Status of Bonds and insurance.
3. Sequencing of critical path work items.
4. Progress payment procedures.
5. Project changes and clarification procedures.
6. Use of Site, access, office and storage areas, security and temporary facilities.
7. Major product delivery and priorities.
8. Contractor's safety plan and representative.

B. Attendees will include:

1. Owner's representatives.
2. Contractor's office representative.
3. Contractor's resident superintendent.
4. Contractor's quality control representative.
5. Subcontractors' representatives whom Engineer may request to attend.
6. Engineer's representatives.
7. Others as appropriate.

1.03 PRELIMINARY SCHEDULES REVIEW MEETING

A. As set forth in General Conditions and Section 01 32 00, Construction Progress Documentation.

1.04 PROGRESS MEETINGS

A. Engineer will schedule regular progress meetings at Site, conducted monthly to review the Work progress, Progress Schedule, Schedule of Submittals,

Application for Payment, contract modifications, and other matters needing discussion and resolution.

B. Attendees will include:

1. Owner's representative(s), as appropriate.
2. Contractor.
3. Engineer's representative(s).
4. Others as appropriate.

1.05 QUALITY CONTROL MEETINGS

A. In accordance with Section 01 45 16.13, Contractor Quality Control.

B. Scheduled by Engineer on regular basis and as necessary to review test and inspection reports, and other matters relating to quality control of the Work and work of other Contractors.

C. Attendees will include:

1. Contractor.
2. Contractor's designated quality control representative.
3. Subcontractors and Suppliers, as necessary.
4. Engineer's representatives.

1.06 PROCESS INSTRUMENTATION AND CONTROL SYSTEMS (PICS) COORDINATION MEETINGS

A. Engineer will schedule meetings at Site, conducted bi-monthly to review specific requirements of PICS work.

B. Attendees will include:

1. Contractor.
2. Owner.
3. PICS Subcontractor/Installer.
4. Engineer's representatives.
5. NIC Systems Corporation.

1.07 PREINSTALLATION MEETINGS

A. When required in individual Specification sections, convene at Site prior to commencing the Work of that section.

B. Require attendance of entities directly affecting, or affected by, the Work of that section.

C. Notify Engineer 5 days in advance of meeting date.

D. Provide suggested agenda to Engineer to include reviewing conditions of installation, preparation and installation or application procedures, and coordination with related Work and work of others.

1.08 FACILITY STARTUP MEETINGS

A. Schedule and attend a minimum of 2 facility startup meetings. The first of such meetings shall be held prior to submitting Facility Startup Plan, as specified in Section 01 91 14, Equipment Testing and Facility Startup, and shall include preliminary discussions regarding such plan.

B. Agenda items shall include, but not be limited to, content of Facility Startup Plan, coordination needed between various parties in attendance, and potential problems associated with startup.

C. Attendees will include:

1. Contractor.
2. Contractor's designated quality control representative.
3. Subcontractors and equipment manufacturer's representatives whom Contractor deems to be directly involved in facility startup.
4. Engineer's representatives.
5. Owner's operations personnel.
6. Others as required by Contract Documents or as deemed necessary by Contractor.

1.09 OTHER MEETINGS

A. In accordance with Contract Documents and as may be required by Owner and Engineer.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01 32 00
CONSTRUCTION PROGRESS DOCUMENTATION

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Preliminary Progress Schedule: Submit at least 7 days prior to preconstruction conference.
2. Detailed Progress Schedule:
   a. Submit initial Detailed Progress Schedule within 60 days after Effective Date of the Agreement.
   b. Submit an Updated Progress Schedule at each update, in accordance with Article Detailed Progress Schedule.
3. Submit with Each Progress Schedule Submission:
   a. Contractor's certification that Progress Schedule submission is actual schedule being used for execution of the Work.
   b. Electronic file compatible with latest version of Project Planner (P6) by Primavera Systems, Inc., or the latest Microsoft Project by Microsoft Corporation.
   c. Progress Schedule: Electronic copies and two hard copies.
   d. Narrative Progress Report: Same number of copies as specified for Progress Schedule.
4. Prior to final payment, submit a final Updated Progress Schedule.

1.02 PRELIMINARY PROGRESS SCHEDULE

A. In addition to basic requirements outlined in General Conditions, show a detailed schedule, beginning with Notice to Proceed, for minimum duration of 120 days, and a summary of balance of Project through Final Completion.

B. Show activities including, but not limited to the following:

1. Notice to Proceed.
2. Permits.
3. Submittals, with review time. Contractor may use Schedule of Submittals specified in Section 01 33 00, Submittal Procedures.
4. Early procurement activities for long lead equipment and materials.
5. Initial Site work.
6. Earthwork.
7. Specified Work sequences and construction constraints.
8. Contract Milestone and Completion Dates.
9. Owner-furnished products delivery dates or ranges of dates.

10. Major structural, mechanical, equipment, electrical, architectural, and instrumentation and control Work.
11. System startup summary.
12. Project close-out summary.
13. Demobilization summary.

C. Update Preliminary Progress Schedule monthly as part of progress payment process. Failure to do so may result in the Owner withholding all or part of the monthly progress payment until the Preliminary Progress Schedule is updated in a manner acceptable to Engineer.

D. Format: In accordance with Article Progress Schedule—Bar Chart.

1.03 DETAILED PROGRESS SCHEDULE

A. In addition to requirements of General Conditions, submit Detailed Progress Schedule beginning with Notice to Proceed and continuing through Final Completion.

B. Show the duration and sequences of activities required for complete performance of the Work reflecting means and methods chosen by Contractor.

C. When accepted by Engineer, Detailed Progress Schedule will replace Preliminary Progress Schedule and become Baseline Schedule. Subsequent revisions will be considered as Updated Progress Schedules.

D. Format: In accordance with Article Progress Schedule—Bar Chart.

E. Update monthly to reflect actual progress and occurrences to date, including weather delays.

1.04 PROGRESS SCHEDULE—BAR CHART

A. General: Comprehensive bar chart schedule, generally as outlined in Associated General Contractors of America (AGC) 580, “Construction Project Planning and Scheduling Guidelines.” If a conflict occurs between the AGC publication and this specification, this specification shall govern.

B. Format:

1. Unless otherwise approved, white paper, 11-inch by 17-inch sheet size.
2. Title Block: Show name of Project and Owner, date submitted, revision or update number, and name of scheduler.
3. Identify horizontally, across the top of the schedule, the timeframe by year, month, and day.

4. Identify each activity with a unique number and a brief description of the Work associated with that activity.
5. Legend: Describe standard and special symbols used.

C. Contents: Identify, in chronological order, those activities reasonably required to complete the Work, including as applicable, but not limited to:

1. Obtaining permits, submittals for early product procurement, and long lead time items.
2. Mobilization and other preliminary activities.
3. Initial Site work.
4. Specified Work sequences, constraints, and Milestones, including Substantial Completion date(s).
5. Subcontract Work.
6. Major equipment design, fabrication, factory testing, and delivery dates.
7. Delivery dates for Owner-furnished products, as specified in Section 01 11 00, Summary of Work.
8. Sitework.
9. Concrete Work.
10. Structural steel Work.
11. Architectural features Work.
12. Conveying systems Work.
13. Equipment Work.
14. Mechanical Work.
15. Electrical Work.
16. Instrumentation and control Work.
17. Interfaces with Owner-furnished equipment.
18. Other important Work for each major facility.
19. Equipment and system startup and test activities.
20. Project closeout and cleanup.
21. Demobilization.

1.05 PROGRESS SCHEDULE—CRITICAL PATH NETWORK

A. General: Comprehensive computer-generated schedule using CPM, generally as outlined in Associated General Contractors of America (AGC) 580, "Construction Project Planning and Scheduling Guidelines." If a conflict occurs between the AGC publication and this specification, this specification shall govern.

B. Contents:

1. Schedule shall begin with the date of Notice to Proceed and conclude with the date of Final Completion.
2. Identify Work calendar basis using days as a unit of measure.

3. Show complete interdependence and sequence of construction and Project-related activities reasonably required to complete the Work.
4. Identify the Work of separate stages and other logically grouped activities, and clearly identify critical path of activities.
5. Reflect sequences of the Work, restraints, delivery windows, review times, Contract Times and Project Milestones set forth in the Agreement and Section 01 31 13, Project Coordination.
6. Include as applicable, at a minimum:
    a. Obtaining permits, submittals for early product procurement, and long lead time items.
    b. Mobilization and other preliminary activities.
    c. Initial Site work.
    d. Specified Work sequences, constraints, and Milestones, including Substantial Completion date(s) Subcontract Work.
    e. Major equipment design, fabrication, factory testing, and delivery dates.
    f. Delivery dates for Owner-furnished products, as specified in Section 01 11 00, Summary of Work.
    g. Sitework.
    h. Concrete Work.
    i. Structural steel Work.
    j. Architectural features Work.
    k. Conveying systems Work.
    l. Equipment Work.
    m. Mechanical Work.
    n. Electrical Work.
    o. Instrumentation and control Work.
    p. Interfaces with Owner-furnished equipment.
    q. Other important Work for each major facility.
    r. Equipment and system startup and test activities.
    s. Project closeout and cleanup.
    t. Demobilization.
7. No activity duration, exclusive of those for Submittal review and product fabrication/delivery, shall be less than 1 day no more than 14 days, unless otherwise approved.
8. Activity duration for Submittal review shall not be less than review time specified unless clearly identified and prior written acceptance has been obtained from Engineer.

C. Network Graphical Display:

1. Plot or print on paper not greater than 30 inches by 42 inches or smaller than 22 inches by 34 inches, unless otherwise approved.
2. Title Block: Show name of Project, Owner, date submitted, revision or update number, and the name of the scheduler. Updated schedules shall indicate data date.

3. Identify horizontally across top of schedule the time frame by year, month, and day.
4. Identify each activity with a unique number and a brief description of the Work associated with that activity.
5. Indicate the critical path.
6. Show, at a minimum, the controlling relationships between activities.
7. Plot activities on a time-scaled basis, with the length of each activity proportional to the current estimate of the duration.
8. Plot activities on an early start basis unless otherwise requested by Engineer.
9. Provide a legend to describe standard and special symbols used.

D. Schedule Report:

1. On 8-1/2-inch by 11-inch white paper, unless otherwise approved.
2. List information for each activity in tabular format, including at a minimum:
    a. Activity Identification Number.
    b. Activity Description.
    c. Original Duration.
    d. Remaining Duration.
    e. Early Start Date (Actual start on Updated Progress Schedules).
    f. Early Finish Date (Actual finish on Updated Progress Schedules).
    g. Late Start Date.
    h. Late Finish Date.
    i. Total Float.
3. Sort reports, in ascending order, as listed below:
    a. Activity number sequence with predecessor and successor activity.
    b. Activity number sequence.
    c. Early-start.
    d. Total float.

1.06 PROGRESS OF THE WORK

A. Updated Progress Schedule shall be submitted monthly and reflect:

1. Progress of Work to within 5 working days prior to submission.
2. Approved changes in Work scope and activities modified since submission.
3. Delays in Submittals or resubmittals, deliveries, or Work.
4. Adjusted or modified sequences of Work.
5. Other identifiable changes.
6. Revised projections of progress and completion.
7. Report of changed logic.

B. Produce detailed subschedules during Project, upon request of Owner or Engineer, to further define critical portions of the Work such as facility shutdowns.

C. If an activity is not completed by its latest scheduled completion date and this failure is anticipated to extend Contract Times (or Milestones), submit, within 7 days of such failure, a written statement as to how nonperformance will be corrected to return Project to acceptable current Progress Schedule. Actions by Contractor to complete the Work within Contract Times (or Milestones) will not be justification for adjustment to Contract Price or Contract Times.

D. Owner may order Contractor to increase plant, equipment, labor force, or working hours if Contractor fails to:

1. Complete a Milestone activity by its completion date.
2. Satisfactorily execute Work as necessary to prevent delay to overall completion of Project, at no additional cost to Owner.

1.07 NARRATIVE PROGRESS REPORT

A. Format:

1. Organize same as Progress Schedule.
2. Identify, on a cover letter, reporting period, date submitted, and name of author of report.

B. Contents:

1. Number of days worked over the period, work force on hand, construction equipment on hand (including utility vehicles such as pickup trucks, maintenance vehicles, stake trucks).
2. General progress of Work, including a listing of activities started and completed over the reporting period, mobilization/demobilization of subcontractors, and major milestones achieved.
3. Contractor's plan for management of Site (for example, lay down and staging areas, construction traffic), use of construction equipment, buildup of trade labor, and identification of potential Contract changes.
4. Identification of new activities and sequences as a result of executed Contract changes.
5. Documentation of weather conditions over the reporting period, and any resulting impacts to the work.
6. Description of actual or potential delays, including related causes, and the steps taken or anticipated to mitigate their impact.
7. Changes to activity logic.
8. Changes to the critical path.

9. Identification of, and accompanying reason for, any activities added or deleted since the last report.
10. Steps taken to recover the schedule from Contractor-caused delays.

1.08 SCHEDULE ACCEPTANCE

A. Engineer's acceptance will demonstrate agreement that:

1. Proposed schedule is accepted with respect to:
   a. Contract Times, including Final Completion and all intermediate Milestones, are within the specified times.
   b. Specified Work sequences and constraints are shown as specified.
   c. Specified Owner-furnished Equipment or Material arrival dates, or range of dates, are included.
   d. Access restrictions are accurately reflected.
   e. Startup and testing times are as specified.
   f. Submittal review times are as specified.
   g. Startup testing duration is as specified, and timing is acceptable.
2. In all other respects, Engineer's acceptance of Contractor's schedule indicates that, in Engineer's judgment, schedule represents reasonable plan for constructing Project in accordance with the Contract Documents. Engineer's review will not make any change in Contract requirements. Lack of comment on any aspect of schedule that is not in accordance with the Contract Documents will not thereby indicate acceptance of that change, unless Contractor has explicitly called the nonconformance to Engineer's attention in submittal. Schedule remains Contractor's responsibility and Contractor retains responsibility for performing all activities, for activity durations, and for activity sequences required to construct Project in accordance with the Contract Documents.

B. Unacceptable Preliminary Progress Schedule:

1. Make requested corrections; resubmit within 10 days.
2. Until acceptable to Engineer as Baseline Progress Schedule, continue review and revision process, including updating schedule on a monthly basis to reflect actual progress and occurrences to date.

C. Unacceptable Detailed Progress Schedule:

1. Make requested corrections; resubmit within 10 days.
2. Until acceptable to Engineer as Baseline Progress Schedule, continue review and revision process.

D. Narrative Report: All changes to activity duration and sequences, including addition or deletion of activities subsequent to Engineer's acceptance of

Baseline Progress Schedule, shall be delineated in Narrative Report current with proposed Updated Progress Schedule.

1.09 ADJUSTMENT OF CONTRACT TIMES

A. Reference General Conditions and Section 01 26 00, Contract Modification Procedures.

B. Evaluation and reconciliation of Adjustments of Contract Times shall be based on the Updated Progress Schedule at the time of proposed adjustment or claimed delay.

C. Float:

1. Float time is a Project resource available to both parties to meet contract Milestones and Contract Times.
2. Use of float suppression techniques such as preferential sequencing or logic, special lead/lag logic restraints, and extended activity times are prohibited, and use of float time disclosed or implied by use of alternate float-suppression techniques shall be shared to proportionate benefit of Owner and Contractor.
3. Pursuant to above float-sharing requirement, no time extensions will be granted nor delay damages paid until a delay occurs which (i) impacts Project's critical path, (ii) consumes available float or contingency time, and (iii) extends Work beyond contract completion date.

D. Claims Based on Contract Times:

1. Where Engineer has not yet rendered formal decision on Contractor's Claim for adjustment of Contract Times, and parties are unable to agree as to amount of adjustment to be reflected in Progress Schedule, reflect an interim adjustment in the Progress Schedule as acceptable to Engineer.
2. It is understood and agreed that such interim acceptance will not be binding on either Contractor or Owner and will be made only for the purpose of continuing to schedule Work until such time as formal decision has been rendered as to an adjustment, if any, of the Contract Times.
3. Revise Progress Schedule prepared thereafter in accordance with Engineer's formal decision.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01 33 00
SUBMITTAL PROCEDURES

PART 1 GENERAL

1.01 DEFINITIONS

A. Action Submittal: Written and graphic information submitted by Contractor that requires Engineer's approval.

B. Deferred Submittal: Information submitted by Contractor for portions of design that are to be submitted to permitting agency for approval prior to installation of that portion of the Work, along with Engineer's review documentation that submittal has been found to be in general conformance with Project's design.

C. Informational Submittal: Information submitted by Contractor that requires Engineer's review and determination that submitted information is in accordance with the Conditions of the Contract.

1.02 PROCEDURES

A. Direct submittals to Engineer and Owner at the following, unless specified otherwise.

1. Electronic Submittals: Email address will be provided at Preconstruction Meeting.
2. Hard Copy: JACOBS
   Attention: Construction Manager
   100 Great Meadow Road, Suite 707
   Weathersfield, CT 06109

B. Electronic Submittals: Submittals shall, unless specifically accepted, shall be made in electronic format.

1. Each submittal shall be an electronic file in Adobe Acrobat Portable Document Format (PDF). Use the latest version available at time of execution of the Agreement.
2. Electronic files that contain more than 10 pages in PDF format shall contain internal bookmarking from an index page to major sections of the document.
3. PDF files shall be set to open "Bookmarks and Page" view.
4. Add general information to each PDF file, including title, subject, author, and keywords.
5. PDF files shall be set up to print legibly at 8.5-inch by 11-inch, 11-inch by 17-inch, or 22-inch by 34-inch. No other paper sizes will be accepted.

6. Submit new electronic files for each resubmittal.
7. Include a copy of the Transmittal of Contractor's Submittal form, located at end of section, with each electronic file.
8. Engineer will reject submittal that is not electronically submitted, unless specifically accepted.
9. Provide Engineer with authorization to reproduce and distribute each file as many times as necessary for Project documentation.
10. Detailed procedures for handling electronic submittals will be discussed at the preconstruction conference.

C. Transmittal of Submittal:

1. Contractor shall:
   a. Review each submittal and check for compliance with Contract Documents.
   b. Stamp each submittal with uniform approval stamp before submitting to Engineer.
      1) Stamp to include Project name, submittal number, Specification number, Contractor's reviewer name, date of Contractor's approval, and statement certifying submittal has been reviewed, checked, and approved for compliance with Contract Documents.
      2) Engineer will not review submittals that do not bear Contractor's approval stamp and will return them without action.
2. Complete, sign, and transmit with each submittal package, one Transmittal of Contractor's Submittal form attached at end of this section.
3. Identify each submittal with the following:
   a. Numbering and Tracking System:
      1) Sequentially number each submittal.
      2) Resubmission of submittal shall have original number with sequential alphabetic suffix.
   b. Specification section and paragraph to which submittal applies.
   c. Project title and Engineer's project number.
   d. Date of transmittal.
   e. Names of Contractor, Subcontractor or Supplier, and manufacturer as appropriate.
4. Identify and describe each deviation or variation from Contract Documents.

D. Format:

1. Do not base Shop Drawings on reproductions of Contract Documents.
2. Package submittal information by individual specification section. Do not combine different specification sections together in submittal package, unless otherwise directed in specification.

3. Present in a clear and thorough manner and in sufficient detail to show kind, size, arrangement, and function of components, materials, and devices, and compliance with Contract Documents.
4. Index with labeled tab dividers in orderly manner.

E. Timeliness: Schedule and submit in accordance Schedule of Submittals and requirements of individual specification sections.

F. Processing Time:

1. Time for review shall commence on Engineer's receipt of submittal.
2. Engineer will act upon Contractor's submittal and transmit response to Contractor not later than 30 days after receipt, unless otherwise specified.
3. Resubmittals will be subject to same review time.
4. No adjustment of Contract Times or Price will be allowed as a result of delays in progress of Work caused by rejection and subsequent resubmittals.

G. Resubmittals: Clearly identify each correction or change made.

H. Incomplete Submittals:

1. Engineer will return entire submittal for Contractor's revision if preliminary review deems it incomplete.
2. When any of the following are missing, submittal will be deemed incomplete:
   a. Contractor's review stamp; completed and signed.
   b. Transmittal of Contractor's Submittal; completed and signed.
   c. Insufficient number of copies.

I. Submittals not required by Contract Documents:

1. Will not be reviewed and will be returned stamped "Not Subject to Review."
2. Engineer will keep one copy and return submittal to Contractor.

1.03 ACTION SUBMITTALS

A. Prepare and submit Action Submittals required by individual specification sections.

B. Shop Drawings:

1. Copies: One electronic or six hard copy.
2. Identify and Indicate:
    a. Applicable Contract Drawing and Detail number, products, units and assemblies, and system or equipment identification or tag numbers.
    b. Equipment and Component Title: Identical to title shown on Drawings.
    c. Critical field dimensions and relationships to other critical features of Work. Note dimensions established by field measurement.
    d. Project-specific information drawn accurately to scale.
3. Manufacturer's standard schematic drawings and diagrams as follows:
    a. Modify to delete information that is not applicable to the Work.
    b. Supplement standard information to provide information specifically applicable to the Work.
4. Product Data: Provide as specified in individual specifications.
5. Deferred Submittal: See Drawings for list of deferred submittals.
    a. Contractor-design drawings and product data related to permanent construction.
        1) Written and graphic information.
        2) Drawings.
        3) Cut sheets.
        4) Data sheets.
        5) Action item submittals requested in individual specification section.
    b. Prior to installation of indicated structural or nonstructural element, equipment, distribution system, or component or its anchorage, submit required supporting data and drawings for review and acceptance by Engineer. Documentation of review and approval provided on Engineer's comment form, along with completed submittal, shall be filed with permitting agency by Contractor and approved by permitting agency prior to installation.
6. Foreign Manufacturers: When proposed, include names and addresses of at least two companies that maintain technical service representatives close to Project.

C. Samples:

1. Copies: Two, unless otherwise specified in individual specifications.
2. Preparation: Mount, display, or package Samples in manner specified to facilitate review of quality. Attach label on unexposed side that includes the following:
    a. Manufacturer name.
    b. Model number.

c. Material.
d. Sample source.

3. Manufacturer's Color Chart: Units or sections of units showing full range of colors, textures, and patterns available.
4. Full-size Samples:
   a. Size as indicated in individual specification section.
   b. Prepared from same materials to be used for the Work.
   c. Cured and finished in manner specified.
   d. Physically identical with product proposed for use.

D. Action Submittal Dispositions: Engineer will review, comment, stamp, and distribute as noted:

1. Approved:
   a. Contractor may incorporate product(s) or implement Work covered by submittal.
   b. Distribution: Electronic.
2. Approved as Noted:
   a. Contractor may incorporate product(s) or implement Work covered by submittal, in accordance with Engineer's notations.
   b. Distribution: Electronic.
      1)
3. Partial Approval, Resubmit as Noted:
   a. Make corrections or obtain missing portions and resubmit.
   b. Except for portions indicated, Contractor may begin to incorporate product(s) or implement Work covered by submittal, in accordance with Engineer's notations.
   c. Distribution: Electronic.
4. Revise and Resubmit:
   a. Contractor may not incorporate product(s) or implement Work covered by submittal.
   b. Distribution: Electronic.

1.04 INFORMATIONAL SUBMITTALS

A. General:

1. Copies: Submit electronic copies, unless otherwise indicated in individual specification section.
2. Refer to individual specification sections for specific submittal requirements.
3. Engineer will review each submittal. If submittal meets conditions of the Contract, Engineer will forward copy to appropriate parties. If Engineer determines submittal does not meet conditions of the Contract and is therefore considered unacceptable, Engineer will retain one copy and return remaining copy with review comments to Contractor and require that submittal be corrected and resubmitted.

B. Certificates:

1. General:
    a. Provide notarized statement that includes signature of entity responsible for preparing certification.
    b. Signed by officer or other individual authorized to sign documents on behalf of that entity.
2. Welding: In accordance with individual specification sections.
3. Installer: Prepare written statements on manufacturer's letterhead certifying installer complies with requirements as specified in individual specification section.
4. Material Test: Prepared by qualified testing agency, on testing agency's standard form, indicating and interpreting test results of material for compliance with requirements.
5. Certificates of Successful Testing or Inspection: Submit when testing or inspection is required by Laws and Regulations or governing agency or specified in individual specification sections.
6. Manufacturer's Certificate of Compliance: In accordance with Section 01 61 00, Common Product Requirements.
7. Manufacturer's Certificate of Proper Installation: In accordance with Section 01 43 33, Manufacturers' Field Services.

C. Construction Photographs: In accordance with Section 01 31 13, Project Coordination, and as may otherwise be required in Contract Documents.

D. Closeout Submittals: In accordance with Section 01 77 00, Closeout Procedures.

E. Contractor-design Data (related to temporary construction):

1. Written and graphic information.
2. List of assumptions.
3. List of performance and design criteria.
4. Summary of loads or load diagram, if applicable.
5. Calculations.
6. List of applicable codes and regulations.
7. Name and version of software.
8. Information requested in individual specification section.

F. Deferred Submittals: See Drawings for list of deferred submittals.

1. Contractor-design data related to permanent construction:
    a. List of assumptions.
    b. List of performance and design criteria.
    c. Summary of loads or load diagram, if applicable.
    d. Calculations.
    e. List of applicable codes and regulations.
    f. Name and version of design software.

g. Factory test results.
h. Informational submittals requested in individual specification section.

2. Prior to installation of indicated structural or nonstructural element, equipment, distribution system, or component or its anchorage, submit calculations and test results of Contractor-designed components for review by Engineer. Documentation of review and indication of compliance with general design intent and project criteria provided on Engineer's comment form as meets conditions of the Contract, along with completed submittal, shall be filed with permitting agency by Contractor and approved by permitting agency prior to installation.

G. Manufacturer's Instructions: Written or published information that documents manufacturer's recommendations, guidelines, and procedures in accordance with individual specification section.

H. Operation and Maintenance Data: As required in Section 01 78 23, Operation and Maintenance Data.

I. Payment:

1. Application for Payment: In accordance with Section 01 29 00, Payment Procedures.
2. Schedule of Values: In accordance with Section 01 29 00, Payment Procedures.
3. Schedule of Estimated Progress Payments: In accordance with Section 01 29 00, Payment Procedures.

J. Quality Control Documentation: As required in Section 01 45 16.13, Contractor Quality Control.

K. Schedules:

1. Schedule of Submittals: Prepare separately or in combination with Progress Schedule as specified in Section 01 32 00, Construction Progress Documentation.
   a. Show for each, at a minimum, the following:
      1) Specification section number.
      2) Identification by numbering and tracking system as specified under Paragraph Transmittal of Submittal.
      3) Estimated date of submission to Engineer, including reviewing and processing time.
   b. On a monthly basis, submit updated Schedule of Submittals to Engineer if changes have occurred or resubmittals are required.
2. Progress Schedules: In accordance with Section 01 32 00, Construction Progress Documentation.

L. Special Guarantee: Supplier's written guarantee as required in individual specification sections.

M. Statement of Qualification: Evidence of qualification, certification, or registration as required in Contract Documents to verify qualifications of professional land surveyor, engineer, materials testing laboratory, specialty Subcontractor, trade, Specialist, consultant, installer, and other professionals.

N. Submittals Required by Laws, Regulations, and Governing Agencies:

1. Promptly submit promptly notifications, reports, certifications, payrolls, and otherwise as may be required, directly to the applicable federal, state, or local governing agency or their representative.
2. Transmit to Engineer for Owner's records one copy of correspondence and transmittals (to include enclosures and attachments) between Contractor and governing agency.

O. Test, Evaluation, and Inspection Reports:

1. General: Shall contain signature of person responsible for test or report.
2. Factory:
    a. Identification of product and specification section, type of inspection or test with referenced standard or code.
    b. Date of test, Project title and number, and name and signature of authorized person.
    c. Test results.
    d. If test or inspection deems material or equipment not in compliance with Contract Documents, identify corrective action necessary to bring into compliance.
    e. Provide interpretation of test results, when requested by Engineer.
    f. Other items as identified in individual specification sections.
3. Field:
    a. As a minimum, include the following:
        1) Project title and number.
        2) Date and time.
        3) Record of temperature and weather conditions.
        4) Identification of product and specification section.
        5) Type and location of test, Sample, or inspection, including referenced standard or code.
        6) Date issued, testing laboratory name, address, and telephone number, and name and signature of laboratory inspector.
        7) If test or inspection deems material or equipment not in compliance with Contract Documents, identify corrective action necessary to bring into compliance.
        8) Provide interpretation of test results, when requested by Engineer.
        9) Other items as identified in individual specification sections.

P. Testing and Startup Data: In accordance with Section 01 91 14, Equipment Testing and Facility Startup.

Q. Training Data: In accordance with Section 01 43 33, Manufacturers' Field Services.

1.05 SUPPLEMENTS

A. The supplements listed below, following "End of Section", are part of this specification.

1. Forms:
   a. Transmittal of Contractor's Submittal.
   b. Manufacturer's Certificate of Compliance with American Iron and Steel Act (to be submitted with shop drawings).
   c. Transfer of Equipment and Spare Parts Form.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

Jacobs

TRANSMITTAL OF CONTRACTOR'S SUBMITTAL

(ATTACH TO EACH SUBMITTAL)

DATE: _____

TO: _____ _____ _____ _____ _____ **FROM**: _____ Contractor _____ _____ _____	Submittal No.: _____ ☐ New Submittal ☐ Resubmittal Project: _____ Project No.: _____ Specification Section No.: _____ **(Cover only one section with each transmittal)** Schedule Date of Submittal: _____

SUBMITTAL TYPE:	☐ Shop Drawing	☐ Sample	☐ Informational
	☐ Deferred		

The following items are hereby submitted:

Number of Copies	Description of Item Submitted (Type, Size, Model Number, Etc.)	Spec. and Para. No.	Drawing or Brochure Number	Contains Variation to Contract	
				No	Yes

Contractor hereby certifies that (i) Contractor has complied with the requirements of Contract Documents in preparation, review, and submission of designated Submittal and (ii) the Submittal is complete and in accordance with the Contract Documents and requirements of laws and regulations and governing agencies.

By: _____

Contractor (Authorized Signature)

INFORMATION FOR AIS CERTIFICATION LETTER
(BASED UPON USEPA GUIDANCE WEBINAR)

All Letters to Certify compliance with the American Iron and Steel (AIS) Provisions must be specific to the materials being incorporated into the project and include the minimum information as follows:

1. MANUFACTURER'S LETTERHEAD
    a. The Certification Letter Must be from the Manufacturer on their letterhead.
2. DATE OF CERTIFICATION LETTER
3. REFERENCE
    a. American Iron and Steel Certification
    b. Project Number, Name, and Location
    c. Specific Items/Products provided to the project
4. IDENTIFY SPECIFIC MANUFACTURING INFORMATION
    a. What is the location(s) of the Foundry/Mill/Factory (City & State) where the specific product was manufactured.
5. IDENTIFY THE SPECIFIC AMERICAN IRON AND STEEL REQUIREMENTS
    a. Especially important if there are references to other domestic preference laws.
6. IDENTIFY TO WHOM WAS THE PRODUCT DELIVERED
    a. This may be a manufacturer who incorporates the AIS materials into their product for use on a project, such as a Pre-Cast Manufacturer.
    b. This may be the General Contractor or a Subcontractor if the product is directly incorporated into the project.
7. SIGNATURE OF MANUFACTURER REPRESENTATIVE CERTIFYING AIS COMPLIANCE

Common Mistakes that will not be acceptable

- Manufacturers or suppliers not referencing the Specific Project and Specific Product Information
- Suppliers or contractors relying on "Made in the USA" stampings, stickers, or labels as proof of AIS compliance
- Manufacturers misinforming suppliers or consulting engineers on AIS Certification requirements OR suppliers misinforming engineers or contractors
- Manufacturers not referencing the American Iron and Steel Act Requirements.

TRANSFER EQUIPMENT/SPARE PARTS

[INSERT PROJECT NAME AND NUMBER]

LOCATION (s): 345 East Shore Parkway, New Haven and/or (Facility) _____

DATE: _____ SPEC. SECTION: _____

ITEM: _____

MODEL NUMBER: _____ SERIAL NUMBER: _____

Transferred FROM: [Insert Contractor Name] by: _____ date: _____ initials: _____

Inventoried BY: [Insert Engineer Name] by: _____ date: _____ initials: _____

MFG. WARRANTEE REQ. ? YES - NO date: _____ O&M MANUAL REQ. ? YES - NO date: _____

TRAINING REQ. ? YES - NO date: _____ Other Req.? _____ YES - NO date: _____

(Testing; Post Startup Adjust; etc.)

SPARE PARTS DESCRIPTION	PART NUMBER	QTY REQ	QTY RECD	COMPLETE	

Received BY: GNHWPCA by: _____ date: _____ initials: _____

Transferred TO: Synagro Northeast by: _____ date: _____ initials: _____

---------- FOR GNHWPCA USE ----------

CMMS Asset Est. by: _____ date: _____ DISTRIBUTION: GC - XXXXXXXX: ENG - XXXXXXX:

PM Schedule Est. by: _____ date: _____ GNH- Dir Ops; Ops Mgr; Maint Admin; Dir Eng;

SCADA Integ & Cntrl: by: _____ date: _____ GNH - PM & File MAINT - Synagro, NE

TRANSFER EQUIPMENT/SPARE PARTS
[INSERT PROJECT NAME AND NUMBER]

LOCATION (s): 345 East Shore Parkway, New Haven and/or (Facility) _____

DATE: _____ SPEC. SECTION: _____

ITEM: _____

MODEL NUMBER: _____ SERIAL NUMBER: _____

SPARE PARTS DESCRIPTION	PART NUMBER	QTY REQ	QTY RECD	COMPLETE	

GC - XXXXXXXX: date: _____ initials: _____ ENG - XXXXXXX: date: _____ initials: _____

GNHWPCA: date: _____ initials: _____ Synagro, N.E. date: _____ initials: _____

SECTION 01 42 13
ABBREVIATIONS AND ACRONYMS

PART 1 GENERAL

1.01 REFERENCE TO STANDARDS AND SPECIFICATIONS OF TECHNICAL SOCIETIES

A. Reference to standards and specifications of technical societies and reporting and resolving discrepancies associated therewith shall be as provided in Article 3 of the General Conditions, and as may otherwise be required herein and in the individual specification sections.

B. Work specified by reference to published standard or specification of government agency, technical association, trade association, professional society or institute, testing agency, or other organization shall meet requirements or surpass minimum standards of quality for materials and workmanship established by designated standard or specification.

C. Where so specified, products or workmanship shall also meet or exceed additional prescriptive or performance requirements included within Contract Documents to establish a higher or more stringent standard of quality than required by referenced standard.

D. Where two or more standards are specified to establish quality, product and workmanship shall meet or exceed requirements of most stringent.

E. Where both a standard and a brand name are specified for a product in Contract Documents, proprietary product named shall meet or exceed requirements of specified reference standard.

F. Copies of standards and specifications of technical societies:

1. Copies of applicable referenced standards have not been bound in these Contract Documents.
2. Where copies of standards are needed by Contractor, obtain a copy or copies directly from publication source and maintain in an orderly manner at the Site as Work Site records, available to Contractor's personnel, Subcontractors, Owner, and Engineer.

1.02 ABBREVIATIONS

A. Abbreviations for trade organizations and government agencies: Following is a list of construction industry organizations and government agencies to which references may be made in the Contract Documents, with abbreviations used.

1.	AA	Aluminum Association
2.	AABC	Associated Air Balance Council
3.	AAMA	American Architectural Manufacturers Association
4.	AASHTO	American Association of State Highway and Transportation Officials
5.	ABMA	American Bearing Manufacturers' Association
6.	ACI	American Concrete Institute
7.	AEIC	Association of Edison Illuminating Companies
8.	AGA	American Gas Association
9.	AGMA	American Gear Manufacturers' Association
10.	AI	Asphalt Institute
11.	AISC	American Institute of Steel Construction
12.	AISI	American Iron and Steel Institute
13.	AITC	American Institute of Timber Construction
14.	ALS	American Lumber Standards
15.	AMCA	Air Movement and Control Association
16.	ANSI	American National Standards Institute
17.	APA	APA – The Engineered Wood Association
18.	API	American Petroleum Institute
19.	APWA	American Public Works Association
20.	AHRI	Air-Conditioning, Heating, and Refrigeration Institute
21.	ASA	Acoustical Society of America
22.	ASABE	American Society of Agricultural and Biological Engineers
23.	ASCE	American Society of Civil Engineers
24.	ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
25.	ASME	American Society of Mechanical Engineers
26.	ASNT	American Society for Nondestructive Testing
27.	ASSE	American Society of Sanitary Engineering
28.	ASTM	ASTM International
29.	AWI	Architectural Woodwork Institute
30.	AWPA	American Wood Preservers' Association
31.	AWPI	American Wood Preservers' Institute
32.	AWS	American Welding Society
33.	AWWA	American Water Works Association
34.	BHMA	Builders Hardware Manufacturers' Association
35.	CBM	Certified Ballast Manufacturer
36.	CDA	Copper Development Association
37.	CGA	Compressed Gas Association
38.	CISPI	Cast Iron Soil Pipe Institute
39.	CMAA	Crane Manufacturers' Association of America
40.	CRSI	Concrete Reinforcing Steel Institute
41.	CS	Commercial Standard
42.	CSA	Canadian Standards Association

43.	CSI	Construction Specifications Institute
44.	DIN	Deutsches Institut für Normung e.V.
45.	DIPRA	Ductile Iron Pipe Research Association
46.	EIA	Electronic Industries Alliance
47.	EJCDC	Engineers Joint Contract Documents' Committee
48.	ETL	Electrical Test Laboratories
49.	FAA	Federal Aviation Administration
50.	FCC	Federal Communications Commission
51.	FDA	Food and Drug Administration
52.	FEMA	Federal Emergency Management Agency
53.	FIPS	Federal Information Processing Standards
54.	FM	FM Global
55.	Fed. Spec.	Federal Specifications (FAA Specifications)
56.	FS	Federal Specifications and Standards (Technical Specifications)
57.	GA	Gypsum Association
58.	GANA	Glass Association of North America
59.	HI	Hydraulic Institute
60.	HMI	Hoist Manufacturers' Institute
61.	IBC	International Building Code
62.	ICBO	International Conference of Building Officials
63.	ICC	International Code Council
64.	ICEA	Insulated Cable Engineers' Association
65.	IFC	International Fire Code
66.	IEEE	Institute of Electrical and Electronics Engineers, Inc.
67.	IESNA	Illuminating Engineering Society of North America
68.	IFI	Industrial Fasteners Institute
69.	IGMA	Insulating Glass Manufacturer's Alliance
70.	IMC	International Mechanical Code
71.	INDA	Association of the Nonwoven Fabrics Industry
72.	IPC	International Plumbing Code
73.	ISA	International Society of Automation
74.	ISO	International Organization for Standardization
75.	ITL	Independent Testing Laboratory
76.	JIC	Joint Industry Conferences of Hydraulic Manufacturers
77.	MIA	Marble Institute of America
78.	MIL	Military Specifications
79.	MMA	Monorail Manufacturers' Association
80.	MSS	Manufacturer's Standardization Society
81.	NAAMM	National Association of Architectural Metal Manufacturers
82.	NACE	NACE International
83.	NBGQA	National Building Granite Quarries Association

84.	NEBB	National Environmental Balancing Bureau
85.	NEC	National Electrical Code
86.	NECA	National Electrical Contractor's Association
87.	NEMA	National Electrical Manufacturers' Association
88.	NESC	National Electrical Safety Code
89.	NETA	InterNational Electrical Testing Association
90.	NFPA	National Fire Protection Association
91.	NHLA	National Hardwood Lumber Association
92.	NICET	National Institute for Certification in Engineering Technologies
93.	NIST	National Institute of Standards and Technology
94.	NRCA	National Roofing Contractors Association
95.	NRTL	Nationally Recognized Testing Laboratories
96.	NSF	NSF International
97.	NSPE	National Society of Professional Engineers
98.	NTMA	National Terrazzo and Mosaic Association
99.	NWWDA	National Wood Window and Door Association
100.	OSHA	Occupational Safety and Health Act (both Federal and State)
101.	PCI	Precast/Prestressed Concrete Institute
102.	PEI	Porcelain Enamel Institute
103.	PPI	Plastic Pipe Institute
104.	PS	Product Standards Section-U.S. Department of Commerce
105.	RMA	Rubber Manufacturers' Association
106.	RUS	Rural Utilities Service
107.	SAE	SAE International
108.	SDI	Steel Deck Institute
109.	SDI	Steel Door Institute
110.	SJI	Steel Joist Institute
111.	SMACNA	Sheet Metal and Air Conditioning Contractors National Association
112.	SPI	Society of the Plastics Industry
113.	SSPC	The Society for Protective Coatings
114.	STI/SPFA	Steel Tank Institute/Steel Plate Fabricators Association
115.	SWI	Steel Window Institute
116.	TEMA	Tubular Exchanger Manufacturers' Association
117.	TCA	Tile Council of North America
118.	TIA	Telecommunications Industry Association
119.	UBC	Uniform Building Code
120.	UFC	Uniform Fire Code
121.	UL	formerly Underwriters Laboratories Inc.
122.	UMC	Uniform Mechanical Code
123.	USBR	U.S. Bureau of Reclamation

124.	WCLIB	West Coast Lumber Inspection Bureau
125.	WI	Wood Institute
126.	WWPA	Western Wood Products Association

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01 43 33
MANUFACTURERS' FIELD SERVICES

PART 1 GENERAL

1.01 DEFINITIONS

A. Person-Day: One person for 8 hours, excluding travel time.

1.02 SUBMITTALS

A. Informational Submittals:

1. Manufacturers Certificate of Compliance: Submit prior to shipment of a product or material or execution of a service.
2. Manufacturers Certificate of Proper Installation: Submit prior to equipment testing.
3. Training Schedule: Submit, 21 days prior to equipment testing.
4. Lesson Plan: Submit, 21 days prior to scheduled training.

1.03 QUALIFICATION OF MANUFACTURER'S REPRESENTATIVE

A. Authorized representative of the manufacturer, factory trained, and experienced in the technical applications, installation, operation, and maintenance of respective equipment, subsystem, or system, with full authority by the equipment manufacturer to issue the certifications required of the manufacturer. Additional qualifications may be specified in the individual specification section.

B. Representative subject to acceptance by Owner and Engineer. No substitute representatives will be allowed unless prior written approval by such has been given.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 FULFILLMENT OF SPECIFIED MINIMUM SERVICES

A. Furnish manufacturers' services, when required by an individual specification section, to meet the requirements of this section.

B. Where time is necessary in excess of that stated in the Specifications for manufacturers' services, or when a minimum time is not specified, time required to perform specified services shall be considered incidental.

C. Schedule manufacturer' services to avoid conflict with other onsite testing or other manufacturers' onsite services.

D. Determine, before scheduling services, that conditions necessary to allow successful testing have been met.

E. Only those days of service approved by Engineer will be credited to fulfill specified minimum services.

F. When specified in individual specification sections, manufacturer's onsite services shall include:

1. Assistance during product (system, subsystem, or component) installation to include observation, guidance, instruction of Contractor's assembly, erection, installation or application procedures.
2. Inspection, checking, and adjustment as required for product (system, subsystem, or component) to function as warranted by manufacturer and necessary to furnish Manufacturer's Certificate of Proper Installation.
3. Revisiting the Site as required to correct problems and until installation and operation are acceptable to Engineer.
4. Resolution of assembly or installation problems attributable to or associated with respective manufacturer's products and systems.
5. Assistance during functional and performance testing, and facility startup and evaluation.
6. Training of Owner's personnel in the operation and maintenance of respective product as required.

3.02 MANUFACTURER'S CERTIFICATE OF COMPLIANCE

A. Furnish a Manufacturer's Certificate of Compliance, a copy of which is attached to this section, when required by an individual specification section, to meet the requirements of this section.

B. Manufacturers Certificate of Compliance shall be completed in full, signed by entity supplying the product, material, or service.

C. Engineer may permit use of certain materials or assemblies prior to sampling and testing if accompanied by accepted certification of compliance.

D. Such form shall certify proposed product, material, or service complies with that specified. Attach supporting reference data, affidavits, and certifications as appropriate.

E. May reflect recent or previous test results on material or product, if acceptable to Engineer.

3.03 MANUFACTURER'S CERTIFICATE OF PROPER INSTALLATION

A. Furnish a Manufacturer's Certificate of Proper Installation form, a copy of which is attached to this section, when required by an individual specification section, to meet the requirements of this section.

B. Manufacturers Certificate of Proper Installation shall be completed and signed by equipment manufacturer's representative.

C. Such form shall certify signing party is a duly authorized representative of manufacturer, is empowered by manufacturer to inspect, approve, and operate their equipment and is authorized to make recommendations required to ensure equipment is complete and operational.

D. Submit Asset Management Forms with Certification of Proper Installation submittal for each unit installed prior to Manufacturer's Training.

3.04 MANUFACTURER'S TRAINING

A. General:

1. Furnish manufacturers' representatives for detailed classroom and hands-on training when required by an individual specification section, to meet the requirements of this section.
2. Furnish trained, articulate personnel to coordinate and expedite training, to be present during training coordination meetings with Owner, and familiar with operation and maintenance manual information specified in Section 01 78 23, Operation and Maintenance Data.
3. Manufacturer's representative shall be familiar with facility operation and maintenance requirements as well as with specified equipment.
4. Furnish complete training materials, to include operation and maintenance data, to be retained by each trainee.

B. Training Schedule:

1. List specified equipment and systems that require training services and show:
   a. Respective manufacturer.
   b. Estimated dates for installation completion.
   c. Estimated training dates.
2. Allow for three sessions of each training module to accommodate multiple shifts of the Owner's personnel. Two sessions pre-startup and one session post startup.
3. Adjust schedule to ensure training of appropriate personnel as deemed necessary by Owner, and to allow full participation by manufacturers' representatives. Adjust schedule for interruptions in operability of equipment.
4. Coordinate with Section 01 32 00, Construction Progress Documentation, and Section 01 91 14, Equipment Testing and Facility Startup.

C. Lesson Plan: Prepare a lesson plan for each course containing the following minimum information:

1. Title and objectives.
2. Recommended attendees (such as, managers, engineers, operators, maintenance).
3. Course description, outline of course content, and estimated class duration.
4. Format (such as, lecture, self-study, demonstration, hands-on).
5. Instruction materials and equipment requirements.
6. Resumes of instructors providing training.

D. Prestartup Training:

1. Coordinate training sessions with Owner's operating personnel, and manufacturers' representatives.
2. Coordinate training secessions with the submission of operation and maintenance manuals in accordance with Section 01 78 23, Operation and Maintenance Data. Operations and maintenance manuals must be received 21 days prior to training.

E. Post-startup Training: Coordinate training of Owner's operating personnel by manufacturer's representatives.

F. Recording of Training Sessions:

1. Furnish audio and color recording of post-startup equipment and instruction sessions, including manufacturers' representatives' hands-on equipment instruction and classroom training.
2. Video training materials shall be produced by a qualified, professional video production company.
3. Use DVD format suitable for playback on standard equipment available commercially in the United States. Blu-ray® DVD format is not acceptable without Engineer's prior approval.
4. Include one training session on each DVD.

3.05 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are part of this Specification.

1. Form: Manufacturer's Certificate of Compliance.

END OF SECTION

MANUFACTURER'S CERTIFICATE OF COMPLIANCE

OWNER: _____

PROJECT NAME: _____

PROJECT NO: _____

PRODUCT, MATERIAL, OR SERVICE SUBMITTED: _____

Comments: _____

_____

_____

_____

_____

_____

I hereby certify that the above-referenced product, material, or service called for by the Contract for the named Project will be furnished in accordance with all applicable requirements. I further certify that the product, material, or service are of the quality specified and conform in all respects with the Contract requirements, and are in the quantity shown.

Date of Execution: _____, 20___

Manufacturer: _____

Manufacturer's Authorized Representative *(print)*: _____

_____

(Authorized Signature)

SECTION 01 45 16.13
CONTRACTOR QUALITY CONTROL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. D3740, Evaluation of Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction.
   b. E329, Use in the Evaluation of Testing and Inspection Agencies as Used in Construction.

1.02 DEFINITIONS

A. Contractor Quality Control (CQC): The means by which Contractor ensures that the construction, to include that performed by subcontractors and suppliers, complies with the requirements of the Contract.

1.03 SUBMITTALS

A. Informational Submittals:

1. CQC Plan: Submit, not later than 30 days after receipt of Notice to Proceed.
2. CQC Report: Submit, weekly, an original and one copy in report form.

1.04 OWNER'S QUALITY ASSURANCE

A. All Work is subject to Owner's quality assurance inspection and testing at all locations and at all reasonable times before acceptance to ensure strict compliance with the terms of the Contract Documents.

B. Owner's quality assurance inspections and tests are for the sole benefit of Owner and do not:

1. Relieve Contractor of responsibility for providing adequate quality control measures.
2. Relieve Contractor of responsibility for damage to or loss of the material before acceptance.
3. Constitute or imply acceptance.
4. Affect the continuing rights of Owner after acceptance of the completed Work.

C. The presence or absence of a quality assurance inspector does not relieve Contractor from any Contract requirement.

D. Promptly furnish all facilities, labor, and material reasonably needed for performing such safe and convenient inspections and tests as may be required by Engineer.

E. Owner may charge Contractor for any additional cost of inspection or test when Work is not ready at the time specified by Contractor for inspection or test, or when prior rejection makes re-inspection or retest necessary. Quality assurance inspections and tests will be performed in a manner that will not unnecessarily delay the Work.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Maintain an adequate inspection system and perform such inspections as will ensure that the Work conforms to the Contract Documents.

B. Maintain complete inspection records and make them available at all times to Owner and Engineer.

C. The quality control system shall consist of plans, procedures, and organization necessary to produce an end product that complies with the Contract Documents. The system shall cover all construction and demolition operations, both onsite and offsite, including Work by subcontractors, fabricators, suppliers and purchasing agents, and shall be keyed to the proposed construction sequence.

3.02 COORDINATION MEETING

A. After the Preconstruction Conference, but before start of construction, and prior to acceptance of the CQC Plan, schedule a meeting with Engineer and Owner to discuss the quality control system.

B. Develop a mutual understanding of the system details, including the forms for recording the CQC operations, control activities, testing, administration of the system for both onsite and offsite Work, and the interrelationship of Contractor's management and control with the Owner's Quality Assurance.

C. There may be occasions when subsequent conferences may be called by either party to reconfirm mutual understandings and/or address deficiencies in the CQC system or procedures that may require corrective action by Contractor.

3.03 QUALITY CONTROL ORGANIZATION

A. CQC System Manager:

1. Designate an individual within Contractor's organization who will be responsible for overall management of CQC and have the authority to act in CQC matters for the Contractor.
2. CQC System Manager may perform other duties on the Project.
3. CQC System Manager shall be an experienced construction person, with a minimum of 3 years construction experience on similar type Work.
4. CQC System Manager shall report to the Contractor's project manager or someone higher in the organization. Project manager in this context shall mean the individual with responsibility for the overall quality and production management of the Project.
5. CQC System Manager shall be onsite during construction; periods of absence may not exceed 2 weeks at any one time.
6. Identify an alternate for CQC System Manager to serve with full authority during the System Manager's absence. The requirements for the alternate will be the same as for designated CQC System Manager.

B. CQC Staff:

1. Designate a CQC staff, available at the Site at all times during progress, with complete authority to take any action necessary to ensure compliance with the Contract. CQC staff members shall be subject to acceptance by Engineer.
2. CQC staff shall take direction from CQC System Manager in matters pertaining to QC.
3. CQC staff must be of sufficient size to ensure adequate QC coverage of Work phases, work shifts, and work crews involved in the construction. These personnel may perform other duties but must be fully qualified by experience and technical training to perform their assigned QC responsibilities and must be allowed sufficient time to carry out these responsibilities.
4. The actual strength of the CQC staff may vary during any specific Work period to cover the needs of the Project. Add additional staff when necessary for a proper CQC organization.

C. Organizational Changes: Obtain Engineer's acceptance before replacing any member of the CQC staff. Requests for changes shall include name, qualifications, duties, and responsibilities of the proposed replacement.

3.04 QUALITY CONTROL PHASING

A. CQC shall include at least three phases of control to be conducted by CQC System Manager for all definable features of Work, as follows:

1. Preparatory Phase:
   a. Notify Owner at least 48 hours in advance of beginning any of the required action of the preparatory phase.
   b. This phase shall include a meeting conducted by the CQC System Manager and attended by the superintendent, other CQC personnel (as applicable), and the foreman responsible for the definable feature. The CQC System Manager shall instruct applicable CQC staff as to the acceptable level of workmanship required in order to meet Contract requirements.
   c. Document the results of the preparatory phase meeting by separate minutes prepared by the CQC System Manager and attached to the QC report.
   d. Perform prior to beginning Work on each definable feature of Work:
      1) Review applicable Contract Specifications.
      2) Review applicable Contract Drawings.
      3) Verify that all materials and/or equipment have been tested, submitted, and approved.
      4) Verify that provisions have been made to provide required control inspection and testing.
      5) Examine the Work area to verify that all required preliminary Work has been completed and is in compliance with the Contract.
      6) Perform a physical examination of required materials, equipment, and sample Work to verify that they are on hand, conform to approved Shop Drawing or submitted data, and are properly stored.
      7) Review the appropriate activity hazard analysis to verify safety requirements are met.
      8) Review procedures for constructing the Work, including repetitive deficiencies.
      9) Document construction tolerances and workmanship standards for that phase of the Work.
      10) Check to verify that the plan for the Work to be performed, if so required, has been accepted by Engineer.
2. Initial Phase:
   a. Accomplish at the beginning of a definable feature of Work:
      1) Notify Owner at least 48 hours in advance of beginning the initial phase.
      2) Perform prior to beginning Work on each definable feature of Work:
         a) Review minutes of the preparatory meeting.
         b) Check preliminary Work to verify compliance with Contract requirements.
         c) Verify required control inspection and testing.

d) Establish level of workmanship and verify that it meets minimum acceptable workmanship standards. Comparison with sample panels is appropriate.
e) Resolve all differences.
f) Check safety to include compliance with and upgrading of the safety plan and activity hazard analysis. Review the activity analysis with each worker.

3) Separate minutes of this phase shall be prepared by the CQC System Manager and attached to the QC report. Exact location of initial phase shall be indicated for future reference and comparison with follow-up phases.
4) The initial phase should be repeated for each new crew to work onsite, or any time acceptable specified quality standards are not being met.

3. Follow-up Phase:
   a. Perform daily checks to verify continuing compliance with Contract requirements, including control testing, until completion of the particular feature of Work.
   b. Daily checks shall be made a matter of record in the CQC documentation and shall document specific results of inspections for all features of Work for the day or shift.
   c. Conduct final follow-up checks and correct all deficiencies prior to the start of additional features of Work that will be affected by the deficient Work. Constructing upon or concealing nonconforming Work will not be allowed.
4. Additional Preparatory and Initial Phases: Additional preparatory and initial phases may be conducted on the same definable features of Work as determined by Owner if the quality of ongoing Work is unacceptable; or if there are changes in the applicable QC staff or in the onsite production supervision or work crew; or if work on a definable feature is resumed after a substantial period of inactivity, or if other problems develop.

3.05 CONTRACTOR QUALITY CONTROL PLAN

A. General:

1. Plan shall identify personnel, procedures, control, instructions, test, records, and forms to be used.
2. An interim plan for the first 30 days of operation will be considered.
3. Construction will be permitted to begin only after acceptance of the CQC Plan or acceptance of an interim plan applicable to the particular feature of Work to be started.
4. Work outside of the features of Work included in an accepted interim plan will not be permitted to begin until acceptance of a CQC Plan or

another interim plan containing the additional features of Work to be started.

B. Content:

1. Plan shall cover the intended CQC organization for the entire Contract and shall include the following, as a minimum:
   a. Organization: Description of the quality control organization, including a chart showing lines of authority and acknowledgment that the CQC staff will implement the three-phase control system (see Paragraph QC Phasing) for all aspects of the Work specified.
   b. CQC Staff: The name, qualifications (in resume format), duties, responsibilities, and authorities of each person assigned a QC function.
   c. Letters of Authority: A copy of a letter to the CQC System Manager signed by an authorized official of the firm, describing the responsibilities and delegating sufficient authorities to adequately perform the functions of the CQC System Manager, including authority to stop Work which is not in compliance with the Contract. The CQC System Manager shall issue letters of direction to all other various quality control representatives outlining duties, authorities and responsibilities. Copies of these letters will also be furnished to Owner.
   d. Submittals: Procedures for scheduling, reviewing, certifying, and managing submittals, including those of subcontractors, offsite fabricators, suppliers and purchasing agents.
   e. Testing: Control, verification and acceptance testing procedures for each specific test to include the test name, frequency, specification paragraph containing the test requirements, the personnel and laboratory responsible for each type of test, and an estimate of the number of tests required.
   f. Procedures for tracking preparatory, initial, and follow-up control phases and control, verification, and acceptance tests, including documentation.
   g. Procedures for tracking deficiencies from identification through acceptable corrective action. These procedures will establish verification that identified deficiencies have been corrected.
   h. Reporting procedures, including proposed reporting formats; include a copy of the CQC report form.

C. Acceptance of Plans: Acceptance of the Contractor's basic and addendum CQC plans is required prior to the start of construction. Acceptance is conditional and will be predicated on satisfactory performance during the construction. Owner reserves the right to require Contractor to make changes in the CQC plan and operations including removal of personnel, as necessary, to obtain the quality specified.

D. Notification of Changes: After acceptance of the CQC plan, Contractor shall notify Engineer, in writing, a minimum of 7 calendar days prior to any proposed change. Proposed changes are subject to acceptance by Engineer.

3.06 CONTRACTOR QUALITY CONTROL REPORT

A. As a minimum, prepare a CQC report for every 7 calendar days. Account for all days throughout the life of the Contract. Reports shall be signed and dated by CQC System Manager. Include copies of test reports and copies of reports prepared by QC staff.

B. Maintain current records of quality control operations, activities, and tests performed, including the Work of subcontractors and suppliers.

C. Records shall be on an acceptable form and shall be a complete description of inspections, the results of inspections, daily activities, tests, and other items, including but not limited to the following:

1. Contractor/subcontractor and their areas of responsibility.
2. Operating plant/equipment with hours worked, idle, or down for repair.
3. Work performed today, giving location, description, and by whom. When a network schedule is used, identify each phase of Work performed each day by activity number.
4. Test and/or control activities performed with results and references to specifications/plan requirements. The control phase should be identified (Preparatory, Initial, Follow-up). List deficiencies noted along with corrective action.
5. Material received with statement as to its acceptability and storage.
6. Identify submittals reviewed, with Contract reference, by whom, and action taken.
7. Offsite surveillance activities, including actions taken.
8. Job safety evaluations stating what was checked, results, and instructions or corrective actions.
9. List instructions given/received and conflicts in Drawings and/or Specifications.
10. Contractor’s verification statement.
11. Indicate a description of trades working on the Project; the number of personnel working; weather conditions encountered; and any delays encountered.
12. These records shall cover both conforming and deficient features and shall include a statement that equipment and materials incorporated in file work and workmanship comply with the Contract.

3.07 SUBMITTAL QUALITY CONTROL

A. Submittals shall be as specified in Section 01 33 00, Submittal Procedures. The CQC organization shall be responsible for certifying that all submittals are in compliance with the Contract requirements. Owner will furnish copies

of test report forms upon request by Contractor. Contractor may use other forms as approved.

3.08 TESTING QUALITY CONTROL

A. Testing Procedure:

1. Perform tests specified or required to verify that control measures are adequate to provide a product which conforms to Contract requirements. Procure services of a licensed testing laboratory. Perform the following activities and record the following data:
   a. Verify testing procedures comply with contract requirements.
   b. Verify facilities and testing equipment are available and comply with testing standards.
   c. Check test instrument calibration data against certified standards.
   d. Verify recording forms and test identification control number system, including all of the test documentation requirements, have been prepared.
   e. Documentation:
      1) Record results of all tests taken, both passing and failing, on the CQC report for the date taken.
      2) Include specification paragraph reference, location where tests were taken, and the sequential control number identifying the test.
      3) Actual test reports may be submitted later, if approved by Engineer, with a reference to the test number and date taken.
      4) Provide directly to Engineer an information copy of tests performed by an offsite or commercial test facility. Test results shall be signed by an engineer registered in the state where the tests are performed.
      5) Failure to submit timely test reports, as stated, may result in nonpayment for related Work performed and disapproval of the test facility for this Contract.

B. Testing Laboratories: Laboratory facilities, including personnel and equipment, utilized for testing soils, concrete, asphalt and steel shall meet criteria detailed in ASTM D3740 and ASTM E329, and be accredited by the American Association of Laboratory Accreditation (AALA), National Institute of Standards and Technology (NIST), National Voluntary Laboratory Accreditation Program (NVLAP), the American Association of State Highway and Transportation Officials (AASHTO), or other approved national accreditation authority. Personnel performing concrete testing shall be certified by the American Concrete Institute (ACI).

3.09 COMPLETION INSPECTION

A. CQC System Manager shall conduct an inspection of the Work at the completion of all Work, or any milestone established by a completion time stated in the Contract.

B. Punchlist:

1. CQC System Manager shall develop a punchlist of items which do not conform to the Contract requirements.
2. Include punchlist in the CQC report, indicating the estimated date by which the deficiencies will be corrected.
3. CQC System Manager or staff shall make a second inspection to ascertain that all deficiencies have been corrected and so notify the Owner.
4. These inspections and any deficiency corrections required will be accomplished within the time stated for completion of the entire Work or any particular increment thereof if the Project is divided into increments by separate completion dates.

END OF SECTION

SECTION 01 45 33
SPECIAL INSPECTION, OBSERVATION, AND TESTING

THIS SECTION IS BEING UPDATED TO 2021 BUILDING CODE

PART 1 GENERAL

1.01 SUMMARY

A. This section covers requirements for Special Inspection, Observation, and Testing required in accordance with Chapter 17 of the 2021 IBC and is in addition to and supplements requirements included in Statement of Special Inspections shown in supplement located at end of this section.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Civil Engineers (ASCE): 7, Minimum Design Loads for Buildings and Other Structures.
2. International Code Council (ICC):
   a. International Building Code (IBC).
   b. Evaluation Service (ICC-ES) Reports and Legacy Reports.

1.03 DEFINITIONS

A. Agencies and Personnel:

1. Agency Having Jurisdiction (AHJ): Permitting building agency; may be a federal, state, local, or other regional department, or individual including building official, fire chief, fire marshal, chief of a fire prevention bureau, labor department, or health department, electrical inspector; or others having statutory authority. AHJ may be Owner when authorized to be self-permitting by governmental permitting agency or when no governmental agency has authority.
2. Approved Agency: An established and recognized agency regularly engaged in conducting tests or furnishing inspection services, when such agency has been approved.
3. Registered Design Professional in Responsible Charge: An individual who is registered or licensed to practice their respective design profession as defined by statutory requirements of professional registration laws of state or jurisdiction in which Project is to be constructed.
4. Special Inspector: Qualified person employed by Owner who will demonstrate competence to the satisfaction of AHJ for inspection of a particular type of construction or operation requiring Special Inspection.

B. Statement of Special Inspections: Detailed written procedure contained in supplement located at end of this section establishing systems and components subject to Special Inspection, Observation, and Testing during construction, type and frequency of testing, extent and duration of Special Inspection, and reports to be completed and distributed by Special Inspector.

C. Special Inspection:

1. Special Inspection: Inspection required of materials, installation, fabrication, erection, or placement of components and connections requiring special expertise to ensure compliance with approved Contract Documents and referenced standards.
2. Special Inspection, Continuous: Full-time observation of work requiring Special Inspection by an approved Special Inspector who is present in area where the Work is being performed.
3. Special Inspection, Periodic: Part-time or intermittent observation of the Work requiring Special Inspection by an approved Special Inspector who is present in area where the Work has been or is being performed, and at completion of the Work.

D. Structural Systems and Components:

1. Diaphragm: Component of structural lateral load resisting system consisting of roof, floor, or other membrane or bracing system acting to transfer lateral forces to vertical resisting elements of structure.
2. Drag Strut or Collector: Component of structural lateral load resisting system consisting of diaphragm or shear wall element that collects and transfers diaphragm shear forces to vertical force-resisting elements or distributes forces within diaphragm or shear wall.
3. Seismic-Force-Resisting System: That part of structural lateral load resisting system that has been considered in the design to provide required resistance to seismic forces identified on Drawings.
4. Shear Wall: Component of structural lateral load resisting system consisting of a wall designed to resist lateral forces parallel to plane of the wall. Unless noted otherwise on Drawings, load-bearing walls with direct in-plane connections to roof and floors shall be considered to be shear walls.
5. Wind Force Resisting System: That part of the structural system that has been considered in the design to provide required resistance to wind forces identified on Drawings.

E. Nonstructural Components:

1. Architectural Component Supports: Structural members or assemblies of members which transmit loads and forces from architectural systems

or components to structure, including braces, frames, struts, and attachments.

2. Electrical Component Supports: Structural members or assemblies which transmit loads and forces from electrical equipment to structure, including braces, frames, legs, pedestals, and tethers, as well as elements forged or cast as part of component for anchorage.
3. Mechanical Component Supports: Structural members or assemblies which transmit loads and forces from mechanical equipment to structure, including braces, frames, skirts, legs, saddles, pedestals, snubbers, and tethers, as well as elements forged or cast as part of component for anchorage.

F. Professional Observation:

1. Does not include or waive responsibility for required Special Inspection or inspections by building official.
2. Requirements are indicated on Statement of Special Inspections provided in supplement located at the end of this section.
3. Geotechnical Observation: Visual observation of selected subgrade bearing surfaces and installation of deep foundation elements by a registered design professional for general conformance to Contract Documents.
4. Structural Observation: Visual observation of structural system(s) by a registered design professional for general conformance to Contract Documents.

1.04 SUBMITTALS (NOT USED)

1.05 STATEMENT OF SPECIAL INSPECTIONS REQUIREMENTS

A. Designated Systems for Inspection:

1. Seismic-force-resisting systems designated under IBC Section 1705 and subject to Special Inspection under Section None required.
2. Wind-force-resisting systems designated under IBC Section 1705: None required.
3. Architectural, Plumbing, Mechanical, and Electrical Components subject to Special Inspection under IBC Section 1705.12.5 and 1705.12.6 for Seismic Resistance: None required.

B. Statement of Special Inspections:

1. As included in supplement located at the end of this section and in support of building permit application, Project-specific requirements were prepared by Registered Design Professional in Responsible

Charge. The following identifies elements of inspection, observation, and testing program to be followed in construction of the Work:

a. Special Inspection and testing required by IBC Section 1705 and other applicable sections and referenced standards therein.
b. Type and frequency of Special Inspection required.
c. Type and frequency of testing required.
d. Required frequency and distribution of testing and Special Inspection reports to be distributed by Special Inspector to Engineer, Contractor, building official, and Owner.
e. Geotechnical Observation to be Performed: Required frequency and distribution of Geotechnical Observation reports by registered design professional to Contractor, building official, and Owner.
f. Structural Observations to be Performed: Not required for this Project.

C. Special Inspection and associated testing of shop fabrication and field construction will be performed by an approved accredited independent agency or by Authority Having Jurisdiction's (AHJ) approved, qualified inspection staff. Owner will secure and pay for services of agency to perform Special Inspection and associated testing.

D. Code required Special Inspection with associated testing and Professional Observation, as provided in Statement of Special Inspections in supplement located at the end of this section and further provided in this section, is for benefit of Owner and does not:

1. Relieve Contractor of responsibility for providing adequate quality control measures.
2. Relieve Contractor of responsibility for damage to or loss of material before acceptance.
3. Constitute or imply acceptance.
4. Affect continuing rights of Owner after acceptance of completed Work.

E. The presence or absence of code required Special Inspector and Professional Observer does not relieve Contractor from Contract requirements.

F. Contractor is responsible for additional costs associated with Special Inspection and Testing and Observation when Work is not ready at time identified by Contractor and Special Inspectors and Professional Observer are onsite, but not able to provide contracted services.

G. Contractor is responsible for associated costs for additional Special Inspection and Testing and Professional Observation by Special Inspectors and Professional Observers required because of rejection of materials of in place Work that cannot be made compliant to Contract Document without additional inspections and observation and testing.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Requirements of the Statement of Special Inspections are provided by the Owner. All other testing and inspections, unless noted otherwise, are provided by Contractor.

B. Provide access to shop or Site for Special Inspection and Testing and Professional Observation requirements.

C. Notify Engineer in advance of required Special Inspection and Professional Observation no later than 48 hours prior to date of Special Inspection and Professional Observation.

D. Provide access for Special Inspector to construction documents.

E. Retain special inspection records on-site to be readily available for review.

F. Cooperate with Special Inspector and provide safe access to the Work to be inspected.

G. Submit Fabricator's Certificates of Compliance for approved fabricators.

H. Provide reasonable auxiliary services as requested by the Special Inspector. Auxiliary services required include, but not limited to:

1. Providing access to the Work and furnishing incidental labor and facilities necessary to facilitate inspections and tests to assist the Special Inspector in performing test/inspections.
2. Providing storage space for the Special Inspector’s exclusive use, such as for storing and curing concrete test samples and delivery of samples to testing laboratories.
3. Providing the Special Inspector with access to all approved submittals.
4. Providing security and protection of samples and test equipment at the Project Site.
5. Provide samples of materials to be tested in required quantities.

I. Materials and systems shall be inspected during placement where Continuous Special Inspection is required.

J. Where Periodic Special Inspection is indicated in the Statement of Special Inspections:

1. Schedule inspections for either during or at completion of their placement or a combination or both.
2. Schedule periodically inspected Work (either inspected during or after its placement) so that corrections can be completed and re-inspected before Work is inaccessible.
3. Sampling a portion of the Work is not allowed. Schedules shall provide for inspection of all Work requiring periodic inspection.

3.02 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this specification:

1. Statement of Special Inspections.

END OF SECTION

STATEMENT OF SPECIAL INSPECTIONS

GENERAL NOTES

1. THE STATEMENT OF SPECIAL INSPECTIONS PROVIDE PROJECT COMPLIANCE WITH THE PROVISIONS OF THE **2021** INTERNATIONAL BUILDING CODE (IBC) CHAPTER 17 FOR SPECIAL INSPECTION, STRUCTURAL OBSERVATION, AND TESTING FOR WIND AND SEISMIC RESISTANCE AS APPLICABLE. EXCEPT WHERE OTHERWISE NOTED, THIS INSPECTION IS OWNER FURNISHED.
2. STANDARD SPECIAL INSPECTION REQUIREMENTS FOR NONSTRUCTURAL COMPONENTS ARE CONTAINED IN TABLE 1.
3. STANDARD SPECIAL INSPECTION REQUIREMENTS FOR STRUCTURAL COMPONENTS, REGARDLESS OF WIND OR SEISMIC DESIGN CATEGORIES, ARE CONTAINED IN TABLE 2. STANDARD TESTING REQUIREMENTS FOR STRUCTURAL COMPONENTS ARE CONTAINED IN TABLE 3.
4. PROJECT SPECIFIC REQUIREMENTS FOR STRUCTURES ASSIGNED TO SEISMIC DESIGN CATEGORIES C, D, E, OR F ARE CONTAINED IN TABLE 4. ADDITIONAL TESTING REQUIREMENTS FOR STRUCTURAL RESISTANCE ARE CONTAINED IN TABLE 6.
5. PROJECT SPECIFIC REQUIREMENTS FOR STRUCTURES SUBJECT TO BASIC WIND SPEEDS [(V_{asd})] IN EXCESS OF 110 MPH ARE CONTAINED IN TABLE 5.
6. FOR ADDITIONAL REQUIREMENTS, REFER TO SPECIFICATION SECTION 01 45 33, SPECIAL INSPECTION, OBSERVATION, AND TESTING. THESE INCLUDE:
   A. CONTRACTOR'S REQUIREMENTS TO PROVIDE ACCESS TO THE WORK FOR REQUIRED INSPECTIONS, AND TO PROVIDE NOTICE OF REQUIRED INSPECTIONS AND STRUCTURAL OBSERVATION.
   B. CONTRACTOR'S STATEMENT OF RESPONSIBILITY FOR WORK TO BE PERFORMED ON SYSTEMS DESIGNATED UNDER THE STATEMENT OF SPECIAL INSPECTIONS FOR WIND OR SEISMIC RESISTANCE.
   C. DEFINITIONS AND TERMINOLOGY USED IN THIS STATEMENT OF SPECIAL INSPECTIONS.

SPECIAL INSPECTION

1. SPECIAL INSPECTION WILL BE IN ACCORDANCE WITH IBC SECTIONS 1704 AND 1705 TOGETHER WITH LOCAL AND STATE AMENDMENTS. REFER TO THE FOLLOWING TABLES FOR PROJECT SPECIFIC INSPECTION TYPES AND FREQUENCIES.
2. SPECIAL INSPECTIONS WILL BE PROVIDED BY A CERTIFIED OR QUALIFIED INSPECTOR AND ASSOCIATED TESTING WILL BE PERFORMED BY AN APPROVED ACCREDITED INDEPENDENT AGENCY. THE OWNER WILL

SECURE AND PAY FOR THE SERVICES OF THE AGENCY TO PERFORM ALL SPECIAL INSPECTION AND ASSOCIATED TESTS. INSPECTORS FOR EACH SYSTEM AND MATERIAL WILL BE INTERNATIONAL CODE COUNCIL (ICC) CERTIFIED OR OTHERWISE APPROVED BY THE BUILDING OFFICIAL.

3. THE SPECIAL INSPECTOR WILL OBSERVE THE INDICATED WORK FOR COMPLIANCE WITH THE APPROVED CONTRACT DOCUMENTS AND SUBMIT RECORDS OF INSPECTION. ALL DISCREPANCIES WILL BE BROUGHT TO THE IMMEDIATE ATTENTION OF THE CONTRACTOR FOR CORRECTION.
4. SPECIAL INSPECTION AND ASSOCIATED TESTING REPORTS WILL BE SUBMITTED TO THE ENGINEER, CONTRACTOR, BUILDING OFFICIAL, AND OWNER WITHIN ONE WEEK OF INSPECTION OR WITHIN ONE WEEK OF TEST COMPLETION. INSPECTIONS FOR WHICH REPORTING WILL BE REQUIRED ARE NOTED IN THE FOLLOWING TABLES.
5. AT THE CONCLUSION OF CONSTRUCTION, A FINAL REPORT DOCUMENTING REQUIRED SPECIAL INSPECTIONS AND CORRECTION OF PREVIOUSLY NOTED DISCREPANCIES WILL BE SUBMITTED.

GEOTECHNICAL OBSERVATION

1. ALL FOUNDATION BEARING SURFACES SHALL BE INSPECTED BY GEOTECHNICAL ENGINEER PRIOR TO PLACEMENT OF REINFORCING STEEL. ADDITIONAL SPECIAL INSPECTION REQUIREMENTS ARE LISTED IN TABLE 1.
2. GEOTECHNICAL TESTING REQUIREMENTS ARE LISTED IN TABLE 3.

STRUCTURAL OBSERVATION

1. STRUCTURAL OBSERVATION, IN ACCORDANCE WITH IBC SECTION 1704.6, TOGETHER WITH LOCAL AND STATE AMENDMENTS, IS NOT REQUIRED.

SPECIAL INSPECTIONS FOR WIND RESISTANCE

1. SPECIAL INSPECTIONS REQUIREMENTS FOR WIND RESISTANCE IN ACCORDANCE WITH IBC SECTION 1705.11 ARE NOT APPLICABLE TO THIS PROJECT.

SPECIAL INSPECTIONS FOR SEISMIC RESISTANCE

1. SPECIAL INSPECTIONS REQUIREMENTS FOR SEISMIC RESISTANCE IN ACCORDANCE WITH IBC SECTION 1705.12 AND 1705.13 ARE NOT APPLICABLE TO THIS PROJECT.

Statement of Special Inspections Prepared by:

Preparer's Seal

_____
Type or Print Name

_____
Signature

_____
Date

TABLE 2

REQUIRED STRUCTURAL SPECIAL INSPECTION
REFER TO SPECIFICATION SECTION 01 45 33

SYSTEM	2021 IBC CODE REFERENCE	REFERENCED STANDARD	PERIODIC OWNER FURNISHED SPECIAL INSPECTION (SEE NOTE 1)	CONTINUOUS OWNER FURNISHED SPECIAL INSPECTION	COMMENTS	TESTING FOR SPECIAL INSPECTION
CONCRETE						
1. INSPECTION OF REINFORCING STEEL	1908.4	ACI 318: 20, 25.2, 25.3, 26.5.1-26.5.3	X			
2. INSPECTION OF ANCHORS POST-INSTALLED IN HARDENED CONCRETE MEMBERS		ACI 318: 17.8.2, 17.8.2.4 ICC-ES EVALUATION REPORTS	X		PROVIDE CONTINUOUS SPECIAL INSPECTION FOR ADHESIVE ANCHORS DESIGNED TO RESIST SUSTAINED TENSION LOADS AND WHERE REQUIRED BY ICC-ES REPORT	
3. VERIFYING USE OF REQUIRED DESIGN MIX	1904.1,1904.2, 1908.2, 1908.3	ACI 318: Ch.19, 26.4.3, 26.4.4	X			

4. AT THE TIME FRESH CONCRETE IS SAMPLED TO FABRICATE SPECIMENS FOR STRENGTH TESTS, PERFORM SLUMP AND AIR CONTENT TESTS, AND DETERMINE THE TEMPERATURE OF THE CONCRETE	1908.1	ASTM C 172, ASTM C 31, ACI 318: 26.4.5, 26.12		X		SEE TABLE 3 FOR CONCRETE TEST REQUIREMENTS
5. INSPECTION FOR MAINTENANCE OF SPECIFIED CURING TEMPERATURE AND TECHNIQUES	1908.9	ACI 318: 26.4.7-26.4.9	X			
6. INSPECT FORMWORK FOR SHAPE, LOCATION AND DIMENSIONS OF THE CONCRETE MEMBER BEING FORMED	1705.3	ACI 318: 26.10.1(b)	X			
7. INSPECTION OF WATERSTOPS FOR PROPER SHAPE, LOCATION, JOINT QUALITY, AND SURROUNDING CONCRETE PLACEMENT			X			
MASONRY LEVEL C						
1. VERIFICATION OF f'_m PRIOR TO CONSTRUCTION AND FOR EVERY 5,000 SQUARE FEET DURING CONSTRUCTION	1705.4	ACI 530: Sec. 3.1.3 ACI 530.1: Art. 1.4B	X			SEE TABLE 3 FOR MASONRY TEST REQUIREMENTS

2. VERIFICATION OF PROPORTIONS OF MATERIALS IN PREMIXED OR PREBLENDED MORTAR, AND GROUT OTHER THAN SELF-CONSOLIDATING GROUT, AS DELIVERED TO THE PROJECT SITE	1705.4	ACI 530: Sec. 3.1.3 ACI 530.1: Art. 2.1, 2.6A, 2.6B	X			
3. VERIFY COMPLIANCE WITH THE APPROVED SUBMITTALS	1705.4	ACI 530.1: Art. 1.5	X			
4. VERIFY THAT THE FOLLOWING ARE IN COMPLIANCE:						
A. PROPORTIONS OF SITE-MIXED MORTAR, GROUT	1705.4	ACI 530: Sec. 3.1.3 ACI 530.1: Art. 2.1, 2.6A, 2.6B	X			
B. GRADE, TYPE, AND SIZE OF REINFORCEMENT AND ANCHOR BOLTS	1705.4	ACI 530: Sec. 6.1, 3.1.3 ACI 530.1: Art. 2.4, 3.4	X			
C. PLACEMENT OF MASONRY UNITS AND CONSTRUCTION OF MORTAR JOINTS		ACI 530: Sec. 3.1.3 ACI 530.1: Art. 3.3B	X			
D. PLACEMENT OF REINFORCEMENT, CONNECTORS	1705.4	ACI 530: Sec. 6.1, 3.1.3 ACI 530.1: Art. 3.2E, 3.4		X		
E. GROUT SPACE PRIOR TO GROUTING	1705.4	ACI 530: Sec. 3.1.3 ACI 530.1: Art. 3.2D, 3.2F		X		
F. SIZE AND LOCATION OF STRUCTURAL ELEMENTS	1705.4	ACI 530: Sec. 3.1.3 ACI 530.1: Art. 3.3F	X			

G. TYPE, SIZE, AND LOCATION OF ANCHORS, INCLUDING OTHER DETAILS OF ANCHORAGE OF MASONRY TO STRUCTURAL MEMBERS, FRAMES OR OTHER CONSTRUCTION	1705.4	ACI 530:Sec. 1.2.1 (e), 6.1.4.3, 6.2.1		X		
H. PREPARATION, CONSTRUCTION, AND PROTECTION OF MASONRY DURING COLD WEATHER (TEMP. BELOW 40 DEGREES F) OR HOT WEATHER (TEMP. ABOVE 90 DEGREES F)	1705.4	ACI 530: Sec. 3.1.3 ACI 530.1: Art. 1.8C, 1.8D	X			
5. OBSERVE PREPARATION OF GROUT SPECIMENS, MORTAR SPECIMENS, AND/OR PRISMS	1705.4	ACI 530: Sec. 3.1.3 ACI 530.1: Art. 1.4B.2		X		SEE TABLE 3 FOR UNIT STRENGTH TESTS FOR MASONRY
STRUCTURAL STEEL						
1. MATERIAL VERIFICATION OF STRUCTURAL STEEL:						
A. IDENTIFICATION MARKINGS TO CONFORM TO AISC 360	1705.2.1, 2203.1	Applicable ASTM Material Standards	X			
B. MANUFACTURER'S CERTIFIED TEST REPORTS	1705.2.1	AISC 360: Sec. N3.2, N5.2	X			

2. PRIOR TO BOLTING, VERIFY THAT THE FOLLOWING ARE IN COMPLIANCE:						
A. MANUFACTURER'S CERTIFICATIONS AVAILABLE FOR FASTENER MATERIALS	1705.2.1	AISC 360: Sec. N3.2, N5.2, N5.6 RCSC: Sec. 2.1, 9.1		X		
B. FASTENERS MARKED IN ACCORDANCE WITH ASTM REQUIREMENTS	1705.2.1	AISC 360: Sec. N3.2, N5.2, N5.6 Applicable ASTM Material Standards	X			
C. PROPER BOLTING PROCEDURE SELECTED FOR JOINT DETAIL	1705.2.1	AISC 360: Sec. N5.6 RCSC: Sec. 4	X			
D. CONNECTING ELEMENTS, INCLUDING THE APPROPRIATE FAYING SURFACE CONDITION AND HOLE PREPARATION, IF SPECIFIED, MEET APPLICABLE REQUIREMENTS	1705.2.1	AISC 360: Sec. N5.6 RCSC: Sec. 3.2, 4	X			
E. PRE-INSTALLATION VERIFICATION TESTING BY INSTALLATION PERSONNEL OBSERVED AND DOCUMENTED FOR FASTENER ASSEMBLIES AND METHODS USED	1705.2.1	AISC 360: Sec. N5.6 RCSC: Sec. 7		X		

F. PROPER STORAGE PROVIDED FOR BOLTS, NUTS, WASHERS AND OTHER FASTENER COMPONENTS	1705.2.1	AISC 360: Sec. N5.6 RCSC: Sec. 2.2	X			
3. VERIFY DURING BOLTING:						
A. FASTENER ASSEMBLIES, OF SUITABLE CONDITION, PLACED IN ALL HOLES AND WASHERS (IF REQUIRED) ARE POSITIONED AS REQUIRED	1705.2.1	AISC 360: Sec. N5.6	X			
B. JOINT BROUGHT TO SNUG-TIGHT CONDITION PRIOR TO THE PRETENSIONING OPERATION	1705.2.1	AISC 360: Sec. N5.6	X			
C. FASTENER COMPONENT NOT TURNED BY THE WRENCH PREVENTED FROM ROTATING	1705.2.1	AISC 360: Sec. N5.6	X			
4. PRIOR TO WELDING, VERIFY THAT THE FOLLOWING ARE IN COMPLIANCE:						
A. APPROVED WELDING PROCEDURE SPECIFICATIONS (WPS) AVAILABLE TO WELDERS AND WELDING INSPECTOR(S)	1705.2.1	AWS D1.1	X			

B. WELDER QUALIFICATIONS AND JOINT FIT-UP	1705.2	AWS D1.1	X		NOTE 2	ALSO SEE REQUIREMENTS OF SPEC. SECTION 05 05 23
5. VERIFY DURING WELDING:						
A. CONTROL AND HANDLING OF WELDING CONSUMABLES	1705.2.1	AWS D1.1	X			
B. ENVIRONMENTAL CONDITIONS	1705.2.1	AWS D1.1	X			
C. COMPLIANCE WITH WPS REQUIREMENTS	1705.2.1	AWS D1.1	X		NOTE 2	ALSO SEE REQUIREMENTS OF SPEC. SECTION 05 05 23 AND TABLE 3 FOR STRUCTURAL STEEL TEST REQUIREMENT
6. AFTER WELDING, VERIFY THE FOLLOWING:						
A. SIZE, LENGTH AND LOCATION OF WELDS	1705.2.1	AWS D1.1	X		NOTE 2	
B. WELDS MEET VISUAL ACCEPTANCE CRITERIA	1705.2.1	AWS D1.1	X		NOTE 2	ALSO SEE REQUIREMENTS OF SPEC. SECTION 05 05 23
C. BACKING REMOVED AND WELD TABS REMOVED (IF REQUIRED)	1705.2.1	AWS D1.1	X			
D. NONDESTRUCTIVE WELDING INSPECTION	1705.2	AWS D1.1	X		NOTE 2	ALSO SEE REQUIREMENTS OF SPEC. SECTION 05 05 23

7. INSPECTION OF STEEL FRAME JOINT DETAILS FOR COMPLIANCE:						
A. DETAILS SUCH AS BRACING AND STIFFENING	1705.2.1		X			
B. MEMBER LOCATIONS	1705.2.1		X			
C. APPLICATION OF JOINT DETAILS AT EACH CONNECTION	1705.2.1		X			
8. INSPECTION OF STEEL ELEMENTS OF COMPOSITE CONSTRUCTION PRIOR TO CONCRETE PLACEMENT:						
A. PLACEMENT AND INSTALLATION OF STEEL DECK	1705.2.1	AISC 360: Table N6.1		X		
STEEL CONSTRUCTION OTHER THAN STRUCTURAL STEEL						
1. MATERIAL VERIFICATION OF COLD-FORMED STEEL DECK:						
A. IDENTIFICATION MARKINGS TO CONFORM TO ASTM STANDARDS SPECIFIED IN THE APPROVED CONSTRUCTION DOCUMENTS	1705.2.2, 2203.1	Applicable ASTM Material Standards	X			
B. MANUFACTURER'S CERTIFIED TEST REPORTS	1705.2.2		X			

2. CONNECTION OF COLD-FORMED STEEL DECK TO SUPPORTING STRUCTURE:						
A. OTHER FASTENERS: VERIFY FASTENERS ARE IN CONFORMANCE WITH APPROVED SUBMITTAL	1705.2.2	AISC 360: SEC N6	X			
ALUMINUM						
1. MATERIAL VERIFICATION OF ALUMINUM:						
A. IDENTIFICATION MARKINGS TO CONFORM TO ASTM STANDARDS SPECIFIED IN THE APPROVED CONSTRUCTION DOCUMENTS	1705.1.1 ITEM 2		X			
B. MANUFACTURERS' CERTIFIED MILL TEST REPORTS	1705.1.1 ITEM 2		X			

NOTES:

1. PERIODIC INSPECTION IS DEFINED AS INSPECTION BY THE SPECIAL INSPECTOR OF ALL MATERIALS AND SYSTEMS, IN SOME CASES PERFORMED DURING THEIR PLACEMENT AND IN ALL CASES PERFORMED UPON COMPLETION OF THEIR PLACEMENT. THE COMPLETION INSPECTION SHALL BE PERFORMED SO THAT WORK CAN BE CORRECTED PRIOR TO OTHER RELATED WORK PROCEEDING AND COVERING INSPECTED WORK.

2. VISUAL INSPECTION IS THE RESPONSIBILITY OF THE CONTRACTOR'S WELDING INSPECTOR(S) AND IS NOT CONSIDERED SPECIAL INSPECTION. CONTRACTOR MUST PROVIDE A QUALIFIED WELDING INSPECTOR TO OVERSEE CONTRACTOR'S WELDING OPERATIONS, AS REQUIRED BY AWS D1.1, SECTIONS 6.1.2 & 6.6, SPEC. SECTION 05 05 23 AND REFERENCED WELDING CODES.

SECTION 01 50 00
TEMPORARY FACILITIES AND CONTROLS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of Nurserymen (AAN): American Standards for Nursery Stock.
2. Federal Emergency Management Agency (FEMA).
3. National Fire Prevention Association (NFPA): 241, Standard for Safeguarding Construction, Alteration, and Demolition Operations.
4. Telecommunications Industry Association (TIA); Electronic Industries Alliance (EIA): 568B, Commercial Building Telecommunications Cabling Standard.
5. U.S. Department of Agriculture (USDA): Urban Hydrology for Small Watersheds.
6. U.S. Weather Bureau: Rainfall-Frequency Atlas of the U.S. for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years.

1.02 SUBMITTALS

A. Informational Submittals:

1. Copies of permits and approvals for construction as required by Laws and Regulations and governing agencies.
2. Temporary Utility Submittals:
    a. Electric power supply and distribution plans.
    b. Water supply and distribution plans.
    c. Dewatering well locations.
3. Temporary Construction Submittals:
    a. Access Roads: Routes, cross-sections, and drainage facilities.
    b. Parking area plans.
    c. Contractor’s field office, storage yard, and storage building plans, including gravel surfaced area.
    d. Fencing and protective barrier locations and details.
    e. Engineer’s field office plans.
    f. Staging area location plan.
    g. Plan for maintenance of existing plant operations.
4. Temporary Control Submittals:
    a. Dust control plan.
    b. Plan for disposal of waste materials and intended haul routes.

1.03 MOBILIZATION

A. Mobilization includes, but is not limited to, these principal items:

1. Obtaining required permits.
2. Preparing Contractor's and Engineer's field office and equipment required for first month operations onto Site.
3. Installing temporary construction power, wiring, and lighting facilities.
4. Providing onsite Internet service.
5. Providing onsite sanitary facilities and potable water facilities as specified and as required by Laws and Regulations, and governing agencies.
6. Arranging for and erection of Contractor's work and storage yard.
7. Posting OSHA required notices and establishing safety programs and procedures.
8. Having Contractor's superintendent at Site full time.
9. Providing access to Contractor's and Engineer's facilities.

B. Use area designated for Contractor's temporary facilities as shown on Drawings.

C. Progress payment for mobilization will not be approved prior to the preparing of Contractor's and Engineer's Field Office access and internet service.

1.04 PROTECTION OF WORK AND PROPERTY

A. Comply with Owner's safety rules while on Owner's property.

B. Keep Owner informed of serious onsite accidents and related claims.

C. Use of Explosives: No blasting or use of explosives will be allowed onsite.

1.05 VEHICULAR TRAFFIC

A. Traffic Control Plan: Adhere to traffic control plan reviewed and accepted by Engineer. Changes to this plan shall be made only by written approval of Engineer. Secure approvals for necessary changes so as not to delay progress of the Work.

B. Traffic Routing Plan: Show sequences of construction affecting use of roadways, time required for each phase of the Work, provisions for decking over excavations and phasing of operations to provide necessary access, and plans for signing, barricading, and striping to provide passages for pedestrians and vehicles.

PART 2 PRODUCTS

2.01 ENGINEER'S FIELD OFFICES

A. Owner to provide field trailer for Engineer on site offices.

B. Contractor to provide temporary fencing around Engineer field trailer and install access gate as shown on the Contract Drawings.

C. Contractor responsible for maintenance and upkeep of Engineer field trailer. This includes regular cleaning, restocking printer, and any other necessary maintenance.

2.02 PROJECT SIGN

A. Refer to Project Sign Detail Attached. Provide and maintain one, 8-foot-wide by 4-foot-high sign constructed of 3/4-inch exterior high density overlaid plywood. Sign shall bear name of Project, Owner, Contractor, Engineer, and other participating agencies. Lettering shall be black applied on white background by an experienced sign painter. Provide exterior type enamel paint. Information to be included and logo graphic will be provided by Engineer. Example of project sign is listed in the supplemental information following this section.

PART 3 EXECUTION

3.01 ENGINEER'S FIELD OFFICE

A. Make available for Engineer's use prior to start of Work at Site and to remain on Site for minimum of 15 days after final acceptance of Work.

1. Service of internet connection.

B. Maintain in good repair and appearance, and provide weekly cleaning service and replenishment, as required, of paper towels, paper cups, hand soap, toilet paper, first-aid kit supplies, and bottled water.

C. Replenish, as needed, copy paper and toner.

3.02 CONTRACTOR'S FIELD OFFICE

A. Locate Contractor's Field Office in Contractor Construction and Staging Area.

B. Power to be provided from Contractor's Temporary power supply specified below.

C. No site potable water connection is available. Provide bottled water for field office as necessary.

D. Sanitary Sewer service is not available. Provide holding tank system or portable toilets as needed for Contractor's Office and Field personnel.

3.03 TEMPORARY UTILITIES

A. Power: Power available at Substation No. 2. Contractor responsible for providing temporary electrical conduits and cables to Contractor's field office. Cost of electric power will be borne by Owner.

B. Lighting: Provide temporary lighting to meet applicable safety requirements to allow erection, application, or installation of materials and equipment, and observation or inspection of the Work.

C. Heating, Cooling, and Ventilating:

1. Provide as required to maintain adequate environmental conditions to facilitate progress of the Work, to meet specified minimum conditions for installation of materials, and to protect materials, equipment, and finishes from damage because of temperature or humidity. Costs for temporary heat shall be borne by Contractor responsible for constructing structure or building as specified in Section 01 11 00, Summary of Work.
2. Provide adequate forced air ventilation of enclosed areas to cure installed materials, to dispense humidity, and to prevent hazardous accumulations of dust, fumes, vapors, or gases.
3. Pay costs of installation, maintenance, operation, removal, and fuel consumed.
4. Provide portable unit heaters, complete with controls, oil- or gas-fired, and suitably vented to outside as required for protection of health and property.
5. If permanent natural gas piping is used for temporary heating units, do not modify or reroute gas piping without approval of utility company. Provide separate gas metering as required by utility.

D. Water:

1. No construction or potable water is available at Site. Make arrangements for and bear costs of providing water required for construction purposes and for drinking by construction personnel during construction.

E. Sanitary and Personnel Facilities:

1. Provide and maintain facilities for Contractor's employees, Subcontractors, and other onsite employers' employees. Service, clean, and maintain facilities and enclosures.
2. Use of Owner's existing sanitary facilities by construction personnel will not be allowed.

F. Telephone Service:

1. Contractor: Arrange and provide onsite telephone service for use during construction. Pay costs of installation and monthly bills.
2. No incoming calls allowed to Owner's plant telephone system.

G. Fire Protection: Furnish and maintain on Site adequate firefighting equipment capable of extinguishing incipient fires. Comply with applicable parts of NFPA 241.

3.04 PROTECTION OF WORK AND PROPERTY

A. General:

1. Perform Work within right-of-way and easements in a systematic manner that minimizes inconvenience to property owners and the public.
2. No residence or business shall be cut off from vehicular traffic for a period exceeding 4 hours, unless special arrangements have been made.
3. Maintain in continuous service existing oil and gas pipelines, underground power, telephone or communication cable, water mains, irrigation lines, sewers, poles and overhead power, and other utilities encountered along line of the Work, unless other arrangements satisfactory to owners of said utilities have been made.
4. Where completion of the Work requires temporary or permanent removal or relocation of existing utility, coordinate activities with owner of said utility and perform work to their satisfaction.
5. Protect, shore, brace, support, and maintain underground pipes, conduits, drains, and other underground utility construction uncovered or otherwise affected by construction operations.
6. Keep fire hydrants and water control valves free from obstruction and available for use at all times.
7. In areas where Contractor's operations are adjacent to or near a utility, such as gas, telephone, television, electric power, water, sewer, or irrigation system, and such operations may cause damage or inconvenience, suspend operations until arrangements necessary for protection have been made by Contractor.
8. Notify property owners and utility offices that may be affected by construction operation at least 2 days in advance: Before exposing a utility, obtain utility owner's permission. Should service of utility be interrupted due to Contractor's operation, notify proper authority immediately. Cooperate with said authority in restoring service as promptly as possible and bear costs incurred.
9. Do not impair operation of existing sewer system. Prevent construction material, pavement, concrete, earth, volatile and corrosive wastes, and other debris from entering sewers, pump stations, or other sewer structures.

10. Maintain original Site drainage wherever possible.

B. Site Security:

1. Erect a temporary security fence at locations shown on Drawings for protection of Owner-furnished products and existing facilities, as specified in Section 32 31 13, Chain Link Fences and Gates. Maintain fence throughout construction period. Obtain Engineer's written permission before removal of temporary security fencing.
2. Provide and maintain additional temporary security fences as necessary to protect the Work and Contractor-furnished products not yet installed.

C. Barricades and Lights:

1. Provide as required by the CT DOT Vehicle Code and in sufficient quantity to safeguard public and the Work.
2. Provide as necessary to prevent unauthorized entry to construction areas and affected roads, streets, and alleyways, inside and outside of fenced area, and as required to ensure public safety and the safety of Contractor's employees, other employer's employees, and others who may be affected by the Work.
3. Provide to protect existing facilities and adjacent properties from potential damage.
4. Locate to enable access by facility operators and property owners.
5. Protect streets, roads, highways, and other public thoroughfares that are closed to traffic by effective barricades with acceptable warning signs.
6. Locate barricades at the nearest intersecting public thoroughfare on each side of blocked section.
7. Illuminate barricades and obstructions with warning lights from sunset to sunrise.

D. Signs and Equipment:

1. Conform to requirements of manual published by the State Department of Transportation.
2. Portable TOW-AWAY-NO STOPPING Signs: Place where approved by police department and Owner.
3. Traffic Cones: Provide to delineate traffic lanes to guide and separate traffic movements.
4. High-Level Warning Flag Units: Provide 2 in advance of traffic approaching the Work, each displaying three flags mounted at a height of 9 feet.
5. ROAD CONSTRUCTION AHEAD Signs: Provide two, size 48 inches by 48 inches. Place in conspicuous locations, approximately 200 feet in advance of the Work, and facing approaching traffic.
6. DETOUR Signs: Provide 2, right arrow or left arrow, placed as approved by Engineer.

7. Provide at obstructions, such as material piles and equipment.
8. Use to alert general public of construction hazards, which would include surface irregularities, unramped walkways, grade changes, and trenches or excavations in roadways and in other public access areas.

E. Trees and Plantings:

1. Protect from damage and preserve trees, shrubs, and other plants outside limits of Work and within limits of Work, which are designated on Drawings to remain undisturbed.
   a. Where practical, tunnel beneath trees when on or near line of trench.
   b. Employ hand excavation as necessary to prevent tree injury.
   c. Do not stockpile materials or permit traffic within drip lines of trees.
   d. Provide and maintain temporary barricades around trees.
   e. Water vegetation as necessary to maintain health.
   f. Cover temporarily exposed roots with wet burlap and keep burlap moist until soil is replaced around roots.
   g. No trees, except those specifically shown on Drawings to be removed, shall be removed without written approval of Engineer.
   h. Dispose of removed trees in a legal manner off the Site.
2. Balling and burlapping of trees indicated for replacement shall conform to recommended specifications set forth in the American Standards for Nursery Stock, published by American Association of Nurserymen. Balls shall be firm and intact and made-balls will not be accepted. Handle ball and burlap trees by ball and not by top.
3. In event of damage to bark, trunks, limbs, or roots of plants that are not designated for removal, treat damage by corrective pruning, bark tracing, application of a heavy coating of tree paint, and other accepted horticultural and tree surgery practices.
4. Replace each plant that dies as a result of construction activities.

F. Existing Structures:

1. Where Contractor contemplates removal of small structures such as mailboxes, signposts, and culverts that interfere with Contractor's operations, obtain approval of property owner and Engineer.
2. Move mailboxes to temporary locations accessible to postal service.
3. Replace items removed in their original location and a condition equal to or better than original.

G. Finished Construction: Protect finished floors and concrete floors exposed as well as those covered with composition tile or other applied surfacing.

H. Waterways: Keep ditches, culverts, and natural drainages continuously free of construction materials and debris.

I. Dewatering: Construct, maintain, and operate cofferdams, channels, flume drains, sumps, pumps, or other temporary diversion and protection works. Furnish materials required, install, maintain, and operate necessary pumping and other equipment for the environmentally safe removal and disposal of water from the various parts of the Work. Maintain foundations and parts of the Work free from water.

J. Archaeological Finds:

1. General: Should finds of an archaeological or paleontological nature be made within Site limits, immediately notify Owner and Engineer and proceed in accordance with General Conditions. Continue the Work in other areas without interruption.
2. Archaeological Finds: Evidence of human occupation or use of an area within contract limits prior to the Year 1840. Evidence may consist of skeletons, stone, or other utensils, or evidence of habitations or structures.
3. Paleontological Finds: Evidence of prehistoric plant or animal life, such as skeletons, bones, fossils, or casts and other indications such as pictographs.
4. Owner may order the Work stopped in other areas if, in Owner's opinion, find is more extensive than may appear from uncovered material.
5. Protection of Finds:
   a. Cover, fence, or otherwise protect finds until notice to resume the Work is given.
   b. Cover finds with plastic film held in place by earth, rocks, or other weights placed outside the find. Should additional backfilling be necessary for safety or to prevent caving, place backfill material loosely over plastic film.
   c. Sheet or shore as necessary to protect excavations underway. Place temporary fence to prevent unauthorized access.
   d. Dewater finds made below water table as necessary to protect construction Work underway. Divert groundwater or surface runoff away from find by ditching or other acceptable means.
6. Removal of Finds:
   a. Finds are property of Owner. Do not remove or disturb finds without Owner's written authorization.
   b. Should Owner elect to have a find removed, provide equipment, labor, and material to permit safe removal of find without damage. Provide transportation for delivery to individuals, institutions, or other places as Owner may find desirable, expedient, or required by law.

K. Endangered and Threatened Species:

1. Take precautions necessary and prudent to protect native endangered and threatened flora and fauna.
2. Notify Engineer of construction activities that might threaten endangered and threatened species or their habitats.
3. Engineer will mark areas known as habitats of endangered and threatened species prior to commencement of onsite activities.
4. Additional areas will be marked by Engineer as other habitats of endangered and threatened species become known during construction.

3.05 TEMPORARY CONTROLS

A. Air Pollution Control:

1. Minimize air pollution from construction operations.
2. Burning of waste materials, rubbish, or other debris will not be permitted on or adjacent to Site.
3. Conduct operations of dumping rock and of carrying rock away in trucks to cause a minimum of dust. Give unpaved streets, roads, detours, or haul roads used in construction area a dust-preventive treatment or periodically water to prevent dust. Strictly adhere to applicable environmental regulations for dust prevention.
4. Provide and maintain temporary dust-tight partitions, bulkheads, or other protective devices during construction to permit normal operation of existing facilities. Construct partitions of plywood, insulating board, plastic sheets, or similar material. Construct partitions in such a manner that dust and dirt from demolition and cutting will not enter other parts of existing building or facilities. Remove temporary partitions as soon as need no longer exists.

B. Noise Control:

1. Provide acoustical barriers so noise emanating from tools or equipment will not exceed legal noise levels.
2. Noise Control Ordinance: Limit of 55 decibels during the day and 45 decibels between 10 p.m. and 7 a.m.
3. Noise Control Plan: Propose plan to mitigate construction noise and to comply with noise control ordinances, including method of construction, equipment to be used, and acoustical treatments.

C. Water Pollution Control:

1. Divert sanitary sewage and nonstorm waste flow interfering with construction and requiring diversion to sanitary sewers. Do not cause or permit action to occur which would cause an overflow to existing waterway.

2. Prior to commencing excavation and construction, obtain Engineer's agreement with detailed plans showing procedures intended to handle and dispose of sewage, groundwater, and dewatering pump discharges.
3. Comply with Section 01 57 13, Temporary Erosion and Sedimentation Control, for stormwater flow and surface runoff.
4. Do not dispose of volatile wastes such as mineral spirits, oil, chemicals, or paint thinner in storm or sanitary drains. Disposal of wastes into streams or waterways is prohibited. Provide acceptable containers for collection and disposal of waste materials, debris, and rubbish.

D. Erosion, Sediment, and Flood Control: Provide, maintain, and operate temporary facilities as specified in Section 01 57 13, Temporary Erosion and Sedimentation Control, to control erosion and sediment releases, and to protect the Work and existing facilities from flooding during construction period.

3.06 STORAGE YARDS AND BUILDINGS

A. Coordinate requirements with Section 01 61 00, Common Product Requirements.

B. Temporary Storage Yards: Construct temporary storage yards for storage of products that are not subject to damage by weather conditions.

C. Temporary Storage Buildings:

1. Provide environmental control systems that meet recommendations of manufacturers of equipment and materials stored.
2. Arrange or partition to provide security of contents and ready access for inspection and inventory.
3. Store combustible materials (paints, solvents, fuels) in a well-ventilated and remote building meeting safety standards.

3.07 ACCESS ROADS

A. Construct access roads as shown and within easements, rights-of-way, or Project limits. Use existing roads where shown. Alignments for new routes shall be approved by Engineer.

B. Maintain drainage ways. Install and maintain culverts to allow water to flow beneath access roads. Provide corrosion-resistant culvert pipe of adequate strength to resist construction loads.

C. Provide gravel, crushed rock, or other stabilization material to permit access by all motor vehicles at all times.

D. Maintain road grade and crown to eliminate potholes, rutting, and other irregularities that restrict access.

E. Coordinate with Engineer detours and other operations affecting traffic and access. Provide at least 72 hours' notice to Engineer of operations that will alter access to Site.

F. Where access road crosses existing fences, install and maintain gates. Gates and gate posts shall conform to those as specified in Section 32 31 13, Chain Link Fences and Gates.

G. Upon completion of construction, restore ground surface disturbed by access road construction as shown on the Drawings.

3.08 PARKING AREAS

A. Control vehicular parking to preclude interference with public traffic or parking, access by emergency vehicles, Owner's operations, or construction operations.

B. Provide parking facilities for personnel working on Project. No employee or equipment parking will be permitted on Owner's existing paved areas, except as specifically designated for Contractor's use.

C. Use area designated on Drawings for parking of Contractor's and Contractor's employees' vehicles.

3.09 VEHICULAR TRAFFIC

A. Comply with Laws and Regulations regarding closing or restricting use of public streets or highways. No public or private road shall be closed, except by written permission of proper authority. Ensure the least possible obstruction to traffic and normal commercial pursuits.

B. Conduct the Work to interfere as little as possible with public travel, whether vehicular or pedestrian.

C. Whenever it is necessary to cross, close, or obstruct roads, driveways, and walks, whether public or private, provide and maintain suitable and safe bridges, detours, or other temporary expedients for accommodation of public and private travel.

D. Road Closures: Maintain satisfactory means of exit for persons residing or having occasion to transact business along route of the Work. If it is necessary to close off roadway or alley providing sole vehicular access to property for periods greater than 2 hours, provide written notice to each owner so affected 3 days prior to such closure. In such cases, closings of up to 4 hours may be allowed. Closures of up to 10 hours may be allowed if a week's written notice is given and undue hardship does not result.

E. Maintenance of traffic is not required if Contractor obtains written permission from Owner and tenant of private property, or from authority having jurisdiction over public property involved, to obstruct traffic at designated point.

F. In making street crossings, do not block more than one-half the street at a time. Whenever possible, widen shoulder on opposite side to facilitate traffic flow. Provide temporary surfacing on shoulders as necessary.

G. Maintain top of backfilled trenches before they are paved, to allow normal vehicular traffic to pass over. Provide temporary access driveways where required. Cleanup operations shall follow immediately behind backfilling.

H. When flaggers and guards are required by regulation or when deemed necessary for safety, furnish them with approved orange wearing apparel and other regulation traffic control devices.

I. Provide snow removal to facilitate normal vehicular traffic on public or private roads affected by construction. Perform snow removal promptly and efficiently by means of suitable equipment whenever necessary for safety, and as may be directed by proper authority.

J. Notify fire department and police department before closing street or portion thereof. Notify said departments when streets are again passable for emergency vehicles. Do not block off emergency vehicle access to consecutive arterial crossings or dead-end streets, in excess of 300 linear feet, without written permission from fire department. Conduct operations with the least interference to fire equipment access, and at no time prevent such access. Furnish Contractor's night emergency telephone numbers to police department.

K. Coordinate traffic routing with that of others working in same or adjacent areas.

3.10 CLEANING DURING CONSTRUCTION

A. In accordance with General Conditions, as may be specified in other Specification sections, and as required herein.

B. Wet down exterior surfaces prior to sweeping to prevent blowing of dust and debris. At least weekly, sweep floors (basins, tunnels, platforms, walkways, roof surfaces), and pick up and dispose of debris.

C. Provide approved containers for collection and disposal of waste materials, debris, and rubbish. At least weekly, dispose of such waste materials, debris, and rubbish offsite.

D. At least weekly, brush sweep entry drive, roadways, and other streets and walkways affected by the Work and where adjacent to the Work.

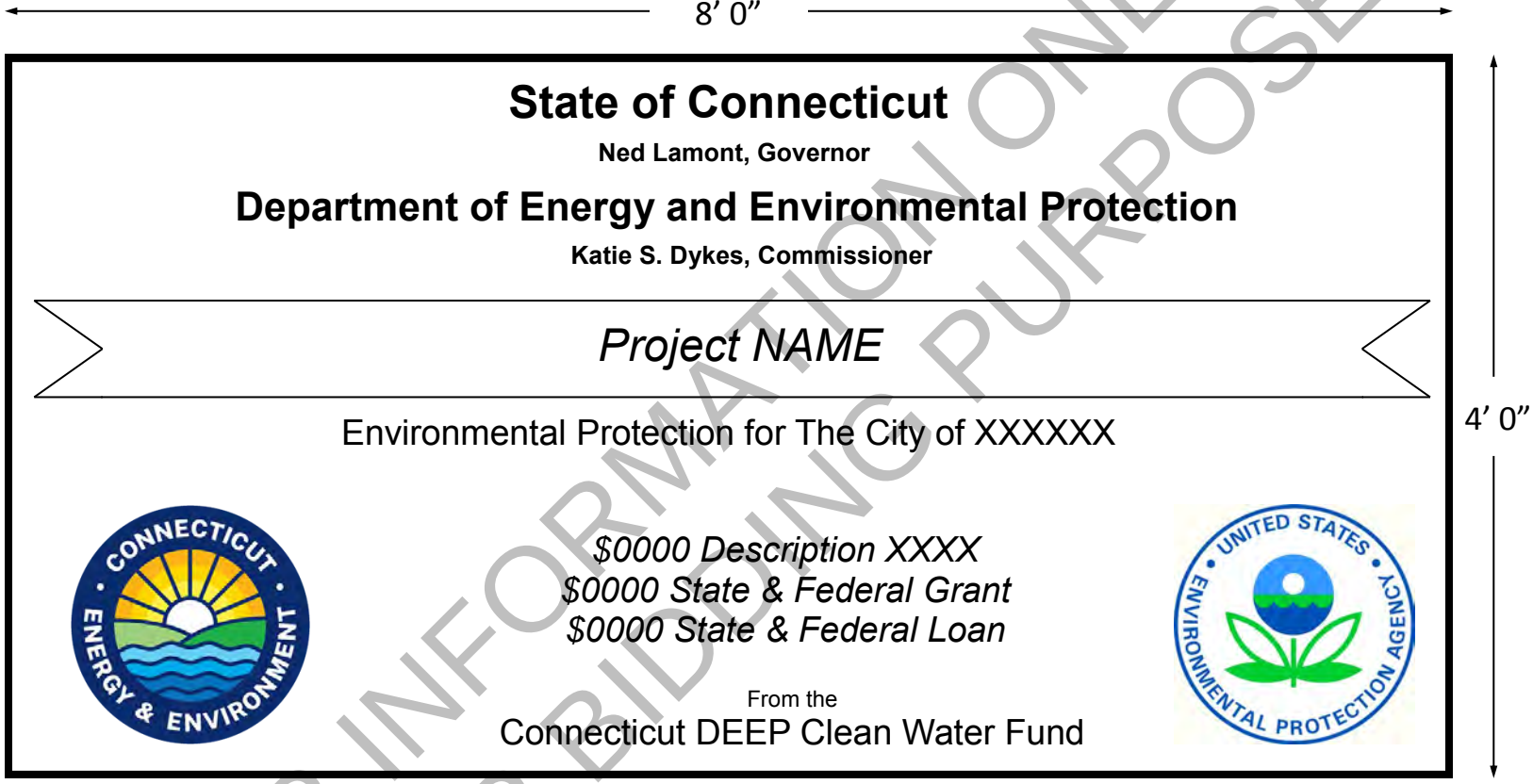
3.11 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this specification.

1. DEEP CWF Project Sign Template.

END OF SECTION

CONNECTICUT CLEAN WATER FUND PROJECT SIGN



Color Scheme:
Lettering in black
Background in white
Banner in yellow
Logo as pictured

Provide adequate supports for sign as site conditions may require. Keep sign a proper distance above prevailing grade to permit public viewing.

April 2023 DRAFT 5

Revised January 2019

SECTION 01 57 13
TEMPORARY EROSION AND SEDIMENT CONTROL

PART 1 GENERAL

1.01 SUMMARY

A. This section covers Work to implement structural and nonstructural Best Management Practices (BMP) to control soil erosion by wind or water and keep eroded sediments and other construction-generated pollutants from moving off project sites. Requirements described in this specification and shown on the Drawings are part of the project Temporary Erosion and Sediment Control Plan (TESC Plan) and are the minimum for all project construction sites and conditions. This specification covers all project activities, including material sources, disposal sites, and offsite mitigation areas unless specific project activities are excluded elsewhere in this specification or in other Contract Documents controlling the Work.

B. National Pollutant Discharge Elimination System: Comply with Federal, state, and local laws, rules and regulations, and the National Pollutant Discharge Elimination System (NPDES) Construction Stormwater Discharge Permit or Permits applicable to the project. A copy of the Project's General Construction Permit, if applicable to the Project, is available from Owner. NPDES General Construction permits are required on projects that involve disturbance of 1 acre or more with potential to discharge stormwater to surface waters.

C. Other Regulations: A local government erosion and sediment control permit may apply and some local agency requirements may be more stringent than this specification. Adequate erosion and sediment control is essential for complying with the federal Endangered Species Act where construction runoff enters waters inhabited by protected species.

1.02 REFERENCES

A. Activities shall conform to the Standard Specifications and Drawings. In the event of a conflict, the more stringent requirement shall apply.

B. The following is a list of standards that may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO): M252, Standard Specification for Corrugated Polyethylene Drainage Pipe.

2. ASTM International (ASTM):
    a. D638, Standard Test Method for Tensile Properties of Plastics.
    b. D2974, Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils.
    c. D3776/D3776M, Standard Test Methods for Mass Per Unit Area (Weight) of Fabric.
    d. D4355, Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
    e. D4397, Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications.
    f. D4491, Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
    g. D4533, Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
    h. D4632/D4632M, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
    i. D4751, Standard Test Method for Determining Apparent Opening Size of a Geotextile
    j. D6241, Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.
    k. D6459, Standard Test Method for Determination of Rolled Erosion Control Product (RECP) Performance in Protecting Hillslopes from Rainfall-Induced Erosion.
    l. D6460, Standard Test Method for Determination of Rolled Erosion Control Product (RECP) Performance in Protecting Earthen Channels from Stormwater-Induced Erosion.
    m. D6475, Standard Test Method for Measuring Mass Per Unit Area of Erosion Control Blankets.
    n. D7322, Standard Test Method for Determination of Rolled Erosion Control Product (RECP) Ability to Encourage Seed Germination and Plant Growth Under Bench-Scale Conditions.
    o. D7367, Standard Test Method for Determining Water Holding Capacity of Fiber Mulches for Hydraulic Planting.
3. National Weather Service:
    a. Precipitation-Frequency of the United States by State/Territory, 2012.
    b. Precipitation Frequency Data Server, 2012.
4. North American Weed Management Association (NAWMA).
5. U.S. Department of Agriculture, Natural Resources Conservation Service: *Urban Hydrology for Small Watersheds*; 1986. Technical Release 55.

6. U.S. Environmental Protection Agency:
    a. Developing Your Stormwater Pollution Prevention Plan: A Guide for Construction Sites, 2007. EPA-833-R-06-004.
    b. National Menu of BMPs, 2012.

1.03 SYSTEM DESCRIPTION

A. Erosion and Sediment Control:

1. Provide, maintain, and operate temporary facilities to control erosion and sediment releases during construction period.
2. Design erosion and sediment controls to handle peak runoff resulting from 25-year, 24-hour storm event based on U.S. Weather Bureau, "Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years." Technical Paper No. 40,1981.
3. Size temporary stormwater conveyances based on procedures presented in U.S. Department of Agriculture, Natural Resources Conservation Service: Urban Hydrology for Small Watersheds, 1986. Technical Release 55.
4. Design temporary flood control facilities for design flood with minimum of 3 feet of freeboard. Design flood shall be as published by FEMA for 100-year recurrence interval.

B. Erosion and Sediment Control (ESC) Lead:

1. Identify the ESC Lead at the preconstruction discussions and in the TESC Plan. The ESC Lead shall have certification in construction site erosion and sediment control from a course approved by Owner.
2. The ESC Lead shall implement the TESC Plan, including, but not limited to:
    a. Installing and maintaining all temporary erosion and sediment control Best Management Practices (BMPs) included in the TESC Plan to assure continued performance of their intended function. Damaged or inadequate TESC BMPs shall be corrected immediately.
    b. Updating TESC Plan to reflect current field conditions.
    c. Terminating TESC Plan.
3. When a TESC Plan is included in the Contract Plans, ESC Lead shall also inspect all areas disturbed by construction activities, all onsite erosion and sediment control BMPs, all stormwater discharge points, and all temporarily stabilized inactive sites per schedule in the Construction Stormwater Discharge Permit(s) or as directed by Engineer. Complete erosion and sediment control inspection form provided by water resource agency or Owner for each inspection and

submit a copy to Engineer no later than end of the next working day following inspection.

C. Personnel Training: Prior to commencement of construction, applicable personnel must have an understanding of the Construction Stormwater Discharge Permit's requirements and their specific responsibilities under the permit. At a minimum, personnel must be trained to understand the following as it relates to the scope of their job duties:

1. The location of all stormwater controls and how to maintain them.
2. Procedures for complying with the pollution prevention requirements.
3. Procedures for conducting inspections, recording findings, and taking corrective action.

D. Temporary Erosion and Sediment Control Plan (Stormwater Pollution Prevention Plan):

1. A TESC Plan is furnished as part of the Drawings, which helps fulfill part of the plan requirement of the NPDES Permit. This initial TESC Plan, when adopted by Contractor, may be used as the basis of the construction TESC Plan. Additional or revised erosion and sediment control features, not shown on the initial TESC Plan, may be required depending on Contractor's methods of operation and schedule.
2. For each phase of the scheduled work, indicate on the TESC Plan all the BMPs proposed and installed for erosion and sediment control to minimize clearing, stabilize exposed soil, divert or temporarily store flows, limit runoff from exposed areas, and filter transported sediment. Include all temporary slopes, constructed for staging or other reasons, which may not have been identified in the original Contract plans. Refer to the current local jurisdiction's erosion and sediment control manual.
3. Some TESC Plan required elements typically required by NPDES permits:
    a. Narrative Site Description:
        1) Nature of construction activity planned for the Site.
        2) Estimates of total site area and the areas of the Site expected to be disturbed.
        3) Soil types found onsite and their erosion potential.
        4) The types of fill materials to be used.
        5) Timetable for sequence of major construction events.
    b. Site Map:
        1) All areas of development.
        2) Drainage patterns.
        3) Areas of soil disturbance, including pre-development and post-development elevation contours.
        4) Areas used for storage of soils or wastes.
        5) Areas where vegetative practices are to be implemented.

6) Location of all erosion and sediment control BMP or structures.
7) Location of all impervious structures and surfaces after project is completed.
8) Springs, wetlands, and other surface waters located onsite.
9) Boundaries of the 100-year floodplain, if determined.
10) Ordinary High Water line, if determined.
11) Location of storm drainage outfalls to receiving waters, if applicable.
12) Details of sediment and erosion controls.
13) Details of detention ponds, storm drain piping, inflow and outflow details.

c. Required BMPs and Procedures for Erosion Prevention, Runoff Control, and Sediment Control:
1) Construction entrances and parking areas.
2) Unpaved site roads such as haul roads.
3) Hauling saturated soils from the Site.
4) Water washed from concrete trucks.
5) Correct installation of erosion and sediment control BMPs.
6) Prompt maintenance and repair of BMPs.
7) Clearing and grading practices to minimize area of exposed soil throughout life of the Project.
8) Schedule of phased clearing operations to limit soils to what can be stabilized.
9) Vegetative practices, including preservation of existing vegetation, seeding, mulching, and buffer strips.
10) Preventing erosion of exposed areas.
11) Diverting flows from exposed slopes.
12) Limiting runoff from exposed areas.
13) Limiting sediment transport within work sites and keeping it from moving off of project areas.
14) Perimeter controls for all clearing and grubbing, both planned and installed.
15) Additional controls for wet season work and temporary work suspensions.
16) Sensitive areas such as wetlands.
17) Offsite material source and waste areas.
18) Dust.
19) Emergency materials stockpiled onsite.
20) Storing flows and filtering sediment.
21) Soil stockpiles.

4. Contractor’s construction TESC Plan and implementation schedules must be prepared by a competent individual. Furnish a signed copy of the TESC Plan with individual’s name, title, state certifications, and employing firm if different than Contractor’s firm.

5. Do not begin any Site activities that have potential to cause erosion or sediment movement until the TESC Plan and implementation schedules are approved by Engineer.
6. Keep a copy of the approved TESC Plan with updated changes onsite during all construction activities. During inactive periods longer than 7 calendar days, keep the TESC Plan onsite or provide a copy to Engineer to retain.
7. Continually update the TESC Plan and schedules as needed for unexpected storm or other events to ensure that sediment-laden water does not leave the construction site. Add approved changes to the TESC Plan no later than 24 hours after implementation.

E. Install high visibility fence along the Site no work areas shown on the Drawings or as instructed by Engineer. Space posts and attach fence fabric to posts as shown on the Drawings. Do not fasten fence to trees. Throughout the life of the Project, preserve and protect delineated area, acting immediately to repair or restore any fencing damaged or removed.

F. Preventing erosion, and controlling runoff, sedimentation, and non-stormwater pollution, requires Contractor to perform temporary Work items including, but not limited to:

1. Providing ditches, berms, culverts, and other measures to control surface water.
2. Building dams, settling basins, energy dissipaters, and other measures, to control downstream flows.
3. Controlling underground water found during construction.
4. Covering or otherwise protecting slopes until permanent erosion control measures are working.

G. To the degree possible, coordinate this temporary Work with permanent drainage and erosion control work the Contract requires.

H. Engineer may require additional temporary control measures if it appears pollution or erosion may result from weather, nature of materials, or progress on the Work.

I. When natural elements rut or erode the slope, restore and repair damage with eroded material where possible, and remove and dispose of any remaining material found in ditches and culverts. When Engineer orders replacement with additional or other materials, unit Contract prices will cover quantities needed.

J. Install all sediment control devices including, but not limited to, sediment ponds, perimeter silt fencing, or other sediment trapping BMPs prior to any ground disturbing activity. Do not expose more erodible earth than necessary during clearing, grubbing, excavation, borrow, or fill activities without written

approval by Engineer. Engineer may increase or decrease the limits based on project conditions. Erodible earth is defined as any surface where soils, grindings, or other materials may be capable of being displaced and transported by rain, wind, or surface water runoff. Cover inactive areas of erodible earth, whether at final grade or not, within specified time period (see [NPDES] Erosion and Sediment Control Permit), using an approved soil covering practice. Phase clearing and grading to maximum extent practical to prevent exposed inactive areas from becoming a source of erosion.

K. Water Management:

1. Manage site water in accordance with the conditions of the waste discharge permit from a local permitting authority. If site water management is not subject to permit, manage as follows:
   a. Groundwater. When groundwater is encountered in an excavation, treat and discharge as follows:
      1) When groundwater conforms to DEEP Water Quality Standards, it may bypass detention and treatment facilities and be routed directly to its normal discharge point at a rate and method that will not cause erosion.
      2) When turbidity of groundwater is similar to turbidity of site runoff, groundwater may be treated using same detention and treatment facilities being used to treat the site runoff and then discharged at a rate that will not cause erosion.
      3) When groundwater turbidity is greater than turbidity of site runoff, treat ground water separately until turbidity is similar to or better than site runoff, and then it may be combined with site runoff and treated as described above.
   b. Process Water:
      1) Do not discharge high pH process water or wastewater (non-stormwater) that is generated onsite, including water generated during concrete grinding, rubblizing, washout, and hydrodemolition activities, to waters of the US or CT regulated waterways, including wetlands. Water may be infiltrated upon approval of Engineer. Offsite disposal of concrete process water is subject to approval of Engineer.
      2) Treat all water generated onsite from construction or washing activities that is more turbid than site runoff separately until turbidity is the same or less than site runoff, and then it may be combined with site runoff and treated as described above. Water may be infiltrated upon approval of Engineer.
   c. Offsite Water: Prior to disruption of normal watercourse, intercept offsite stormwater and pipe it either through or around the Project Site. This water shall not be combined with onsite stormwater. Discharge offsite water at its preconstruction outfall point

preventing an increase in erosion below the site. Submit proposed method for performing this Work for Engineer's approval.

L. Dispersion/Infiltration: Convey water only to dispersion or infiltration areas designated in the TESC Plan or to sites approved by Engineer. Water shall be conveyed to designated dispersion areas at a rate such that, when runoff leaves the area and enters waters of the US or CT regulated waterways, turbidity standards are achieved. Convey water to designated infiltration areas at a rate that does not produce surface runoff.

M. Detention/Retention Pond Construction: Whether permanent or temporary, construct before beginning other grading and excavation Work in the area that drains into that pond. Install temporary conveyances concurrently with grading in accordance with the TESC Plan so that newly graded areas drain to the pond as they are exposed.

N. Pollution Control: Use BMPs to prevent or minimize stormwater exposure to pollutants from spills; vehicle and equipment fueling, maintenance, and storage; other cleaning and maintenance activities; and waste handling activities. These pollutants include fuel, hydraulic fluid, and other oils from vehicles and machinery, as well as debris, leftover paints, solvents, and glues from construction operations. Implement the following BMPs when applicable:

1. Written spill prevention and response procedures.
2. Employee training on spill prevention and proper disposal procedures.
3. Spill kits in all vehicles.
4. Regular maintenance schedule for vehicles and machinery.
5. Material delivery and storage controls.
6. Training and signage.
7. Covered storage areas for waste and supplies.

O. If Engineer orders the Work suspended, continue to control erosion, pollution, and runoff during the shutdown.

P. Nothing in this section shall relieve Contractor from complying with other Contract requirements.

1.04 SUBMITTALS

A. Informational Submittals:

1. When a TESC Plan is included in the Drawings, either adopt or modify the TESC Plan. Provide a schedule for TESC Plan implementation and incorporate it into Contractor's progress schedule. Obtain Engineer's approval of the TESC Plan and schedule before any Work begins.

2. Modified TESC Plans shall meet all requirements of the applicable jurisdictions.
3. The TESC Plan shall cover all areas that may be affected inside and outside the limits of the Project (including all Owner-provided sources, disposal sites, and haul roads, and all nearby land, streams, and other bodies of water).
4. Allow at least 5 working days for Engineer to review any original or revised TESC Plan. Failure to approve all or part of any such Plan shall not make Owner liable to Contractor for any Work delays.

PART 2 PRODUCTS

2.01 CHECK DAMS

A. Specified by Contractor with approval of Engineer.

2.02 COIR LOG

A. Logs made of 100 percent durable coconut (coir) fiber uniformly compacted within woven netting.

B. Netting: Made of bristle coir twine with minimum strength of 80 pounds tensile strength. Nominal 2-inch by 2-inch openings.

C. Log Segments: Maximum length of 20 feet, with a minimum diameter as shown on the Drawings.

D. Log Minimum Density: 7 lbs/cf.

E. Stakes: Untreated softwood species with a notch to secure rope ties.

F. Rope Ties: 1/4-inch diameter commercially available hemp rope.

2.03 COMPOST BLANKET

A. Composed of products resulting from the biological degradation and transformation of plant-derived materials under controlled conditions designed to promote aerobic decomposition and:

1. Stable in oxygen consumption and carbon dioxide generation.
2. Mature and suitable for serving as a soil amendment or an erosion control BMP.
3. Appropriate in Moisture Content: No visible free water or dust produced when handling material.
4. Test compost products in accordance with U.S. Composting Council Testing Methods for the Examination of Compost and Composting

(TMECC) 02.02-B, “Sample Sieving for Aggregate Size Classification.”

B. Meet the following criteria for Coarse Compost:

1. Gradation:

Sieve Size	Percent Passing	
	Minimum	Maximum
3"	100	
1"	90	100
3/4"	70	100
1/4"	40	60
Maximum particle length of 6 inches.		

2. pH: Between 6.0 and 8.5 when tested in accordance with U.S. Composting Council TMECC 04.11-A, “1:5 Slurry pH”.
3. Manufactured Inert Material (Plastic, Concrete, Ceramics, Metal, etc.): Less than 1.0 percent by weight per U.S. Composting Council TMECC 03.08-A “Classification of Inerts by Sieve Size”.
4. Minimum Organic Matter: 40 percent by dry weight basis as determined by U.S. Composting Council TMECC 05.07A “Loss-On-Ignition Organic Matter Method (LOI)”.
5. Soluble salt content: less than 4.0 mmhos/cm when tested in accordance with U.S. Composting Council TMECC 04.10 “Electrical Conductivity”.
6. Maturity: Greater than 80 percent in accordance with U.S. Composting Council TMECC 05.05-A, “Germination and Root Elongation”.
7. Stability: 7 mg CO2–C/g OM/day or below in accordance with U.S. Composting Council TMECC 05.08-B “Carbon Dioxide Evolution Rate”.
8. The compost product must originate a minimum of 65 percent by volume from recycled plant waste. A maximum of 35 percent by volume of feedstocks, source-separated food waste, and/or biosolids may be substituted for recycled plant waste. Provide a list of feedstock sources by percentage in final compost product.
9. Engineer may evaluate compost for maturity using U.S. Composting Council TMECC 05.08-E “Solvita® Maturity Index”. Coarse Compost shall score a 5 or above on the Solvita® Compost Maturity Test.

2.04 COMPOST SOCK

A. Provide socks fabricated from of extra heavy weight biodegradable fabric, with a minimum strand thickness of 5 mils.

B. Fill fabric with Coarse Compost.

C. Diameter: 8 inches minimum.

D. Fabric: Clean, evenly woven, and free of encrusted concrete or other contaminating materials. Shall be free from cuts, tears, broken or missing yarns. Shall be free of thin, open, or weak areas. Shall be free of any type of preservative.

E. Wood Stakes: Untreated softwood species, be 2-inch by 2-inch nominal dimension and 36 inches in length.

2.05 EROSION CONTROL BLANKET (MATTING), BIODEGRADABLE

A. Temporary erosion control blanket shall be made of natural plant fibers. Supply independent test results meeting the following:

Properties	ASTM Test Method	Requirements
Protecting Slopes from Rainfall-Induced Erosion	D6459: Test in one soil type. Soil tested shall be sandy loam as defined by the NRCS Soil Texture Triangle.	Maximum C factor of 0.15 using Revised Universal Soil Loss Equation (RUSLE)
Dry Weight per Unit Area	D6475	0.36 lb/sq. yd. minimum
Performance in Protecting Earthen Channels from Stormwater-Induced Erosion	D6460: Test in one soil type. Soil tested shall be loam as defined by the NRCS Soil Texture Triangle.	1.0 lb/sq. ft. minimum
Seed Germination Enhancement	D7322	200 percent minimum
Netting, if present, shall be biodegradable with a life span not to exceed 1 year.		

B. For permanent erosion control blanket, see Section 31 32 00, Soil Stabilization.

2.06 FILTRATION SYSTEM

A. Sand: The sand filtration system shall be rapid or slow. Rapid sand filters achieve relatively high hydraulic flow rates, on the order of 2 gpm/sf to 20 gpm/sf, because they have automatic backwash systems to remove

accumulated solids. Slow sand filters have very low hydraulic rates, on the order of 0.02 gpm/sf, because they do not have backwash systems.

B. Chemical: The chemical treatment system shall consist of a stormwater collection system (either temporary diversion or the permanent site drainage system), a storage pond (or portable trailer-mounted tanks), pumps, a chemical feed system, treatment cells, and interconnecting piping.

2.07 GEOTEXTILE

A. Geotextiles shall consist only of long chain polymeric fibers or yarns formed into a stable network such that the fibers or yarns retain their position relative to each other during handling, placement, and design service life. At least 95 percent by weight of the material shall be polyolefins or polyesters. The material shall be free from defects or tears. Geotextile shall also be free of any treatment or coating which might adversely alter its hydraulic or physical properties after installation. Geotextile properties shall be as specified in Section 31 32 19.16, Geotextile, or as described in Table 1 through Table 3.

Table 1
Geotextile for Permanent Erosion Control

Geotextile Property	ASTM Test Method	Geotextile Property Requirements					
		Permanent Erosion Control				Ditch Lining	
		Moderate Survivability		High Survivability			
		Woven	Nonwoven	Woven	Nonwoven	Woven	Nonwoven
AOS	D4751	See Table 2		See Table 2		U.S. No. 30 max.	
Water Permittivity	D4491	See Table 2		See Table 2		0.02 sec^{-1} min.	
Grab Tensile Strength, in machine and x-machine direction	D4632/ D4632M	250 lb min.	160 1b min.	315 lb min.	200 lb min.	250 lb min.	160 lb min.
Grab Failure Strain, in machine and x-machine direction	D4632/ D4632M	15% -50%	≥50%	15% -50%	≥50%	<50%	≥50%
Seam Breaking Strength	D4632/ D4632M	220 lb min.	140 lb min.	270 lb min.	180 lb min.	220 lb min.	140 lb min.
Puncture Resistance	D6241	495 lb min.	310 lb min.	620 lb min.	430 lb min.	495 lb min.	310 lb min.
Tear Strength, in machine and x-machine direction	D4533	80 lb min.	50 lb min.	112 lb min.	79 lb min.	80 lb min.	50 lb min.

Table 1 Geotextile for Permanent Erosion Control							
Geotextile Property	ASTM Test Method	Geotextile Property Requirements					
		Permanent Erosion Control				Ditch Lining	
		Moderate Survivability		High Survivability			
		Woven	Nonwoven	Woven	Nonwoven	Woven	Nonwoven
Ultraviolet (UV) Radiation Stability	D4355	70% strength retained min., after 500 hours in xenon arc device					

Table 2 Filtration Properties for Geotextile for Permanent Erosion Control				
Geotextile Property	ASTM Test Method	Geotextile Property Requirements		
		Class A	Class B	Class C
AOS	D4751	U.S. No. 40 max.	U.S. No. 60 max.	U.S. No. 70 max.
Water Permittivity	D4491	0.7 sec^{-1} min.	0.4 sec^{-1} min.	0.2 sec^{-1} min.

Table 3 Geotextile for Temporary Silt Fence			
Geotextile Property	ASTM Test Method	Geotextile Property Requirements	
		Unsupported Between Posts	Supported Between Posts with Wire or Polymeric Mesh
AOS	D4751	U.S. No. 30 max. for silt wovens, U.S. No. 50 for all other geotextile types, U.S. No. 100 min.	
Water Permittivity	D4491	0.2 sec^{-1} min.	
Grab Tensile Strength, in machine and x-machine direction	D4632/ D4632M	180 lb min. in machine direction, 100 lb min. in x-machine direction	100 lb min.
Grab Failure Strain, in machine and x-machine direction	D4632/ D4632M	30% max. at 180 lb or more	
Ultraviolet (UV) Radiation Stability	D4355	70% strength retained min., after 500 hours in xenon arc device	

2.08 GRAVEL FILTER, WOOD CHIP OR COMPOST BERM

A. Rock Material Used for Filter Berms: Clean 3/4-inch rock, with no recycled materials.

B. Wood Chips Used for Wood Chip Berm: As specified in Article Wood Chips and Wood Shavings.

C. Compost Used for Compost Berms: Coarse compost as specified in Article Compost Blanket.

2.09 HIGH VISIBILITY FENCING

A. High Visibility Fence: UV stabilized, orange, high-density polyethylene or polypropylene mesh.

B. Height: 4 feet minimum.

C. Support Posts: Wood or steel with sufficient strength and durability to support the fence through the life of the Project.

2.10 INLET PROTECTION

A. As specified under Article Geotextile.

2.11 MULCH

A. Short-Term: Provide independent test results documenting that the mulch meets the requirements in Table 4, Short-Term Mulch Test Requirements.

Table 4
Short-Term Mulch Test Requirements

Properties	Test Method	Requirements
Performance in Protecting Slopes from Rainfall-Induced Erosion.	ASTM D6459. Test in one soil type. Soil tested shall be sandy loam as defined by the National Resources Conservation Service (NRCS) Soil Texture Triangle.	C Factor = 0.15 maximum using Revised Universal Soil Loss Equation (RUSLE)

B. Moderate-Term: Within 48 hours of application, the Moderate-Term Mulch shall bond with soil surface to create a continuous, absorbent, flexible, erosion-resistant blanket that allows for seed germination and plant growth and conforms to the requirements in Table 5, Moderate-Term Mulch Test Requirements. Provide test results documenting that the mulch meets the requirements in Table 5, Moderate-Term Mulch Test Requirements. Supply independent test results.

Table 5 Moderate-Term Mulch Test Requirements		
Properties	**Test Method**	**Requirements**
Performance in Protecting Slopes from Rainfall-Induced Erosion.	ASTM D6459. Test in one soil type. Soil tested shall be sandy loam as defined by the NRCS Soil Texture Triangle.	C Factor = 0.05 maximum using Revised Universal Soil Loss Equation (RUSLE)

C. Long-Term:

1. Provide Long-Term Mulch with demonstrated ability:
   a. To adhere to soil and create a blanket-like mass within 2 hours of application.
   b. To bond with the soil surface to create a continuous, porous, absorbent, and flexible erosion-resistant blanket that allows for seed germination and plant growth.
   c. To conform to the requirements in Table 6, Long-Term Mulch Test Requirements.
   d. Provide test results documenting that mulch meets requirements in Table 6, Long-Term Mulch Test Requirements. Supply independent test results.

Table 6 Long-Term Mulch Test Requirements		
Properties	**Test Method**	**Requirements**
Performance in Protecting Slopes from Rainfall-Induced Erosion.	ASTM D6459. Test in one soil type. Soil tested shall be sandy loam as defined by the NRCS Soil Texture Triangle.	C Factor = 0.01 maximum using Revised Universal Soil Loss Equation (RUSLE)

2.12 OUTLET PROTECTION

A. Size riprap or quarry spall to resist movement under design flows. Install at least 8 inches deep. Provide riprap or quarry spall material free of extraneous material.

2.13 PLASTIC COVERING

A. Clear plastic meeting requirements of ASTM D4397 for polyethylene sheeting having a minimum thickness of 6 mils.

2.14 POLYACRYLAMIDE (PAM)

A. Meet ANSI/NSF Standard 60 for drinking water treatment with an AMD content not to exceed 0.05 percent.

B. Anionic, linear, and not cross-linked.

C. Minimum average molecular weight greater than 5 mg/mole and minimum 30 percent charge density.

D. 80 percent active ingredients minimum with moisture content not exceeding 10 percent by weight.

E. Delivered in a dry granular or powder form.

2.15 SEDIMENT CONTROL BARRIERS

A. Specified by Contractor with approval of Engineer. May include Compost Filter Sock or Compost Filter Berm.

2.16 SEEDING

A. See Section 32 92 00, Turf and Grasses.

2.17 SILT (SEDIMENT) FENCE

A. Per 2002 Connecticut Guidelines on Erosion and Sediment Control Section 5-11.

2.18 STABILIZED CONSTRUCTION ENTRANCE

A. Construct a pad from stone 3 inches to 6 inches in size, placed at least 8 inches deep and not less than 50 feet long.

B. Provide aggregate free of extraneous materials that may cause or contribute to track out.

C. Place separation geotextile under the rock to prevent fine sediment from pumping up into the rock pad. See Article Geotextile for required geotextile properties.

D. Use of constructed or constructed/manufactured steel plates with ribs (such as, shaker/rumble plates or corrugated steel plates) for entrance/exit access is allowable.

2.19 STRAW

A. Straw:

1. Air dried condition free of noxious weeds, seeds, and other materials detrimental to plant life. Hay is not acceptable. Provide weed-free documentation:
   a. Certified Weed Free Straw using North American Weed Management Association (NAWMA) standards.
   b. Provide documentation that material is steam or heat treated to kill seeds.
   c. Provide U.S. or state's Department of Agriculture laboratory test reports, dated within 90 days prior to date of application, showing there are no viable seeds in the straw.

B. Straw Mulch: Suitable for spreading with mulch blower equipment.

C. Posts for Straw Bales: 2-inch by 2-inch untreated wood or commercially manufactured metal posts.

2.20 STREET CLEANING

A. Use self-propelled pickup street sweeper(s). Mechanical broom sweepers are not allowed where environmental concerns exist about storm water pollution or air quality.

2.21 TACKIFIERS

A. Biodegradable Hydraulically Applied Erosion Control Products (HECPs) in a dry condition, free of noxious weeds, seeds, chemical printing ink, germination inhibitors, herbicide residue, chlorine bleach, rock, metal, plastic, and other materials detrimental to plant life. Up to 5 percent by weight may be photodegradable material.

B. Suitable for spreading with a hydroseeder.

C. Furnish HECPs premixed by the manufacturer. Under no circumstances will field mixing of additives or components be acceptable.

D. Provide test results, dated within 3 years prior to the date of application, from an independent, accredited laboratory, as approved by Engineer, showing that the product meets the HECP requirements in Table 7.

Table 7 HECP Requirements		
Properties	**Test Method**	**Requirements**
Acute Toxicity	EPA-821-R-02-012 Methods for Measuring Acute Toxicity of Effluents. Test leachate from recommended application rate receiving 2 inches of rainfall per hour using static test for No-Observed-Adverse-Effect-Concentration (NOEC).	Four replicates are required with no statistically significant reduction in survival in 100 percent leachate for a Daphnid at 48 hours and Oncorhynchus mykiss (rainbow trout) at 96 hours.
Solvents	EPA 8260B	Benzene: < 0.03 mg/kg Methylene chloride: < 0.02 mg/kg Naphthalene: < 5 mg/kg Tetrachloreoethylene: < 0.05 mg/kg Toluene: < 7 mg/kg Trichloroethylene: < 0.03 mg/kg Xylenes: < 9 mg/kg
Heavy Metals	EPA 6020A Total Metals	Antimony: < 4 mg/kg Arsenic: < 6 mg/kg Barium: < 80 mg/kg Boron: < 100 mg/kg Cadmium: < 2 mg/kg Chromium: < 2 mg/kg Copper: < 5 mg/kg Lead: < 5 mg/kg Mercury: < 2 mg/kg Nickel: < 2 mg/kg Selenium: < 10 mg/kg Strontium: < 30 mg/kg Zinc: < 5 mg/kg
Water Holding Capacity	ASTM D7367	900 percent minimum
Organic Matter Content	ASTM D2974	90 percent minimum
Moisture Content	ASTM D2974	15 percent

Table 7 HECP Requirements		
Properties	**Test Method**	**Requirements**
Seed Germination Enhancement	ASTM D7322	Long-Term: 420 percent minimum Moderate-Term: 400 percent minimum Short-Term: 200 percent minimum

2.22 TEMPORARY CURB

A. Temporary curbs may consist of asphalt, concrete, sand bags, compost socks, wattles, or geotextile/plastic encased berms of sand or gravel, or as approved by Engineer.

2.23 TEMPORARY PIPE SLOPE DRAIN

A. Corrugated polyethylene drain pipe, couplings and fittings (up to 10-inch) meeting the requirements of AASHTO M252 Type C (corrugated both inside and outside) or Type S (corrugated outer wall and smooth inner liner).

1. Maximum Pipe Size: 10 inches in diameter.

2.24 TEMPORARY SEDIMENT TRAP

A. Temporary ponding area with a rock weir or perforated riser pipe at the outlet, formed by excavation or constructing a weir. Specified by Contractor with approval of Engineer.

2.25 TIRE WASH FACILITY

A. Specified by Contractor with approval of Engineer. Wheel wash facilities should have a non-erosive base, and a small grade change, 6 inches to 12 inches for a 10-foot-wide pond, to allow sediment to flow to low side of pond to help prevent re-suspension of sediment. A drainpipe with a 2-foot to 3-foot riser should be installed at low side of pond to allow for cleaning and refilling. Pond should be deep enough to hold 14 inches of water after displacement. Alternatively, pressure washing combined with an adequately-sized and adequately-surfaced pad with direct drainage to a 10-foot by 10-foot sump can be very effective.

2.26 WATTLES

A. Cylinders of biodegradable plant material such as weed-free straw, coir, compost, wood chips, excelsior, or wood fiber or shavings encased within biodegradable netting.

B. Diameter: 5 inches minimum.

C. Netting Material: Clean, evenly woven, and free of encrusted concrete or other contaminating materials such as preservatives. Also free from cuts, tears, or weak places with a minimum lifespan of 6 months.

D. Compost Filler: Coarse compost, wood chips, or wood shavings.

E. Wood Stakes: Untreated softwood species, 2-inch by 2-inch nominal dimension and 36 inches in length.

2.27 WOOD CHIPS AND WOOD SHAVINGS

A. Wood Chips: Derived from softwood species not containing resin, tannin, or other compounds in quantities that would be detrimental to plant life, and meeting the following loose volume gradation:

1. 2-inch Sieve Size: 95 percent to 100 percent passing.
2. No. 4 Sieve Size: 0 percent to 30 percent passing.

B. Wood Shavings: Provide shavings with 80 percent of the fibers 6 inches or longer between 0.030 inch wide and 0.50 inch wide, and between 0.017 inch thick and 0.13 inch thick.

PART 3 EXECUTION

3.01 PREPARATION

A. Engineer's acceptance of the TESC Plan is required prior to starting earth disturbing activities.

B. Include proposed stockpile areas and installation of temporary erosion control devices, ditches, or other facilities in Work phasing plans.

C. Areas designated for Contractor's use during Project may be temporarily developed as specified to provide working, staging, and administrative areas. Include control of sediment from these areas in the TESC Plan.

D. Check Dams: Install check dams as soon as construction will allow, or when designated by Engineer. Contractor may substitute a different check dam, in lieu of what is specified in the Contract, with approval of Engineer. Check dam is a temporary or permanent structure, built across a minor channel.

Water shall not flow through check dam structure. Construct check dams to create a ponding area upstream of dam to allow pollutants to settle, with water from increased flows channeled over a spillway in check dam. Construct check dam to prevent erosion in area below spillway. Place check dams perpendicular to flow of water and install in accordance with the Drawings. Extend outer edges up sides of conveyance to prevent water from going around check dam. Provide check dams of sufficient height to maximize detention, without causing water to leave ditch. Place sandbags so that initial row makes tight contact with ditch line for length of dam. Stagger subsequent rows so center of bag is placed over space between bags on previous lift.

E. Coir Log: Install coir logs in accordance with the Drawings.

F. Compost Blanket: Place compost blanket to a depth of 3 inches over bare soil prior to seeding or other planting. Place an organic tackifier over entire composted area when dry or windy conditions are present or expected before final application of mulch or erosion control blanket. Apply tackifier immediately after compost application to prevent compost from leaving area.

G. Compost Sock: Exercise care when installing compost socks to ensure method of installation minimizes disturbance of waterways and prevents sediment or pollutant discharge into waterbodies. Lace compost socks together, end-to-end, with coir rope to create a continuous length. Bury loose ends of continuous length 3 feet to 5 feet laterally into the bankslope. Install the upper surface of compost sock parallel to slope. Provide finished grades of a natural appearance with smooth transitions. Secure compost sock with wood stakes or live stakes of species as indicated on the Drawings. Drive stakes into place centered on top of compost sock and spaced 3 feet on center throughout length of sock.

H. Erosion Control Blanket (Matting), Biodegradable: Temporary Erosion Control Blankets are used as an erosion prevention device and to enhance establishment of vegetation. Install erosion control blankets according to manufacturer's recommendations.

1. Erosion control blankets with an open area of 60 percent or greater may be installed prior to seeding and fertilizing. Install blankets with less than 60 percent open space immediately following seeding and fertilizing operation.
2. Select erosion control blanket material for an area based on the intended function; slope or ditch stabilization and Site-specific factors including soil, slope gradient, rainfall, and flow exposure. Do not use erosion Control Blankets on slopes or in ditches that exceed manufacturer's recommendations.
3. For permanent erosion control blanket, see Section 31 32 00, Soil Stabilization.

I. Filtration System:

1. Sand: Rapid sand filtration systems shall have stormwater pumped from a trap, pond, or tank through filtration system. Slow sand filtration systems shall have flow through using gravity. Sand media filter shall have automatic backwashing features that can filter to 50 μm particle size. Screen or bag filters shall filter down to 5 μm. Fiber wound filters shall remove particles down to 0.5 μm. Sequence filters from the largest to the smallest pore opening. Filtration may be used in conjunction with polymer treatment in a portable system to assure capture of the flocculated solids.
2. Chemical: Prior to discharge, sample each batch of treated and test for compliance with pH and turbidity limits, which may be established by water quality standards or a Site-specific discharge permit. Sampling and testing for other pollutants may be necessary. Obtain regulatory approval and provide a qualified, trained operator, if required by law.

J. Gravel Filter, Wood Chip, or Compost Berm: Construct filter berms to retain sediment and direct flows.

1. Gravel Filter Berm: 1-foot minimum height. Maintain at this height for entire time berm is in use.
2. Wood Chip Berm: 2-foot minimum height. Maintain at this height for entire time berm is in use.
3. Construct compost berm of course compost in accordance with the detail on the Drawings.

K. High Visibility Fencing: Install high visibility fencing in accordance with the Drawings.

L. Inlet Protection: Install inlet protection below or above, or as a prefabricated cover at each inlet grate, as shown on the Drawings. Install inlet protection devices prior to beginning clearing, grubbing or earthwork activities. Geotextile fabric used in prefabricated inlet protection devices must meet or exceed the requirements for Moderate Survivability and minimum filtration properties. When depth of accumulated sediment and debris reaches approximately one-half the height of an internal device or one-third the height of external device (or less when so specified by the manufacturers) or as designated by Engineer, remove deposits and stabilize onsite.

1. Below Inlet Grate:
    a. Prefabricated units specifically designed for inlet protection.
    b. Must remain securely attached to drainage structure when fully loaded with sediment and debris or at the maximum level of sediment and debris specified by manufacturer.

2. Above Inlet Grate:
    a. Devices may be silt fence, sandbags, or prefabricated units specifically designed for inlet protection.
    b. Must remain securely in place around drainage structure under all conditions.
3. Inlet Grate Cover:
    a. Prefabricated units specifically designed for inlet protection and:
        1) Be a sewn geotextile fabric unit fitted to individual grate and completely enclosing grate.
        2) Have built-in lifting devices to allow manual access of stormwater system.
        3) Use an orange monofilament geotextile fabric.
    b. Check dams or functionally equivalent devices may be used as inlet protection devices with approval of Engineer.

M. Mulch: Furnish, haul, and evenly apply at rates indicated and spread on seeded areas within 48 hours after seeding unless otherwise specified.

1. Distribute straw mulch material with an approved mulch spreader that uses forced air to blow mulch material on seeded areas.
2. Apply wood strand mulch by hand or by straw blower on seeded areas.
3. Hydraulically apply Short-Term Mulch at the rate of 2,500 pounds per acre. May be applied in one lift.
4. Hydraulically apply Moderate-Term Mulch and Long-Term Mulch at the rate of 3,500 pounds per acre with no more than 2,000 pounds applied in any single lift. Mulch may be applied with seed and fertilizer in moist climates. In dry climates, apply seed and fertilizer in a single application followed by mulch application. Provide mulch suitable for application with a hydroseeder.
5. Cover temporary seed applied outside application windows established in Section 32 92 00, Turf and Grasses, with a mulch containing either Moderate-Term Mulch or Long-Term Mulch, as designated by Engineer.
6. Mulch areas not accessible by mulching equipment by approved hand methods.

N. Outlet Protection: Provide outlet protection to prevent scour at outlets of ponds, pipes, ditches, or other conveyances.

O. Plastic Covering: Use clear plastic covering to promote seed germination when seeding is performed outside of specified dates. Use black plastic covering for stockpiles or other areas where vegetative growth is unwanted. Place plastic with at least a 12-inch overlap of all seams. Install and maintain plastic cover tolon prevent water from cutting under the plastic and to prevent cover from blowing open in the wind.

P. Polyacrylamide (PAM): See Tackifiers.

Q. Sediment Control Barriers: Install sediment control barriers in accordance with TESC Plan or manufacturer's recommendations in the areas of clearing, grubbing, earthwork, or drainage prior to starting those activities. Maintain sediment control barriers until soils are stabilized.

R. Seeding: See Section 32 92 00, Turf and Grasses.

S. Silt (Sediment) Fence:

1. Silt fence shall be installed in accordance with the Drawings. When backup support is used, use steel wire with a maximum mesh spacing of 2 inches by 4 inches, or plastic mesh as resistant to ultraviolet radiation as the geotextile it supports. Provide wire or plastic mesh with strength equivalent to or greater than as required for unsupported geotextile (for example, 180 pounds grab tensile strength in the machine direction).
2. Attach geotextile to posts and support system using staples, wire, or in accordance with manufacturer's recommendations. Geotextile shall be sewn together at the point of manufacture, or at a location approved by Engineer, to form geotextile lengths as required.
3. Provide wood or steel support posts at sewn seams and overlaps and as shown on the Drawings and necessary to support fence.
4. Wood Posts: Minimum dimensions of 1-1/4-inch by 1-1/4-inch by the minimum length shown on the Drawings.
5. Steel Posts: Minimum weight of 0.90 lb/ft.
6. When sediment deposits reach approximately one-third the height of the silt fence, remove and stabilize deposits.

T. Stabilized Construction Entrance: Construct temporary stabilized construction entrance in accordance with the Drawings, prior to beginning any clearing, grubbing, earthwork, or excavation. When stabilized entrance no longer prevents track out of sediment or debris, either rehabilitate existing entrance to original condition or construct a new entrance.

U. Street Cleaning: Use self-propelled pickup street sweepers whenever required by Engineer to prevent transport of sediment and other debris off Project Site. Provide street sweepers designed and operated to meet air quality standards. Street washing with water will require approval by Engineer. Intentional washing of sediment into storm sewers or drainage ways must not occur. Vacuuming or dry sweeping and material pickup must be used to cleanup released sediments.

V. Tackifiers:

1. Mix and apply tackifier in accordance with manufacturer's recommendations. If applied with a hydroseeder, add Short-Term Mulch

as a tracer at a rate of 125 pounds to 250 pounds per acre to visibly aid uniform application.

2. Soil Binding Using Polyacrylamide (PAM): Apply PAM on bare soil completely dissolved and mixed in water or applied as a dry powder. Apply dissolved PAM at a rate of not more than 2/3 pound per 1,000 gallons of water per acre. Apply a minimum of 200 pounds per acre of Short-Term Mulch with the dissolved PAM. Dry powder applications may be at a rate of 5 pounds per acre using a hand-held fertilizer spreader or a tractor-mounted spreader.
    a. Apply PAM only to areas that drain to completed sedimentation control BMPs in accordance with the TESC Plan. PAM may be reapplied on actively worked areas after a 48-hour period.
    b. PAM shall not be applied during rainfall or to saturated soils.

W. Temporary Curb: Provide temporary curbs to divert or redirect water around erodible soils. Temporary curbs shall be installed along pavement edges to prevent runoff from flowing onto erodible slopes. Water shall be directed to areas where erosion can be controlled. Temporary curbs shall be a minimum of 4 inches in height. Ponding shall not be in roadways.

X. Temporary Pipe Slope Drain: Corrugated polyethylene drain pipe constructed in accordance with the Drawings. Use water interceptor dikes or temporary curbs to direct water into pipe slope drain. Entrance to drain may consist of a prefabricated funnel device specifically designed for application, rock, sand bags, or as approved by Engineer. Construct pipe with gasketed watertight fittings and secure to slope with metal "T" posts, wood stakes, sand bags, or as approved by Engineer. Discharge water to a stabilized conveyance, sediment trap, stormwater pond, rock splash pad, vegetated strip, or as approved by Engineer. Install pipe so that water does not pond on road surface.

Y. Temporary Sediment Trap: Form trap by constructing a berm or by partial or complete excavation. Direct the discharge flow to a stabilized conveyance outlet or level spreader.

Z. Tire Wash Facility: When the Contract requires a tire wash (in conjunction with a stabilized entrance), include details for tire wash and method for containing and treating sediment-laden runoff as part of the TESC Plan. All vehicles leaving the Site shall stop and wash sediment from their tires. Keep the water level 12 inches to 14 inches deep. Change wash water a minimum of once per day. Polymers may be used to promote coagulation and flocculation in a closed-loop system. Polyacrylamide (PAM) added to the wheel wash water at a rate of 0.25 pound to 0.5 pound per 1,000 gallons of water increases effectiveness and reduces cleanup time.

AA. Wattles: Install wattles as soon as construction will allow or when designated by Engineer. Begin trench construction and wattle installation at base of slope and work uphill. Spread excavated material evenly along the uphill slope and compact using hand tamping or other method approved by Engineer. On gradually sloped or clay-type soils, provide trenches 2 inches to 3 inches deep. On loose soils, in high rainfall areas, or on steep slopes, provide trenches 3 inches to 5 inches deep, or half the thickness of the wattle. Exercise care when installing wattles to minimize disturbance of waterways and prevent sediment or pollutant discharge into waterbodies.

BB. Wood Chips and Wood Shavings: Install in accordance with the Drawings.

3.02 ADDITIONAL REQUIREMENTS

A. Natural Buffer or Equivalent:

1. Unless natural buffer between the Project Site and receiving waters has previously been eliminated by pre-existing development disturbances, comply with one of the following alternatives if stormwater from construction will discharge to surface water:
   a. Provide a 50-foot, undisturbed natural buffer between construction disturbances and surface water.
   b. Provide an undisturbed natural buffer that is less than 50 feet supplemented by additional erosion and sediment controls, which in combination, achieve a sediment load reduction that is equivalent to a 50-foot buffer.
   c. If it is infeasible to provide an undisturbed natural buffer of any size, implement erosion and sediment controls that achieve a sediment load reduction that is equivalent to a 50-foot buffer.

3.03 MAINTENANCE

A. The ESCP measures described in this specification are minimum requirements for anticipated Site conditions. During the construction period, upgrade these measures as needed to comply with all applicable local, state, and federal erosion and sediment control regulations.

B. Maintain erosion and sediment control BMPs so they properly perform their function until Engineer determines they are no longer needed.

C. Construction activities must avoid or minimize excavation and creation of bare ground during wet weather.

D. The intentional washing of sediment into storm sewers or drainage ways must not occur. Vacuuming or dry sweeping and material pickup must be used to cleanup released sediments.

E. Inspect BMPs in accordance with the schedule in the Construction Stormwater Discharge Permit(s) or as directed by Engineer.

F. Complete an inspection report within 24 hours of an inspection. Each inspection report shall be signed and identify corrective actions. Document that corrective actions are performed within 7 days of identification. Keep a copy of all inspection reports at the Site or at an easily accessible location.

G. Unless otherwise specified, remove deposits before the depth of accumulated sediment and debris reaches approximately height of BMP. Dispose of debris or contaminated sediment at approved locations. Clean sediments may be stabilized onsite using BMPs as approved by Engineer.

H. Sediment Fence: Remove trapped sediment before it reaches one-third of the above ground fence height and before fence removal.

I. Other Sediment Barriers (such as biobags): Remove sediment before it reaches 2 inches depth above ground height and before BMP removal.

J. Catch Basins: Clean before retention capacity has been reduced by 50 percent.

K. Sediment Basins and Sediment Traps: Remove trapped sediments before design capacity has been reduced by 50 percent and at completion of Project.

L. Initiate repair or replacement of damaged erosion and sediment control BMPs immediately, and work completed by end of next work day. Significant replacement or repair must be completed within 7 days, unless infeasible.

M. Within 24 hours, remediate any significant sediment that has left construction site. Investigate cause of the sediment release and implement steps to prevent a recurrence of discharge within same 24 hours. Perform in-stream cleanup of sediment according to applicable regulations.

N. At end of each work day, stabilize or cover soil stockpiles or implement other BMPs to prevent discharges to surface waters or conveyance systems leading to surface waters.

O. Temporarily stabilize soils at end of shift before holidays and weekends, if needed. Ensure soils are stable during rain events at all times of year.

P. Initiate stabilization by no later than end of next work day after construction work in an area has stopped permanently or temporarily.

Q. Within 14 days of initiating stabilization or as specified in permit, either seed or plant stabilized area (see Section 32 92 00, Turf and Grasses); or apply non-vegetative measures and cover all areas of exposed soil. Seed dry areas as soon as Site conditions allow. Ensure that vegetation covers at least 70 percent

of stabilized area. In areas where Contractor's activities have compromised erosion control functions of existing grasses, overseed existing grass. Non-vegetative measures may include blown straw and a tackifier, loose straw, or an adequate covering of compost mulch. Complete initial stabilization within 7 days if storm water discharges to surface waters impaired for sediment or nutrients, or high quality waters.

R. Provide permanent erosion control measures on all exposed areas. Do not remove temporary sediment control practices until permanent vegetation or other cover of exposed areas is established. However, do remove all temporary erosion control measures as exposed areas become stabilized, unless doing so conflicts with local requirements. Properly dispose of construction materials and waste, including sediment retained by temporary BMPs.

3.04 EMERGENCY MATERIALS

A. Provide, stockpile, and protect the following emergency erosion and sediment control materials on the Project Site for unknown weather or erosion conditions. Emergency materials are in addition to other erosion control materials required to implement and maintain the TESC Plan. Replenish emergency materials as they are used. Remove all unused emergency materials from the Project Site at completion of the Project.

Item	Quantity
Silt (sediment) fence	100 ft
Plastic sheeting	260 sq. ft.
Rope	1,000 ft
Sand bags (empty, to be filled as needed)	50
Straw bales	10
Biofilter bags (with stakes)	10
Inflatable pipe plugs	One for each size of pipe
Water pump and hose	One

3.05 REMOVAL

A. When Engineer determines that an erosion control BMP is no longer required, remove BMP and all associated hardware from the Project limits. When materials are biodegradable, Engineer may approve leaving temporary BMP in place.

B. Permanently stabilize all bare and disturbed soil after removal of erosion and sediment control BMPs. Dress sediment deposits remaining after BMPs have been removed to conform to existing grade. Prepare and seed graded area. If installation and use of erosion control BMPs have compacted or otherwise rendered soil inhospitable to plant growth, such as construction entrances, take measures to rehabilitate soil to facilitate plant growth. This may include, but is not limited to, ripping the soil, incorporating soil amendments, or seeding with specified seed.

3.06 MEASUREMENT AND PAYMENT

A. Check Dams will be measured per linear foot one time only along the completed check dam. Unit Contract Price per linear foot for Check Dam shall be full pay for all equipment, labor, and materials to perform the Work as specified, including installation, removal, and disposal at an approved disposal site. No additional measurement will be made for check dams required to be rehabilitated or replaced as a result of wear.

B. Coir Log will be measured by linear foot along ground line of completed installation. Unit Contract Price per linear foot for Coir Log shall be full pay for all equipment, labor, and materials to perform the Work as specified, including installation, removal, and disposal at an approved disposal site.

C. Compost Blanket will be measured by square yard along the ground slope line of surface area covered and accepted.

D. Compost Sock will be measured by linear foot. Unit Contract Price for Compost Sock shall include removal and disposal of compost sock fabric if photodegradable fabric is not used.

E. Emergency Erosion and Sediment Control Materials: No additional payment will be made for stockpiling Emergency Erosion and Sediment Control Materials on Project Site.

F. Erosion Control Blanket (matting) will be measured by square yard along ground slope line of surface area covered and accepted. Unit Contract price per square yard for Erosion Control Blanket shall be full pay for all costs to complete the specified Work.

G. ESC Lead will be measured per day for each day that an inspection is made, and a report is filed.

H. Filtration System will be measured per each and shall be full pay for all costs to obtain, install, operate, and remove the system as specified.

I. Gravel Filter, Wood Chip, or Compost Berm will be measured by linear foot along ground line of completed installation. Unit Contract Price per linear foot

of berm shall be full pay for all equipment, labor, and materials to perform the Work as specified, including installation, removal, and disposal at an approved disposal site.

J. High Visibility Fence will be measured by linear foot along ground line of completed fence. Unit Contract Price per linear foot for High Visibility Fence shall be full pay for all costs to obtain, install, maintain, and remove fence as specified. Once removed, fencing shall remain property of Contractor.

K. Inlet Protection will be measured per each for each initial installation at a drainage structure. Unit Contract Price per each for Inlet Protection shall be full pay for all equipment, labor, and materials to perform the Work as specified, including installation, removal, and disposal at an approved disposal site.

L. Mulch will be measured by the acre by ground slope measurement or through use of design data.

M. Natural Buffer or Equivalent: No additional payment will be made for providing a Natural Buffer or Equivalent on the Project Site.

N. Outlet Protection will be measured per each initial installation at an outlet location. Unit Contract Price per each for Outlet Protection shall be full payment for all costs incurred to complete the Work.

O. Plastic Covering will be measured by the square yard along ground slope line of surface area covered and accepted. Unit Contract Price per square yard for Plastic Covering shall be full pay for all equipment, labor, and materials to perform the Work as specified, including removal and disposal at an approved disposal site.

P. Polyacrylamide (PAM). See Tackifiers.

Q. Sediment Control Barrier will be measured by linear foot along ground line of completed barrier.

R. Seeding: See Section 32 92 00, Turf and Grasses.

S. Silt (Sediment) Fence will be measured by linear foot along ground line of completed installation.

T. Stabilized Construction Entrance will be measured by square yard for each entrance constructed.

U. Street Cleaning will be measured by the hour for actual time spent cleaning pavement, as authorized by Engineer. Time to move equipment to or from the area on which street cleaning is required, will not be measured.

V. Tackifiers (Polyacrylamide) will be measured by the acre by ground slope measurement or calculated by use of design data. Unit Contract Price per acre for Tackifier shall be full payment for all costs incurred to complete the Work.

W. Temporary Curb will be measured by the linear foot. Unit Contract Price per linear foot for Temporary Curb shall include all costs to install, maintain, remove, and dispose of temporary curb.

X. Temporary Pipe Slope Drain will be measured by the linear foot. Unit Contract Price per linear foot shall be full pay for all Work to complete and remove the installation of pipe slope drain as shown on the Drawings. All materials remain the property of Contractor after removal.

Y. Temporary Sediment Trap will be measured per each for each trap installed.

Z. Tire Wash facility will be measured per each for each wash installed. Unit Contract Price per each for tire wash shall include all costs associated with constructing, operating, maintaining, and removing the tire wash.

AA. Wattles will be measured by the linear foot.

BB. Wood Chips and Wood Shavings will be measured by the square yard along the ground slope line of surface area covered and accepted.

CC. Erosion Control will be measured and paid on a lump sum basis. Erosion Control includes:

1. Providing the ESC Lead.
2. Developing, revising, and documenting TESC Plan.
3. Mobilization.
4. Monitoring activities.
5. Furnishing, stockpiling, protecting, restocking, and removing emergency materials.
6. Preparing Project for winter shutdown.
7. Inspecting, maintaining, and removing erosion control devices.
8. Restoring, mulching, tacking, and seeding all disturbed ground, work, and storage areas not otherwise covered.

DD. No separate or additional payment will be made for:

1. Removing and disposing of sediment build-up behind sediment fences and sediment barriers.
2. Removing and reinstalling required appurtenances to modify temporary slope drains as the embankment slopes are changed.
3. Constructing and removing temporary slope berms.
4. Applying dust control.

5. Erosion control for work outside construction limits including, but not limited to, borrow pits, haul roads, disposal sites, and equipment storage sites.

EE. When only Erosion Control is listed in the Contract Schedule of Items, no separate or additional payment will be made for modifications or additions to the BMPs that become necessary for permit compliance during construction.

END OF SECTION

SECTION 01 61 00
COMMON PRODUCT REQUIREMENTS

PART 1 GENERAL

1.01 DEFINITIONS

A. Products:

1. New items for incorporation in the Work, whether purchased by Contractor or Owner for the Project, or taken from previously purchased stock, and may also include existing materials or components required for reuse.
2. Includes the terms material, equipment, machinery, components, subsystem, system, hardware, software, and terms of similar intent and is not intended to change meaning of such other terms used in Contract Documents, as those terms are self-explanatory and have well recognized meanings in construction industry.
3. Items identified by manufacturer's product name, including make or model designation, indicated in manufacturer's published product literature, that is current as of the date of the Contract Documents.

1.02 DESIGN REQUIREMENTS

A. Where Contractor design is specified, design of installation, systems, equipment, and components, including supports and anchorage, shall be in accordance with provisions of the International Building Code (IBC) indicated on the Drawings. See General Structural Notes drawings for project specific design criteria.

1.03 ENVIRONMENTAL REQUIREMENTS

A. Altitude: Provide materials and equipment suitable for installation and operation under rated conditions at sea level.

B. Provide equipment and devices installed outdoors or in unheated enclosures capable of continuous operation within an ambient temperature range of 10 degrees F to104 degrees F.

1.04 PREPARATION FOR SHIPMENT

A. When practical, factory assemble products. Mark or tag separate parts and assemblies to facilitate field assembly. Cover machined and unpainted parts that may be damaged by the elements with strippable protective coating.

B. Package products to facilitate handling and protect from damage during shipping, handling, and storage. Mark or tag outside of each package or crate

to indicate its purchase order number, bill of lading number, contents by name, name of Project and Contractor, equipment number, and approximate weight. Include complete packing list and bill of materials with each shipment.

C. Extra Materials, Special Tools, Test Equipment, and Expendables:

1. Furnish as required by individual Specifications.
2. Schedule:
    a. Ensure that shipment and delivery occurs concurrent with shipment of associated equipment.
    b. Transfer to Owner shall occur immediately subsequent to Contractor's acceptance of equipment from Supplier.
3. Packaging and Shipment:
    a. Package and ship extra materials and special tools to avoid damage during long term storage in original cartons insofar as possible, or in appropriately sized, hinged-cover, wood, plastic, or metal box.
    b. Prominently displayed on each package, the following:
        1) Manufacturer's part nomenclature and number, consistent with Operation and Maintenance Manual identification system.
        2) Applicable equipment description.
        3) Quantity of parts in package.
        4) Equipment manufacturer.
4. Deliver materials to project Site.
5. Notify Engineer upon arrival for transfer of materials.
6. Replace extra materials and special tools found to be damaged or otherwise inoperable at time of transfer to Owner.

D. Request a minimum 7-day advance notice of shipment from manufacturer. Upon receipt of manufacturer's advance notice of shipment, promptly notify Engineer of anticipated date and place of equipment arrival.

E. Factory Test Results: Reviewed and accepted by Engineer before product shipment as required in individual Specification sections.

1.05 DELIVERY AND INSPECTION

A. Deliver products in accordance with accepted current Progress Schedule and coordinate to avoid conflict with the Work and conditions at Site. Deliver anchor bolts and templates sufficiently early to permit setting prior to placement of structural concrete.

B. Deliver products in undamaged condition, in manufacturer's original container or packaging, with identifying labels intact and legible. Include on label, date of manufacture and shelf life, where applicable.

C. Unload products in accordance with manufacturer's instructions for unloading or as specified. Record receipt of products at Site. Promptly inspect for completeness and evidence of damage during shipment.

D. Remove damaged products from Site and expedite delivery of identical new undamaged products, and remedy incomplete or lost products to provide that specified, so as not to delay progress of the Work.

1.06 HANDLING, STORAGE, AND PROTECTION

A. Handle and store products in accordance with manufacturer's written instructions and in a manner to prevent damage. Store in approved storage yards or sheds provided in accordance with Section 01 50 00, Temporary Facilities and Controls. Provide manufacturer's recommended maintenance during storage, installation, and until products are accepted for use by Owner.

B. Manufacturer's instructions for material requiring special handling, storage, or protection shall be provided prior to delivery of material.

C. Arrange storage in a manner to provide easy access for inspection. Make periodic inspections of stored products to ensure that products are maintained under specified conditions, and free from damage or deterioration. Keep running account of products in storage to facilitate inspection and to estimate progress payments for products delivered, but not installed in the Work.

D. Store electrical, instrumentation, and control products, and equipment with bearings in weather-tight structures maintained above 60 degrees F. Protect electrical, instrumentation, and control products, and insulate against moisture, water, and dust damage. Connect and operate continuously space heaters furnished in electrical equipment.

E. Store fabricated products above ground on blocking or skids, and prevent soiling or staining. Store loose granular materials in well-drained area on solid surface to prevent mixing with foreign matter. Cover products that are subject to deterioration with impervious sheet coverings; provide adequate ventilation to avoid condensation.

F. Store finished products that are ready for installation in dry and well-ventilated areas. Do not subject to extreme changes in temperature or humidity.

G. After installation, provide coverings to protect products from damage due to traffic and construction operations. Remove coverings when no longer needed.

H. Hazardous Materials: Prevent contamination of personnel, storage area, and Site. Meet requirements of product specification, codes, and manufacturer's instructions.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide manufacturer's standard materials suitable for service conditions, unless otherwise specified in the individual Specifications.

B. Where product specifications include a named manufacturer, with or without model number, and also include performance requirements, named manufacturer's products must meet the performance specifications.

C. Like items of products furnished and installed in the Work shall be end products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation and maintenance, spare parts and replacement, manufacturer's services, and implement same or similar process instrumentation and control functions in same or similar manner.

D. Do not use materials and equipment removed from existing premises, except as specifically permitted by Contract Documents.

E. Provide interchangeable components of the same manufacturer, for similar components, unless otherwise specified.

F. Equipment, Components, Systems, and Subsystems: Design and manufacture with due regard for health and safety of operation, maintenance, and accessibility, durability of parts, and shall comply with applicable OSHA, state, and local health and safety regulations.

G. Regulatory Requirement: Coating materials shall meet federal, state, and local requirements limiting the emission of volatile organic compounds and for worker exposure.

H. Safety Guards: Provide for all belt or chain drives, fan blades, couplings, or other moving or rotary parts. Cover rotating part on all sides. Design for easy installation and removal. Use 16-gauge or heavier; galvanized steel, aluminum coated steel, or galvanized or aluminum coated 1/2-inch mesh expanded steel. Provide galvanized steel accessories and supports, including bolts. For outdoors application, prevent entrance of rain and dripping water.

I. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.

2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

J. Equipment Finish:

1. Provide manufacturer's standard finish and color, except where specific color is indicated.
2. If manufacturer has no standard color, provide equipment with finish as approved by Engineer.

K. Special Tools and Accessories: Furnish to Owner, upon acceptance of equipment, all accessories required to place each item of equipment in full operation. These accessory items include, but are not limited to, adequate oil and grease (as required for first lubrication of equipment after field testing), light bulbs, fuses, hydrant wrenches, valve keys, handwheels, chain operators, special tools, and other spare parts as required for maintenance.

L. Lubricant: Provide initial lubricant recommended by equipment manufacturer in sufficient quantity to fill lubricant reservoirs and to replace consumption during testing, startup, and operation until final acceptance by Owner.

M. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 FABRICATION AND MANUFACTURE

A. General:

1. Manufacture parts to U.S.A. standard sizes and gauges.
2. Two or more items of the same type shall be identical, by the same manufacturer, and interchangeable.
3. Design structural members for anticipated shock and vibratory loads.
4. Use 1/4-inch minimum thickness for steel that will be submerged, wholly or partially, during normal operation.
5. Modify standard products as necessary to meet performance Specifications.

B. Lubrication System:

1. Require no more than weekly attention during continuous operation.
2. Convenient and accessible; oil drains with bronze or stainless steel valves and fill-plugs easily accessible from the normal operating area or platform. Locate drains to allow convenient collection of oil during oil changes without removing equipment from its installed position.
3. Provide constant-level oilers or oil level indicators for oil lubrication systems.
4. For grease type bearings, which are not easily accessible, provide and install stainless steel tubing; protect and extend tubing to convenient location with suitable grease fitting.

2.03 SOURCE QUALITY CONTROL

A. Where Specifications call for factory testing to be witnessed by Engineer, notify Engineer not less than 14 days prior to scheduled test date, unless otherwise specified.

B. Calibration Instruments: Bear the seal of a reputable laboratory certifying instrument has been calibrated within the previous 12 months to a standard endorsed by the National Institute of Standards and Technology (NIST).

C. Factory Tests: Perform in accordance with accepted test procedures and document successful completion.

PART 3 EXECUTION

3.01 INSPECTION

A. Inspect materials and equipment for signs of pitting, rust decay, or other deleterious effects of storage. Do not install material or equipment showing such effects. Remove damaged material or equipment from the Site and expedite delivery of identical new material or equipment. Delays to the Work resulting from material or equipment damage that necessitates procurement of new products will be considered delays within Contractor's control.

3.02 MANUFACTURER'S CERTIFICATE OF COMPLIANCE

A. When so specified, a Manufacturer's Certificate of Compliance, a copy of which is attached to this section, shall be completed in full, signed by entity supplying the product, material, or service, and submitted prior to shipment of product or material or execution of the services.

B. Engineer may permit use of certain materials or assemblies prior to sampling and testing if accompanied by accepted certification of compliance.

C. Such form shall certify proposed product, material, or service complies with that specified. Attach supporting reference data, affidavits, and certifications as appropriate.

D. May reflect recent or previous test results on material or product, if acceptable to Engineer.

3.03 INSTALLATION

A. Equipment Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned.

B. No shimming between machined surfaces is allowed.

C. Install the Work in accordance with NECA Standard of Installation, unless otherwise specified.

D. Repaint painted surfaces that are damaged prior to equipment acceptance.

E. Do not cut or notch any structural member or building surface without specific approval of Engineer.

F. Handle, install, connect, clean, condition, and adjust products in accordance with manufacturer's instructions, and as may be specified. Retain a copy of manufacturers' instruction at Site, available for review at all times.

G. For material and equipment specifically indicated or specified to be reused in the Work:

1. Use special care in removal, handling, storage, and reinstallation to assure proper function in the completed Work.
2. Arrange for transportation, storage, and handling of products that require offsite storage, restoration, or renovation. Include costs for such Work in the Contract Price.

3.04 FIELD FINISHING

A. In accordance with Section 09 90 00, Painting and Coating, and individual Specification sections.

3.05 ADJUSTMENT AND CLEANING

A. Perform required adjustments, tests, operation checks, and other startup activities.

3.06 LUBRICANTS

A. Fill lubricant reservoirs and replace consumption during testing, startup, and operation prior to acceptance of equipment by Owner.

3.07 SUPPLEMENTS

A. The supplement listed below, following “End of Section,” is part of this specification.

1. Form: Manufacturer’s Certificate of Compliance.

END OF SECTION

MANUFACTURER'S CERTIFICATE OF COMPLIANCE

OWNER: _____

PROJECT NAME: _____

PROJECT NO: _____

PRODUCT, MATERIAL, OR SERVICE SUBMITTED: _____

Comments: _____

_____

_____

_____

_____

_____

I hereby certify that the above-referenced product, material, or service called for by the Contract for the named Project will be furnished in accordance with all applicable requirements. I further certify that the product, material, or service are of the quality specified and conform in all respects with the Contract requirements, and are in the quantity shown.

Date of Execution: _____, 20___

Manufacturer: _____

Manufacturer's Authorized Representative *(print)*: _____

_____

(Authorized Signature)

SECTION 01 77 00
CLOSEOUT PROCEDURES

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Submit prior to application for final payment.
   a. Record Documents with As-Built Survey: As required in General Conditions.
   b. Approved Shop Drawings and Samples: As required in the General Conditions.
   c. Special bonds, Special Guarantees, and Service Agreements.
   d. Consent of Surety to Final Payment: As required in General Conditions.
   e. Releases or Waivers of Liens and Claims: As required in General Conditions.
   f. Releases from Agreements.
   g. Final Application for Payment: Submit in accordance with procedures and requirements stated in Section 01 29 00, Payment Procedures.
   h. Extra Materials: As required by individual Specification sections.

1.02 RECORD DOCUMENTS

A. Quality Assurance:

1. Furnish qualified and experienced person, whose duty and responsibility shall be to maintain record documents.
2. Accuracy of Records:
   a. Coordinate changes within record documents, making legible and accurate entries on each sheet of Drawings and other documents where such entry is required to show change.
   b. Purpose of Project record documents is to document factual information regarding aspects of the Work, both concealed and visible, to enable future modification of the Work to proceed without lengthy and expensive Site measurement, investigation, and examination.
3. Make entries within 24 hours after receipt of information that a change in the Work has occurred.
4. Prior to submitting each request for progress payment, request Engineer's review and approval of current status of record documents. Failure to properly maintain, update, and submit record documents may result in a deferral by Engineer to recommend whole or any part of Contractor's Application for Payment, either partial or final.

1.03 RELEASES FROM AGREEMENTS

A. Furnish Owner written releases from property owners or public agencies where side agreements or special easements have been made, or where Contractor's operations have not been kept within the Owner's construction right-of-way.

B. In the event Contractor is unable to secure written releases:

1. Inform Owner of the reasons.
2. Owner or its representatives will examine the Site, and Owner will direct Contractor to complete the Work that may be necessary to satisfy terms of the side agreement or special easement.
3. Should Contractor refuse to perform this Work, Owner reserves right to have it done by separate contract and deduct cost of same from Contract Price or require Contractor to furnish a satisfactory bond in a sum to cover legal Claims for damages.
4. When Owner is satisfied that the Work has been completed in agreement with Contract Documents and terms of side agreement or special easement, right is reserved to waive requirement for written release if: (i) Contractor's failure to obtain such statement is due to grantor's refusal to sign, and this refusal is not based upon any legitimate Claims that Contractor has failed to fulfill terms of side agreement or special easement, or (ii) Contractor is unable to contact or has had undue hardship in contacting grantor.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 MAINTENANCE OF RECORD DOCUMENTS

A. General:

1. Promptly following commencement of Contract Times, secure from Engineer at no cost to Contractor, one complete set of Contract Documents. Drawings will be full size.
2. Label or stamp each record document with title, "RECORD DOCUMENTS," in neat large, printed letters.
3. Record information concurrently with construction progress and within 24 hours after receipt of information that change has occurred. Do not cover or conceal Work until required information is recorded.

B. Preservation:

1. Maintain documents in a clean, dry, legible condition and in good order. Do not use record documents for construction purposes.

2. Make documents and Samples available at all times for observation by Engineer.

C. Making Entries on Drawings:

1. Using an erasable colored pencil (not ink or indelible pencil), clearly describe change by graphic line and note as required.
   a. Color Coding:
      1) Green when showing information deleted from Drawings.
      2) Red when showing information added to Drawings.
      3) Blue and circled in blue to show notes.
2. Date entries.
3. Call attention to entry by "cloud" drawn around area or areas affected.
4. Legibly mark to record actual changes made during construction, including, but not limited to:
   a. Depths of various elements of foundation in relation to finished first floor data if not shown or where depth differs from that shown.
   b. Horizontal and vertical locations of existing and new Underground Facilities and appurtenances, and other underground structures, equipment, or Work. Reference to at least two measurements to permanent surface improvements.
   c. Location of internal utilities and appurtenances concealed in the construction referenced to visible and accessible features of the structure.
   d. Locate existing facilities, piping, equipment, and items critical to the interface between existing physical conditions or construction and new construction.
   e. Changes made by Addenda and Field Orders, Work Change Directive, Change Order, and Engineer's written interpretation and clarification using consistent symbols for each and showing appropriate document tracking number.
5. Dimensions on Schematic Layouts: Show on record drawings, by dimension, the centerline of each run of items such as are described in previous subparagraph above.
   a. Clearly identify the item by accurate note such as "cast iron drain," "galv. water," and the like.
   b. Show, by symbol or note, vertical location of item ("under slab," "in ceiling plenum," "exposed," and the like).
   c. Make identification so descriptive that it may be related reliably to Specifications.

3.02 FINAL CLEANING

A. At completion of the Work or of a part thereof and immediately prior to Contractor's request for certificate of Substantial Completion; or if no

certificate is issued, immediately prior to Contractor's notice of completion, clean entire Site or parts thereof, as applicable.

1. Leave the Work and adjacent areas affected in a cleaned condition satisfactory to Owner and Engineer.
2. Remove grease, dirt, dust, paint or plaster splatter, stains, labels, fingerprints, and other foreign materials from exposed surfaces.
3. Repair, patch, and touch up marred surfaces to specified finish and match adjacent surfaces.
4. Clean all windows.
5. Clean and wax wood, vinyl, or painted floors.
6. Broom clean exterior paved driveways and parking areas.
7. Hose clean sidewalks, loading areas, and others contiguous with principal structures.
8. Rake clean all other surfaces.
9. Remove snow and ice from access to buildings.
10. Replace air-handling filters and clean ducts, blowers, and coils of ventilation units operated during construction.
11. Leave water courses, gutters, and ditches open and clean.

B. Use only cleaning materials recommended by manufacturer of surfaces to be cleaned.

END OF SECTION

SECTION 01 78 23
OPERATION AND MAINTENANCE DATA

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Detailed information for the preparation, submission, and Engineer's review of Operations and Maintenance (O&M) Data, as required by individual Specification sections.

1.02 DEFINITIONS

A. Preliminary Data: Initial and subsequent submissions for Engineer's review.

B. Final Data: Engineer-accepted data, submitted as specified herein.

C. Maintenance Operation: As used on Maintenance Summary Form is defined to mean any routine operation required to ensure satisfactory performance and longevity of equipment. Examples of typical maintenance operations are lubrication, belt tensioning, adjustment of pump packing glands, and routine adjustments.

1.03 SEQUENCING AND SCHEDULING

A. Equipment and System Data:

1. Preliminary Data:
   a. Do not submit until Shop Drawing for equipment or system has been reviewed and approved by Engineer.
   b. Submit prior to shipment date.
2. Final Data: Submit Instructional Manual Formatted data not less than 30 days prior to equipment or system field functional testing. Submit Compilation Formatted and Electronic Media Formatted data prior to Substantial Completion of Project.

B. Materials and Finishes Data:

1. Preliminary Data: Submit at least 15 days prior to request for final inspection.
2. Final Data: Submit within 10 days after final inspection.

1.04 DATA FORMAT

A. Prepare preliminary and final data in the form of an instructional manual. Prepare final data in data compilation format and on electronic media.

B. Instructional Manual Format:

1. Binder: Commercial quality, permanent, three-ring or three-post binders with durable plastic cover.
2. Size: 8-1/2 inches by 11 inches, minimum.
3. Cover: Identify manual with typed or printed title "OPERATION AND MAINTENANCE DATA" and list:
    a. Project title.
    b. Designate applicable system, equipment, material, or finish.
    c. Identity of separate structure as applicable.
    d. Identify volume number if more than one volume.
    e. Identity of general subject matter covered in manual.
    f. Identity of equipment number and Specification section.
4. Spine:
    a. Project title.
    b. Identify volume number if more than one volume.
5. Title Page:
    a. Contractor name, address, and telephone number.
    b. Subcontractor, Supplier, installer, or maintenance contractor's name, address, and telephone number, as appropriate.
        1) Identify area of responsibility of each.
        2) Provide name and telephone number of local source of supply for parts and replacement.
6. Table of Contents:
    a. Neatly typewritten and arranged in systematic order with consecutive page numbers.
    b. Identify each product by product name and other identifying numbers or symbols as set forth in Contract Documents.
7. Paper: 20-pound minimum, white for typed pages.
8. Text: Manufacturer's printed data, or neatly typewritten.
9. Three-hole punch data for binding and composition; arrange printing so that punched holes do not obliterate data.
10. Material shall be suitable for reproduction, with quality equal to original. Photocopying of material will be acceptable, except for material containing photographs.

C. Data Compilation Format:

1. Compile all Engineer-accepted preliminary O&M data into a hard-copy, hard-bound set.
2. Each set shall consist of the following:
    a. Binder: Commercial quality, permanent, three-ring or three-post binders with durable plastic cover.

b. Cover: Identify each volume with typed or printed title "OPERATION AND MAINTENANCE DATA, VOLUME NO. ___ OF ___", and list:
   1) Project title.
   2) Contractor's name, address, and telephone number.
   3) If entire volume covers equipment or system provided by one Supplier include the following:
      a) Identity of general subject matter covered in manual.
      b) Identity of equipment number and Specification section.

c. Provide each volume with title page and typed table of contents with consecutive page numbers. Place contents of entire set, identified by volume number, in each binder.

d. Table of contents neatly typewritten, arranged in a systematic order:
   1) Include list of each product, indexed to content of each volume.
   2) Designate system or equipment for which it is intended.
   3) Identify each product by product name and other identifying numbers or symbols as set forth in Contract Documents.

e. Section Dividers:
   1) Heavy, 80-pound cover weight, tabbed with numbered plastic index tabs.
   2) Fly-Leaf:
      a) For each separate product, or each piece of operating equipment, with typed description of product and major component parts of equipment.
      b) List with Each Product:
         (1) Name, address, and telephone number of Subcontractor, Supplier, installer, and maintenance contractor, as appropriate.
         (2) Identify area of responsibility of each.
         (3) Provide local source of supply for parts and replacement.
      c) Identity of separate structure as applicable.

f. Assemble and bind material, as much as possible, in same order as specified in the Contract Documents.

D. Electronic Media Format:

1. Portable Document Format (PDF):
   a. After all preliminary data has been found to be acceptable to Engineer, submit Operation and Maintenance data in PDF format on CD.
   b. Files to be exact duplicates of Engineer-accepted preliminary data. Arrange by specification number and name.

c. Files to be fully functional and viewable in most recent version of Adobe Acrobat.

1.05 SUBMITTALS

A. Informational:

1. Data Outline: Submit two copies of a detailed outline of proposed organization and contents of Final Data prior to preparation of Preliminary Data.
2. Preliminary Data:
   a. Submit two copies for Engineer's review.
   b. If data meets conditions of the Contract:
      1) One copy will be returned to Contractor.
      2) One copy will be forwarded to Resident Project Representative.
   c. If data does not meet conditions of the Contract:
      1) All copies will be returned to Contractor with Engineer's comments (on separate document) for revision.
      2) Engineer's comments will be retained in Engineer's file.
      3) Resubmit two copies revised in accordance with Engineer's comments.
3. Final Data: Submit two copies in format specified herein.

1.06 DATA FOR EQUIPMENT AND SYSTEMS

A. Content For Each Unit (or Common Units) and System:

1. Product Data:
   a. Include only those sheets that are pertinent to specific product.
   b. Clearly annotate each sheet to:
      1) Identify specific product or part installed.
      2) Identify data applicable to installation.
      3) Delete references to inapplicable information.
   c. Function, normal operating characteristics, and limiting conditions.
   d. Performance curves, engineering data, nameplate data, and tests.
   e. Complete nomenclature and commercial number of replaceable parts.
   f. Original manufacturer's parts list, illustrations, detailed assembly drawings showing each part with part numbers and sequentially numbered parts list, and diagrams required for maintenance.
   g. Spare parts ordering instructions.
   h. Where applicable, identify installed spares and other provisions for future work (e.g., reserved panel space, unused components, wiring, terminals).
2. As-installed, color-coded piping diagrams.

3. Charts of valve tag numbers, with the location and function of each valve.
4. Drawings: Supplement product data with Drawings as necessary to clearly illustrate:
    a. Format:
        1) Provide reinforced, punched, binder tab; bind in with text.
        2) Reduced to 8-1/2 inches by 11 inches, or 11 inches by 17 inches folded to 8-1/2 inches by 11 inches.
        3) Where reduction is impractical, fold and place in 8-1/2-inch by 11-inch envelopes bound in text.
        4) Identify Specification section and product on Drawings and envelopes.
    b. Relations of component parts of equipment and systems.
    c. Control and flow diagrams.
    d. Coordinate drawings with Project record documents to assure correct illustration of completed installation.
5. Instructions and Procedures: Within text, as required to supplement product data.
    a. Format:
        1) Organize in consistent format under separate heading for each different procedure.
        2) Provide logical sequence of instructions for each procedure.
        3) Provide information sheet for Owner's personnel, including:
            a) Proper procedures in event of failure.
            b) Instances that might affect validity of guarantee or Bond.
    b. Installation Instructions: Including alignment, adjusting, calibrating, and checking.
    c. Operating Procedures:
        1) Startup, break-in, routine, and normal operating instructions.
        2) Test procedures and results of factory tests where required.
        3) Regulation, control, stopping, and emergency instructions.
        4) Description of operation sequence by control manufacturer.
        5) Shutdown instructions for both short and extended duration.
        6) Summer and winter operating instructions, as applicable.
        7) Safety precautions.
        8) Special operating instructions.
    d. Maintenance and Overhaul Procedures:
        1) Routine maintenance.
        2) Guide to troubleshooting.
        3) Disassembly, removal, repair, reinstallation, and re-assembly.
6. Guarantee, Bond, and Service Agreement: In accordance with Section 01 77 00, Closeout Procedures.

B. Content for Each Electric or Electronic Item or System:

1. Description of Unit and Component Parts:
    a. Function, normal operating characteristics, and limiting conditions.
    b. Performance curves, engineering data, nameplate data, and tests.
    c. Complete nomenclature and commercial number of replaceable parts.
    d. Interconnection wiring diagrams, including control and lighting systems.
2. Circuit Directories of Panelboards:
3. Electrical service.
4. Control requirements and interfaces.
5. Communication requirements and interfaces.
6. List of electrical relay settings, and control and alarm contact settings.
7. Electrical interconnection wiring diagram, including as applicable, single-line, three-line, schematic and internal wiring, and external interconnection wiring.
8. As-installed control diagrams by control manufacturer.
9. Operating Procedures:
    a. Routine and normal operating instructions.
    b. Startup and shutdown sequences, normal and emergency.
    c. Safety precautions.
    d. Special operating instructions.
10. Maintenance Procedures:
    a. Routine maintenance.
    b. Guide to troubleshooting.
    c. Adjustment and checking.
    d. List of relay settings, control and alarm contact settings.
11. Manufacturer's printed operating and maintenance instructions.
12. List of original manufacturer's spare parts, manufacturer's current prices, and recommended quantities to be maintained in storage.

C. Maintenance Summary:

1. Compile individual Maintenance Summary for each applicable equipment item, respective unit or system, and for components or sub-units.
2. Format:
    a. Use Maintenance Summary Form bound with this section or electronic facsimile of such.
    b. Each Maintenance Summary may take as many pages as required.
    c. Use only 8-1/2-inch by 11-inch size paper.
    d. Complete using typewriter or electronic printing.
3. Include detailed lubrication instructions and diagrams showing points to be greased or oiled; recommend type, grade, and temperature range of lubricants and frequency of lubrication.

4. Recommended Spare Parts:
    a. Data to be consistent with manufacturer's Bill of Materials/Parts List furnished in O&M manuals.
    b. "Unit" is the unit of measure for ordering the part.
    c. "Quantity" is the number of units recommended.
    d. "Unit Cost" is the current purchase price.

1.07 DATA FOR MATERIALS AND FINISHES

A. Content for Architectural Products, Applied Materials, and Finishes:

1. Manufacturer's data, giving full information on products:
    a. Catalog number, size, and composition.
    b. Color and texture designations.
    c. Information required for reordering special-manufactured products.
2. Instructions for Care and Maintenance:
    a. Manufacturer's recommendation for types of cleaning agents and methods.
    b. Cautions against cleaning agents and methods that are detrimental to product.
    c. Recommended schedule for cleaning and maintenance.

B. Content for Moisture Protection and Weather Exposed Products:

1. Manufacturer's data, giving full information on products:
    a. Applicable standards.
    b. Chemical composition.
    c. Details of installation.
2. Instructions for inspection, maintenance, and repair.

1.08 SUPPLEMENTS

A. The supplements listed below, following "End of Section", are part of this Specification.

1. Forms: Maintenance Summary Form.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

MAINTENANCE SUMMARY FORM

PROJECT:_____ CONTRACT NO.:_____

1. EQUIPMENT ITEM_____

2. MANUFACTURER _____

3. EQUIPMENT/TAG NUMBER(S) _____

4. WEIGHT OF INDIVIDUAL COMPONENTS (OVER 100 POUNDS)_____

5. NAMEPLATE DATA (hp, voltage, speed, etc.) _____

6. MANUFACTURER'S LOCAL REPRESENTATIVE _____

   a. Name_____ Telephone No. _____

   b. Address _____

7. MAINTENANCE REQUIREMENTS

Maintenance Operation Comments	**Frequency**	**Lubricant (If Applicable)**
List briefly each maintenance operation required and refer to specific information in manufacturer's standard maintenance manual, if applicable. (Reference to manufacturer's catalog or sales literature is not acceptable.)	List required frequency of each maintenance operation.	Refer by symbol to lubricant required.

8. LUBRICANT LIST

Reference Symbol	Shell	Exxon Mobile	Chevron Texaco	BP Amoco	Or Equal
List symbols used in No. 7 above.	List equivalent lubricants, as distributed by each manufacturer for the specific use recommended.				

9. RECOMMENDED SPARE PARTS FOR OWNER'S INVENTORY.

Part No.	Description	Unit	Quantity	Unit Cost
Note: Identify parts provided by this Contract with two asterisks.				

SECTION 01 78 25
ASSET MANAGEMENT INFORMATION

PART 1 GENERAL

1.01 DEFINITIONS

A. Preliminary Asset Summary Information: Initial and subsequent submissions for Engineer's review.

B. Final Asset Summary Information: Engineer-accepted data, submitted as specified herein.

C. Preliminary Maintenance Summary Information: Initial and subsequent submissions for Engineer's review.

D. Final Maintenance Summary Information: Engineer-accepted data, submitted as specified herein.

E. Maintenance Tasks: As used on Maintenance Summary Form is defined to mean any routine operation required to ensure satisfactory performance and longevity of equipment. Examples of typical maintenance operations are lubrication, belt tensioning, adjustment of pump packing glands, and routine adjustments.

1.02 SEQUENCING AND SCHEDULING

A. Asset Data:

1. Preliminary Asset Summary Information: Submit no later than 30 days after equipment installation. Preliminary Asset Summary Information requires approval by the Engineer prior to manufacturer's startup.
2. Final Asset Summary Information: Submit no later than 30 days after manufacturer startup.

B. Maintenance Data:

1. Preliminary Maintenance Summary Information: Do not submit until Shop Drawing for equipment or system has been reviewed and approved by Engineer. Preliminary Maintenance Summary Information requires approval by the Engineer prior to manufacturer's startup.
2. Final Maintenance Summary Information: Submit no later than 30 days after manufacturer startup.

1.03 SUBMITTALS

A. All information submitted to the Engineer for review shall be prepared by the manufacturer/ manufacturer's representative and Contractor as indicated on

the forms and submitted in accordance with Section 01 33 00, Submittal Procedures.

B. Prepare Preliminary Information:

1. Submit completed Asset Summary Form and Maintenance Summary Form in an electronic format.
   a. See Attachments A & B for examples.
2. Submit attachments in an electronic format.

C. Prepare Final Information in a Compilation Format:

1. Compile all Engineer-accepted preliminary Asset Summary Information and Maintenance Information into separate hard-copy, hard-bound sets, with USB for electronic files.
2. Each set shall consist of the following:
   a. Engineer approved Asset Summary Form, hardcopy and Excel file format.
   b. Engineer approved Maintenance Summary Form, hardcopy and Excel file format.
   c. Attachments:
      1) Engineer approved Startup Report.
      2) Engineer approved O&M Manual; PDF format divided into files not to exceed 50 mb.
      3) Digital Photograph of Installed Asset not to exceed 1 mb.

1.04 DATA FOR EQUIPMENT AND SYSTEMS

A. Asset Summary Forms:

1. Compile individual Asset Summary Forms for each applicable equipment item, respective unit or system, and for components or sub-units.
2. Format:
   a. An electronic copy of the Asset Summary Form can be provided by the Engineer upon request.
   b. Each Asset Summary Form may take as many pages as required.
   c. Use only 8-1/2-inch by 11-inch size pages.
   d. All files submitted to the Engineer shall be in Excel and/or PDF Format. Files submitted shall be fully functional and viewable in most recent version of Adobe Acrobat. No handwritten forms will be accepted.
3. Required Information:
   a. All relevant fields on the Asset Summary Form are to be filled out in their entirety before submission to the Engineer for review. Incomplete forms will not be accepted by the Engineer.
   b. Information fields on the form that are not relevant to the installed equipment are to be entered with “Not Applicable”.

c. Engineer holds the right to determine information relevance or to request additional information based on equipment/asset type.

B. Maintenance Summary Forms:

1. Compile individual Maintenance Summary Forms for each applicable equipment item, respective unit or system, and for components or sub-units.
2. Format:
   a. An electronic copy of the Maintenance Summary Form can be provided by the Engineer upon request.
   b. Each Maintenance Summary may take as many pages as required.
   c. Use only 8-1/2-inch by 11-inch size pages.
   d. All files submitted to the Engineer shall be in PDF Format. Files submitted shall be fully functional and viewable in most recent version of Adobe Acrobat. No handwritten forms will be accepted.
3. Include detailed lubrication instructions and diagrams showing points to be greased or oiled; recommend type, grade, and temperature range of lubricants and frequency of lubrication.
4. Recommended Spare Parts:
   a. Data to be consistent with manufacturer's Bill of Materials/Parts List furnished in O&M manuals.

1.05 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are part of this Specification.

1. Asset Summary Form.
2. Maintenance Summary Form.
3. Asset Summary Form Examples.
4. Maintenance Summary Form Examples.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

ASSET SUMMARY FORM

For Completion by Manufacturer's Representative:

Owner Name: GNHWPCA
Facility Site: _____
Project Number/Name: _____
Shown on Plan Sheet: _____

General:

Description: _____ Tag #: _____

Type: _____

Area: _____

Building/Room: _____

Vendor: _____ Website: _____

Manufacturer: _____ Website: _____

Model #: _____ Serial #: _____ Mfg Job #: _____
if serial # is unavailable

Install Date: _____ Purchase Date: _____

Start-up Date: _____ Warranty End Date: _____

Budgetary Value of Equipment (FOB Site): $ _____

Specification(s):

Pump Size/Size	Pump Flow	Pump Head	Pump Media

HP	Frame	RPM	Voltage

Component(s):

		Specifications (if applicable)			
ID	Component Name - Mfg.	HP	Frame	RPM	Voltage
1					
2					
3					
4					
5					

ASSET SUMMARY FORM cont.

For Completion by Contract Holder:

Installed Cost: $ _____

Attachment(s):

ID	Attachment Name
1	
2	
3	

Existing Asset(s):

If replacing existing asset, record the tag and descripition of each existing asset:

Tag	Description

Contact Information:

General Contr.: _____ Email: _____

Phone: _____

Design Engineer: _____ Email: _____

Phone: _____

Sub-Contractor: _____ Email: _____

Phone: _____

For Owner Use Only:

Representative: _____ CMMS Upload Date: _____

CMMS Asset ID: _____

For Completion by Manufacturer's Representative:

MAINTENANCE SUMMARY FORM

Manufacturer's Local Rep: _____

Name: _____

Address: _____

Telephone: _____

Weight of Individual Components (Over 100 Pounds): _____

Maintenance Requirements:

Maintenance Task	Frequency	Lubricants
List each maintenance operation required and refer to specific information in the manufacturer's standard maintenance manual, if applicable. (Reference to manufacturer's catalog or sales literature is not acceptable.)	List required frequency of each maintenance operation	Refer by symbol to lubricant required.

MAINTENANCE SUMMARY FORM cont.

Lubricant List:

Reference Symbol	Shell	Exxon Mobile	Chevron Texaco	BP Amoco	Or Equal
List symbols used in No. 7 above.	List equivalent lubricants, as distributed by each manufacturer for the specific use recommended.				

Recommended Spare Parts for Owners Inventory:

Part No.	Description	Unit	Qty	Unit Cost	Stored Location

Note: Identify parts provided by this Contract with two asterisks.
Stored Location is recorded by Owner

RECOMMENDED OUTSIDE SERVICE ACTIVITIES

Maintenance Task	Frequency	Authorized Vendor(s)
List each maintenance operation to be performed by an Authorized Vendor	List required frequency of each maintenance operation	Provide Authorized Vendor and Contact Information.

ASSET SUMMARY FORM - EXAMPLE 1 - ATTACHMENT A

For Completion by Manufacturer's Representative:

Owner Name: GNHWPCA
Project Number/Name: CWF2010-01
Facility Site: ESWPAF
Shown on Plan Sheet: 80-D-202

General:

Description: Return Activiated Sludge Pump 6
Tag #: P-32-1-06

Type: Centrifugal Pump Horizontal

Area: North Basement

Building/Room: Facility 52 Activated Sludge Pump Station

Vendor: Rodnev Co.
Website: www.rodnevco.com/

Manufacturer: GNH Pumps
Website: www.gnhpumps.com/

Model #: K250-400/G-3-F
Serial #: 315707
Mfg Job #: (if serial # is unavailable)

Install Date: 1/1/2016
Purchase Date: 12/1/2014

Start-up Date: 3/5/2016
Warranty End Date: 3/5/2017

Budgetary Value of Equipment: $15,000

Specification(s):

Pump Size/Size	Pump Flow	Pump Head	Pump Media
10" X 10"	3475 gpm	40	RAS

HP	Frame	RPM	Voltage
50		1180	460

Component(s):

		Specifications (if applicable)			
ID	Component Name	HP	Frame	RPM	Voltage
1	Horizontal Motor - WEG	50	365T	1180	460
2	Coupling Drive				
3	Check Valve - Surge Buster				
4	Discharge Plug Valve - Milliken				
5	Suction Plug Valve - Milliken				

ASSET SUMMARY FORM cont.

For Completion by Contract Holder:

Installed Cost: $30,000

Attachment(s):

ID	Attachment Name
1	RAS Pump O&M Manual
2	Electronic Photo - Pump 6
3	Start up/COPI

Existing Asset(s):

If replacing existing asset, record the tag and descripition of each existing asset:

Tag	Description
Ex29765	Auma Centrifugal Pump Horizontal

Contact Information:

General Contr.: _____ Email: _____

Phone: _____

Design Engineer: _____ Email: _____

Phone: _____

Sub-Contractor: _____ Email: _____

Phone: _____

For Owner Use Only:

Representative: _____ CMMS Upload Date: _____

CMMS Asset ID: _____

ASSET SUMMARY FORM - EXAMPLE 2 - ATTACHMENT B

For Completion by Manufacturer's Representative:

Owner Name: GNHWPCA
Project Number/Name: CWF2010-01
Facility Site: ESWPAF
Shown on Plan Sheet: 80-D-202

General:

Description: Air Flow Control Valve
Tag #: FCV-21-4 - 1

Type: Flow Control Valve

Area: BRB Basin 1 - Zone 3

Building/Room: Facility 50 - BRB Basins

Vendor: Rodnev Co.
Website: www.rodnevco.com/

Manufacturer: GNH Autovalve
Website: www.gnhvalve.com/

Model #: Series 400
Serial #: AH145900
Mfg Job #: (if serial # is unavailable)

Install Date: 7/27/2015
Purchase Date: 5/27/2015

Start-up Date: 7/27/2015
Warranty End Date: 7/27/2016

Budgetary Value of Equipment: $5,000

Specification(s):

Pump Size/Size	Pump Flow	Pump Head	Pump Media
6"			

HP	Frame	RPM	Voltage

Component(s):

		Specifications (if applicable)			
ID	Component Name	HP	Frame	RPM	Voltage
1	Electric Valve Actuator - GNH				460
2					
3					
4					
5					

ASSET SUMMARY FORM cont.

For Completion by Contract Holder:

Installed Cost: $7,500

Attachment(s):

ID	Attachment Name
1	Valve O&M Manual
2	Electronic Photo - ABZ Valve
3	Start up/COPI

Existing Asset(s):

If replacing existing asset, record the tag and descripition of each existing asset:

Tag	Description

Contact Information:

General Contr.: _____ Email: _____

Phone: _____

Design Engineer: _____ Email: _____

Phone: _____

Sub-Contractor: _____ Email: _____

Phone: _____

For Owner Use Only:

Representative: _____ CMMS Upload Date: _____

CMMS Asset ID: _____

For Completion by Manufacturer's Representative:

MAINTENANCE SUMMARY FORM - Example 1 - ATTACHMENT A

Manufacturer's Local Rep: Rodnev Co.

Name: John Daley

Address: 345 Main St. New Haven, CT 06511

Telephone: 203-555-5555

Weight of Individual Components (Over 100 Pounds): 2850 lbs

Maintenance Requirements:

Maintenance Task	Frequency	Lubricants
List each maintenance operation required and refer to specific information in the manufacturer's standard maintenance manual, if applicable. (Reference to manufacturer's catalog or sales literature is not acceptable.)	List required frequency of each maintenance operation	Refer by symbol to lubricant required.
Inspect Coupling Rubber inserts for wear	1/yr	NA
Grease Motor Bearings	1-2 years or 15,000 hrs	mobil polyrex em
Change seal oil	1-2 years or 10,000 hrs	Vegetable oil or any SAE 30 non detergent oil

MAINTENANCE SUMMARY FORM cont.

Lubricant List:

Reference Symbol	Shell	Exxon Mobile	Chevron Texaco	BP Amoco	Or Equal
List symbols used in No. 7 above.	List equivalent lubricants, as distributed by each manufacturer for the specific use recommended.				
Bearing Grease		Mobile Polyrex EM			
Seal Oil					Vegetable

Recommended Spare Parts for Owners Inventory:

Part No.	Description	Unit	Qty	Unit Cost	Stored Location
**433.01	Inner Seal		2		
433.02	Outer Seal		2		
502	Case Wear Ring		2		
932,01-4	Circlip	4	2		
421.01,421.02	Lip Seals	2	2		
411	Oring Kit		4		

Note: Identify parts provided by this Contract with two asterisks.
Stored Location is recorded by Owner

RECOMMENDED OUTSIDE SERVICE ACTIVITIES

Maintenance Task	Frequency	Authorized Vendor(s)
List each maintenance operation to be performed by an Authorized Vendor	List required frequency of each maintenance operation	Provide Authorized Vendor and Contact Information.

For Completion by Manufacturer's Representative:

MAINTENANCE SUMMARY FORM - Example 2 - ATTACHMENT B

Manufacturer's Local Rep: Rodnev Co.

Name: John Daley

Address: 345 Main St. New Haven, CT 06511

Telephone: 203-555-5555

Weight of Individual Components (Over 100 Pounds): N/A

Maintenance Requirements:

Maintenance Task	Frequency	Lubricants
List each maintenance operation required and refer to specific information in the manufacturer's standard maintenance manual, if applicable. (Reference to manufacturer's catalog or sales literature is not acceptable.)	List required frequency of each maintenance operation	Refer by symbol to lubricant required.
Verify position feed back to actual valve position	1/yr	NA

MAINTENANCE SUMMARY FORM cont.

Lubricant List:

Reference Symbol	Shell	Exxon Mobile	Chevron Texaco	BP Amoco	Or Equal
List symbols used in No. 7 above.	List equivalent lubricants, as distributed by each manufacturer for the specific use recommended.				

Recommended Spare Parts for Owners Inventory:

Part No.	Description	Unit	Qty	Stored Location

Note: Identify parts provided by this Contract with two asterisks.
Stored Location is recorded by Owner

RECOMMENDED OUTSIDE SERVICE ACTIVITIES

Maintenance Task	Frequency	Authorized Vendor(s)
List each maintenance operation to be performed by an Authorized Vendor	List required frequency of each maintenance	Provide Authorized Vendor and Contact

ASSET SUMMARY FORM

Owner Name: _____ Project Number/Name: _____

Facility Name: _____

General Contractor: _____ Email: _____ Phone:

Design Engineer: _____ Email: _____ Phone:

Sub-Contractor: _____ Email: _____ Phone:

Tag #	Description	Type	Area	Building/Room

For Owner Use Only:

Representative: _____

Vendor	Website	Manufacturer	Website

CMMS Upload Date: _____

Model #	Serial #	Mfg Job #	Install Date	Start-up Date

Purchase Date	Pump Size	Pump Flow	Pump Head	Pump Media	HP	Frame	RPM	Voltage

Component(s)	HP	Frame	RPM	Voltage	Existing Asset(s)

Attachment(s)

SECTION 01 88 15
ANCHORAGE AND BRACING

PART 1 GENERAL

1.01 SUMMARY

A. This section covers requirements for anchorage and bracing of equipment, distribution systems, and other nonstructural components required in accordance with the ICC 2021 International Building Code (IBC), for seismic, wind, gravity, soil, and operational loads.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Institute of Steel Construction (AISC) 360, Specification for Structural Steel Buildings.
2. American Society of Civil Engineers (ASCE): ASCE 7, Minimum Design Loads for Buildings and Other Structures.
3. International Code Council (ICC): International Building Code (IBC).
4. State of Connecticut.

1.03 DEFINITIONS

A. Authority Having Jurisdiction (AHJ): Permitting building agency; may be a federal, state, local, or other regional department, or individual including building official, fire chief, fire marshal, chief of a fire prevention bureau, labor department, or health department, electrical inspector; or others having statutory authority. AHJ may be Owner when authorized to be self-permitting by governmental permitting agency or when no governmental agency has authority.

1.04 DESIGN AND PERFORMANCE REQUIREMENTS

A. General:

1. Anchorage and bracing systems shall be designed by a qualified professional engineer registered in the State of Connecticut.
2. Design anchorage into concrete including embedment in accordance with ACI 318-19; Chapter 17, and Project Specifications.
   a. Unless otherwise noted, design for cracked concrete condition.
3. Design anchorage and bracing of architectural, mechanical, and electrical components and systems in accordance with this section, unless a design is specifically provided within Contract Documents or where exempted hereinafter.

4. Design attachments, braces, and anchors for equipment, components, and distribution systems to structure for gravity, seismic, wind, and operational loading.
5. Anchor and brace piping and ductwork, whether exempt or not exempt for this section, so that lateral or vertical displacement does not result in damage or failure to essential architectural, mechanical, or electrical equipment.
6. Architectural Components: Includes, but are not limited to, nonstructural walls and elements, partitions, cladding and veneer, access flooring, signs, cabinets, suspended ceilings, and glass in glazed curtain walls and partitions.
7. Provide supplementary framing where required to transfer anchorage and bracing loads to structure.
8. Adjust equipment pad sizes or provide additional anchorage confinement reinforcing to provide required anchorage capacities.
9. SDC B; Mechanical, electrical, architectural, non-structural components are exempt from seismic design requirements.
10. For components exempted from design requirements of this section, provide bolted, welded, or otherwise positively fastened attachments to supporting structure.

B. Design Loads:

1. Gravity: Design anchorage and bracing for self-weight and superimposed loads on components and equipment.
2. Wind: Design anchorage and bracing for wind criteria provided on General Structural Notes on Drawings for exposed architectural components and exterior and wind-exposed mechanical and electrical equipment. Alternately, manufacturer certification may be provided for components such as roofing and flashing to verify attachments meet Project-specific design criteria.
3. Operational:
    a. For loading supplied by equipment manufacturer for IBC required load cases.
    b. Loads may include equipment vibration, torque, thermal effects, effects of internal contents (weight and sloshing), water hammer, and other load-inducing conditions.
    c. Locate braces to minimize vibration to or movement of structure.
    d. For vibrating loads, use anchors meeting requirements of Section 05 50 00, Metal Fabrications or Section 05 05 19, Post-Installed Anchors, for anchors with designated capacities for vibratory loading per manufacturer’s ICC-ES report.

1.05 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. List of architectural, mechanical, and electrical equipment requiring Contractor-designed anchorage and bracing, unless specifically exempted.
   b. Manufacturers' engineered hardware product data.
   c. Attachment assemblies' drawings; include connection hardware, braces, and anchors or anchor bolts for nonexempt components, equipment, and systems.
   d. Submittal will be rejected if proposed anchorage method would create excessive stress to supporting member. Revise anchorages and strengthen structural support to eliminate overstressed condition.

B. Informational Submittals:

1. Anchorage and Bracing Calculations: For attachments, braces, and anchorages, include IBC and Project-specific criteria as noted on General Structural Notes on Drawings, in addition to manufacturer's specific criteria used for design; sealed by a civil or structural engineer registered in the State of Connecticut.
2. Manufacturer's hardware installation requirements.

C. Deferred Submittals:

1. Submit deferred Action Submittals such as Shop Drawings with supporting deferred informational submittals such as calculations no less than 4 weeks in advance of installation of component, equipment or distribution system to be anchored to structure.

1.06 SOURCE QUALITY CONTROL

A. Contractor and supplier responsibilities to accommodate Owner-furnished shop fabrication related special inspections and testing are provided in Project's Statement of Special Inspections in Supplement located at the end of Section 01 45 33, Special Inspection, Observation, and Testing.

B. Provide all other specified, regulatory required, or required repair verification inspection and testing that is not listed in Statement of Special Inspections in accordance with Section 01 45 16.13, Contractor Quality Control.

C. Provide Source Quality Control for welding and hot-dip galvanizing of anchors in accordance with Section 05 50 00, Metal Fabrications.

PART 2 PRODUCTS

2.01 GENERAL

A. Design and construct attachments and supports transferring loads to structure of materials and products suitable for application and in accordance with design criteria shown on Drawings and nationally recognized standards.

B. Provide anchor bolts for anchorage of equipment to concrete or masonry in accordance with Section 05 50 00, Metal Fabrications. Provide anchor bolts of the size, minimum embedment, and spacing designated in calculations submitted by Contractor and accepted by Engineer.

C. Provide post-installed concrete and masonry anchors for anchorage of equipment to concrete or masonry in accordance with Section 05 05 19, Post-Installed Anchors. Provide post-installed anchors of the size, minimum embedment, and spacing designated in calculations submitted by Contractor and accepted by Engineer.

D. Do not use powder-actuated fasteners or sleeve anchors for seismic attachments and anchorage where resistance to tension loads is required. Do not use expansion anchors, other than undercut anchors, for nonvibration isolated mechanical equipment rated over 10 horsepower.

PART 3 EXECUTION

3.01 GENERAL

A. Make attachments, bracing, and anchorage in such a manner that component lateral force is transferred to lateral force resisting system of structure through a complete load path.

B. Anchor tall and narrow equipment such as motor control centers and telemetry equipment at base and within 12 inches from top of equipment, unless approved otherwise by Engineer.

3.02 INSTALLATION

A. Do not install components or their anchorages or restraints prior to review and acceptance by Engineer and AHJ.

3.03 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. In accordance with Section 05 50 00, Metal Fabrications and Section 05 05 19, Post-Installed Anchors.

B. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in Statement of Special Inspections Plan in Supplement located at end of Section 01 45 33, Special Inspection,

Observation, and Testing. Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection, Observation, and Testing.

C. Provide any other specified, regulatory required, or required repair verification inspection and testing that is not listed in Statement of Special Inspections in accordance with Section 01 45 16.13, Contractor Quality Control.

END OF SECTION

SECTION 01 91 14
EQUIPMENT TESTING AND FACILITY STARTUP

PART 1 GENERAL

1.01 DEFINITIONS

A. Facility: Entire Project, or an agreed-upon portion, including all of its unit processes.

B. Functional Test: Test or tests in presence of Engineer and Owner to demonstrate that installed equipment meets manufacturer's installation, calibration, and adjustment requirements and other requirements as specified.

C. Performance Test: Test or tests performed after any required functional test in presence of Engineer and Owner to demonstrate and confirm individual equipment meets performance requirements specified in individual sections.

D. Unit Process: As used in this section, a unit process is a portion of the facility that performs a specific process function.

E. Facility Performance Demonstration:

1. A demonstration, conducted by Contractor, with assistance of Owner, to demonstrate and document the performance of the entire operating facility, both manually and automatically (if required), based on criteria developed in conjunction with Owner and as accepted by Engineer.
2. Such demonstration is for the purposes of (i) verifying to Owner entire facility performs as a whole, and (ii) documenting performance characteristics of completed facility for Owner's records. Neither the demonstration nor the evaluation is intended in any way to make performance of a unit process or entire facility the responsibility of Contractor, unless such performance is otherwise specified.

1.02 SUBMITTALS

A. Informational Submittals:

1. Facility Startup and Performance Demonstration Plan.
2. Functional and performance test results.
3. Completed Unit Process Startup Form for each unit process.
4. Completed Facility Performance Demonstration/Certification Form.

1.03 FACILITY STARTUP AND PERFORMANCE DEMONSTRATION PLAN

A. Develop a written plan, in conjunction with Owner's operations personnel; to include the following:

1. Step-by-step instructions for startup of each unit process and the complete facility.
2. Unit Process Startup Form (sample attached), to minimally include the following:
   a. Description of the unit process, including equipment numbers/nomenclature of each item of equipment and all included devices.
   b. Detailed procedure for startup of the unit process, including valves to be opened/closed, order of equipment startup, etc.
   c. Startup requirements for each unit process, including water, power, chemicals, etc.
   d. Space for evaluation comments.
3. Facility Performance Demonstration/Certification Form (sample attached), to minimally include the following:
   a. Description of unit processes included in the facility startup.
   b. Sequence of unit process startup to achieve facility startup.
   c. Description of computerized operations, if any, included in the facility.
   d. Contractor certification facility is capable of performing its intended function(s), including fully automatic operation.
   e. Signature spaces for Contractor and Engineer.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Facility Startup Meetings: Schedule, in accordance with requirements of Section 01 31 19, Project Meetings, to discuss test schedule, test methods, materials, chemicals and liquids required, facilities operations interface, and Owner involvement.

B. Contractor's Testing and Startup Representative:

1. Designate and furnish one or more personnel to coordinate and expedite testing and facility startup.
2. Representative(s) shall be present during startup meetings and shall be available at all times during testing and startup.

C. Provide temporary valves, gauges, piping, test equipment and other materials and equipment required for testing and startup.

D. Provide Subcontractor and equipment manufacturers' staff adequate to prevent delays. Schedule ongoing work so as not to interfere with or delay testing and startup.

E. Owner will:

1. Provide water, power, chemicals, and other items as required for startup, unless otherwise indicated.
2. Operate process units and facility with support of Contractor.
3. Provide labor and materials as required for laboratory analyses.
4. Furnish assistance of manufacturer's representative(s) for Owner-furnished products, as specified in Section 01 64 00, Owner-Furnished Products.
5. Make available spare parts, special tools, and operation and maintenance information for Owner-furnished products.

3.02 EQUIPMENT TESTING

A. Preparation:

1. Complete installation before testing.
2. Furnish qualified manufacturers' representatives, when required by individual Specification sections.
3. Obtain and submit from equipment manufacturer's representative Manufacturer's Certificate of Proper Installation Form, in accordance with Section 01 43 33, Manufacturers' Field Services, when required by individual Specification sections.
4. Equipment Test Report Form: Provide written test report for each item of equipment to be tested, to include the minimum information:
   a. Owner/Project Name.
   b. Equipment or item tested.
   c. Date and time of test.
   d. Type of test performed (Functional or Performance).
   e. Test method.
   f. Test conditions.
   g. Test results.
   h. Signature spaces for Contractor and Engineer as witness.
5. Cleaning and Checking: Prior to beginning functional testing:
   a. Calibrate testing equipment in accordance with manufacturer's instructions.
   b. Inspect and clean equipment, devices, connected piping, and structures to ensure they are free of foreign material.
   c. Lubricate equipment in accordance with manufacturer's instructions.
   d. Turn rotating equipment by hand when possible, to confirm that equipment is not bound.

e. Open and close valves by hand and operate other devices to check for binding, interference, or improper functioning.
f. Check power supply to electric-powered equipment for correct voltage.
g. Adjust clearances and torque.
h. Test piping for leaks.

6. Ready-to-test determination will be by Engineer based at least on the following:
   a. Acceptable Operation and Maintenance Data.
   b. Notification by Contractor of equipment readiness for testing.
   c. Receipt of Manufacturer's Certificate of Proper Installation, if so specified.
   d. Adequate completion of work adjacent to, or interfacing with, equipment to be tested, including items to be furnished by Owner.
   e. Availability and acceptability of manufacturer's representative, when specified, to assist in testing of respective equipment.
   f. Satisfactory fulfillment of other specified manufacturer's responsibilities.
   g. Equipment and electrical tagging complete.
   h. Delivery of all spare parts and special tools.

B. Functional Testing:

1. Conduct as specified in individual Specification sections.
2. Notify Owner and Engineer in writing at least 15 days prior to scheduled date of testing.
3. Prepare Equipment Test Report summarizing test method and results.
4. When, in Engineer's opinion, equipment meets functional requirements specified, such equipment will be accepted for purposes of advancing to performance testing phase, if so required by individual Specification sections. Such acceptance will be evidenced by Engineer/Owner's signature as witness on Equipment Test Report.

C. Demonstration Testing:

1. Conduct as specified in individual Specification sections.
2. Notify Engineer and Owner in writing at least 15 days prior to scheduled date of test.
3. Performance testing shall not commence until equipment has been accepted by Engineer as having satisfied functional test requirements specified.
4. Type of fluid, gas, or solid for testing shall be as specified.
5. Unless otherwise indicated, furnish labor, materials, and supplies for conducting the test and taking samples and performance measurements.
6. Prepare Equipment Test Report summarizing test method and results.

7. When, in Engineer's opinion, equipment meets performance requirements specified, such equipment will be accepted as to conforming to Contract requirements. Such acceptance will be evidenced by Engineer's signature on Equipment Test Report.

3.03 STARTUP OF UNIT PROCESSES

A. Prior to unit process startup, equipment within unit process shall be accepted by Engineer as having met functional and demonstration testing requirements specified.

B. Make adjustments, repairs, and corrections necessary to complete unit process startup.

C. Startup shall be considered complete when, in opinion of Engineer, unit process has operated in manner intended for 5 continuous days without significant interruption. This period is in addition to functional or performance test periods specified elsewhere.

D. Significant Interruption: May include any of the following events:

1. Failure of Contractor to provide and maintain qualified onsite startup personnel as scheduled.
2. Failure to meet specified functional operation for more than 2 consecutive hours.
3. Failure of any critical equipment or unit process that is not satisfactorily corrected within 5 hours after failure.
4. Failure of any noncritical equipment or unit process that is not satisfactorily corrected within 8 hours after failure.
5. As determined by Engineer.

E. A significant interruption will require startup then in progress to be stopped. After corrections are made, startup test period to start from beginning again.

3.04 FACILITY PERFORMANCE DEMONSTRATION

A. When, in the opinion of Engineer, startup of all unit processes has been achieved, sequence each unit process to the point that facility is operational.

B. Demonstrate proper operation of required interfaces within and between individual unit processes.

C. After facility is operating, complete performance testing of equipment and systems not previously tested.

D. Document, as defined in Facility Startup and Performance Demonstration Plan, the performance of the facility until all unit processes are operable and under control of computer system.

E. Certify, on the Facility Performance Demonstration/Certification Form, that facility is capable of performing its intended function(s), including fully automatic and computerized operation.

3.05 SUPPLEMENTS

A. Supplements listed below, following "End of Section," are a part of this Specification:

1. Unit Process Startup Form.
2. Facility Performance Demonstration/Certification Form.

END OF SECTION

UNIT PROCESS STARTUP FORM

OWNER:_____ **PROJECT:**_____

Unit Process Description: (Include description and equipment number of all equipment and devices):

Startup Procedure (Describe procedure for sequential startup and evaluation, including valves to be opened/closed, order of equipment startup, etc.):

Startup Requirements (Water, power, chemicals, etc.):_____

Evaluation Comments:_____

FACILITY PERFORMANCE DEMONSTRATION/CERTIFICATION FORM

OWNER:_____ **PROJECT:**_____

Unit Processes Description (List unit processes involved in facility startup):

_____

_____

_____

_____

Unit Processes Startup Sequence (Describe sequence for startup, including computerized operations, if any):

_____

_____

_____

_____

_____

Contractor Certification that Facility is capable of performing its intended function(s), including fully automatic operation:

Contractor: _____ **Date:** _____**, 20____**

Engineer: _____ **Date:** _____**, 20____**

(Authorized Signature)

Greater New Haven Water Pollution Control Authority

New Haven, Connecticut

BIDDING REQUIREMENTS
AND
CONTRACT DOCUMENTS

for the construction of the

Process Air Compressor System for Low Level Nitrogen Removal at the East Shore Water Pollution Abatement Facility

Project No. CWF 2019-04

Volume 2
100% Technical Specifications

JACOBS

Wethersfield, CT

July 2023

Project No. E2X90000

Copy No._____

SECTION 02 41 00
DEMOLITION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this Section:

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): Guideline K, Containers for Recovered Non-flammable Fluorocarbon Refrigerants.
2. American National Standards Institute (ANSI): A10.6, Safety Requirements for Demolition Operations.
3. Occupational Safety and Health Administration (OSHA), U.S. Code of Federal Regulations (CFR) Title 29 Part 1926—Occupational Safety and Health Regulations for Construction.
4. Environmental Protection Agency (EPA), U.S. Code of Federal Regulations (CFR), Title 40:
   a. Part 61—National Emission Standards for Hazardous Air Pollutants.
   b. Part 82—Protection of Stratospheric Ozone.
   c. Part 273—Standards for Universal Waste Management.

1.02 DEFINITIONS

A. ACM: Asbestos-containing material.

B. Demolition: Dismantling, razing, destroying, or wrecking of any fixed building or structure or any part thereof. Demolition also includes removal of pipes, manholes tanks, conduit, and other underground facilities, whether as a separate activity or in conjunction with construction of new facilities.

C. Modify: Provide all necessary material and labor to modify an existing item to the condition indicated or specified.

D. Relocate: Remove, protect, clean and reinstall equipment, including electrical, instrumentation, and all ancillary components required to make the equipment fully functional, to the new location identified on the Drawings.

E. Remove: Provide all necessary labor, equipment and storage or disposal requirements to physically move an existing item off of the Owner's property.

F. Renovation: Altering a facility or one or more facility components in any way.

G. Salvage/Salvageable: Remove and deliver, to the specified location(s), the equipment, building materials, or other items so identified to be saved from

destruction, damage, or waste; such property to remain that of Owner. Unless otherwise specified, title to items identified for demolition shall revert to Contractor.

H. Universal Waste Lamp: In accordance with 40 CFR 273, the bulb or tube portion of an electric lighting device, examples of which include, but are not limited to, fluorescent, high-intensity discharge, neon, mercury vapor, high-pressure sodium, and metal halide lamps.

I. Universal Waste Thermostat: A temperature control device that contains metallic mercury in an ampule attached to a bimetal sensing element, and mercury-containing ampules that have been removed from these temperature control devices in compliance with the requirements of 40 CFR 273.

1.03 SUBMITTALS

A. Informational Submittals:

1. Submit proposed Demolition/Renovation Plan, in accordance with requirements specified herein, for approval before such Work is started.
2. Submit copies of any notifications, authorizations and permits required to perform the Work.
3. Copies of reports and other documentation required for abandoning wells.
4. Submit a shipping receipt or bill of lading for all universal waste shipped.

1.04 REGULATORY AND SAFETY REQUIREMENTS

A. When applicable, demolition Work shall be accomplished in strict accordance with 29 CFR 1926-Subpart T.

B. Comply with federal, state, and local hauling and disposal regulations. In addition to the requirements of the General Conditions, Contractor’s safety requirements shall conform to ANSI A10.6.

C. Furnish timely notification of this demolition project to applicable federal, state, regional, and local authorities in accordance with 40 CFR 61-Subpart M.

1.05 DEMOLITION/RENOVATION PLAN

A. Demolition/Renovation Plan shall provide for safe conduct of the Work and shall include:

1. Detailed description of methods and equipment to be used for each operation.
2. The Contractor’s planned sequence of operations, including coordination with other work in progress.

3. Procedures for removal and disposition of materials specified to be salvaged.
4. Disconnection schedule of utility services.
5. Temporary pipe supports required to safely complete Work. Comply with submittal requirements of Section 40 05 15, Piping Support Systems.

B. Include statements affirming Contractor inspection of the existing aeration basin operating deck, framing members and existing pipe supports, and their suitability to perform as a safe working platform or, if inspection reveals a safety hazard to workers, state provisions for securing the safety of the workers throughout the performance of the Work.

1.06 SEQUENCING AND SCHEDULING

A. The Work of this Specification shall not commence until Contractor's Demolition/Renovation Plan has been approved by Engineer.

B. Include the Work of this Specification in the progress schedule, as specified in Section 01 32 00, Construction Progress Documentation.

C. Areas in which the Work is to be accomplished will be available in accordance with construction phasing drawings and Section 01 31 13, Project Coordination.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXISTING FACILITIES TO BE DEMOLISHED OR RENOVATED

A. General:

1. Demolish piping, supports, conduit, electrical equipment, handrails, roof etc., as shown on the drawings.

B. Utilities and Related Equipment:

1. Notify Engineer or appropriate utilities to turn off affected services at least 48 hours before starting demolition activities.
2. Remove existing utilities as indicated and terminate in a manner conforming to the nationally recognized code covering the specific utility and approved by Engineer.
3. When utility lines are encountered that are not indicated on the Drawings, notify Engineer prior to further work in that area.

C. Paving and Slabs:

1. Remove concrete and asphaltic concrete paving and slabs including aggregate base as indicated to a depth of 12 inches below existing adjacent grade.
2. Provide neat sawcuts at limits of pavement removal as indicated.

D. Concrete:

1. Core drill corners of new opening to avoid overcutting adjacent reinforcing in existing concrete to remain. Saw concrete along straight lines to a depth of not less than 2 inches. Make each cut in walls perpendicular to the face and in alignment with the cut in the opposite face. Break out the remainder of the concrete provided that the broken area is concealed in the finished Work, and the remaining concrete is sound.
2. At locations where the broken face cannot be concealed, grind smooth or saw cut entirely through the concrete. Repair exposed rebar ends and embeds as shown on Drawings.
3. Where new concrete adjoins existing concrete, thoroughly clean and mechanically roughen existing concrete surfaces to roughness profile of 3/16 inch. Rebar and small embeds at existing concrete may be required to be left to engage new concrete. Saturate surface with water for 24 hours prior to placing new concrete. The new Work shall tie into the existing construction as shown on Drawings.

E. Patching:

1. Where removals leave holes and damaged surfaces exposed in the finished Work, patch and repair to match adjacent finished surfaces as to texture and finish.
2. Where new Work is to be applied to existing surfaces, perform removals and patching in a manner to produce surfaces suitable for receiving new Work.
3. Patching shall be as specified and indicated, and shall include fill holes and depressions caused by previous physical damage or left as a result of removals in existing masonry or concrete surfaces with an approved patching material, applied in accordance with the manufacturer's printed instructions.

F. Electrical:

1. Cut off concealed or embedded conduit, boxes, or other materials a minimum of 3/4 inch below final finished surface.
2. When removing designated equipment, conduit and wiring may require rework to maintain service to other equipment.
3. Rework existing circuits, or provide temporary circuits as necessary during renovation to maintain service to existing lighting and equipment

not scheduled to be renovated. Existing equipment and circuiting shown are based upon limited field surveys. Verify existing conditions, make all necessary adjustments, and record the Work on the Record Drawings. This shall include, but is not limited to, swapping and other adjustments to branch circuits and relocation of branch circuit breakers within panelboards as required to accomplish the finished work.

4. Reuse of existing luminaires, devices, conduits, boxes, or equipment will be permitted only where specifically indicated.
5. Raceways and cabling not scheduled for reuse.
6. Inaccessibly Concealed: Cut off and abandon in place.
7. Exposed or Concealed Above Accessible Ceilings: Remove.
8. Raceways and Cabling Scheduled for Future Use: Cap/seal and tag.
9. Relocating Equipment: Extend existing wiring or run new wiring from the source.
10. Where the existing raceway is concealed, the outlet box shall be cleaned, and a blank cover plate installed.
11. Where the concealed raceway is uncovered remove raceway (or extended to new location if appropriate).
12. Provide new typewritten panelboard circuit directory cards.

G. Roofing:

1. Roof material is to be treated as if it contains Asbestos and shall be handled and disposed of as hazardous material.

H. Paint:

1. Any paint disturbed during demolition activities is to be treated as if it contains lead and shall be handled and disposed of as hazardous material.

I. Joint Filler/Mortar:

1. Joint filler and mortar are to be treated as if they contain PCBs and shall be handled and disposed of as hazardous material.

3.02 PROTECTION

A. Dust and Debris Control:

1. Prevent the spread of dust and debris to occupied portions of the building and avoid the creation of a nuisance or hazard in the surrounding area. Do not use water if it results in hazardous or objectionable conditions such as, but not limited to, ice, flooding, or pollution.
2. Vacuum and dust the Work area daily.
3. Sweep pavements as often as necessary to control the spread of debris that may result in foreign object damage potential to vehicular traffic.

4. Prevent dust and debris from falling into the biological reaction basins. The basins must be protected from falling debris, construction ladders and staging, etc. The Contractor will be responsible for any repairs to equipment and or structures. Any fines accrued by the Owner due to process upsets caused by dust or debris falling into the biological reaction basins will be the responsibility of the Contractor.

B. Traffic Control Signs: Where pedestrian and driver safety is endangered in the area of removal Work, use traffic barricades with flashing lights.

C. Existing Work:

1. Survey the site and examine the Drawings and Specifications to determine the extent of the Work before beginning any demolition or renovation.
2. Take necessary precautions to avoid damage to existing items scheduled to remain in place, to be reused, or to remain the property of Owner; any Contractor-damaged items shall be repaired or replaced as directed by Engineer.
3. Provide temporary weather protection during interval between removal of existing exterior surfaces and installation of new to ensure that no water leakage or damage occurs to structure or interior areas of existing building.
4. Ensure that structural elements are not overloaded as a result of or during performance of the Work. Responsibility for additional structural elements or increasing the strength of existing structural elements as may be required as a result of any Work performed under this Contract shall be that of the Contractor. Repairs, reinforcement, or structural replacement must have Engineer approval.
5. Do not overload pavements to remain.

D. Weather Protection: For portions of the building scheduled to remain, protect building interior and materials and equipment from weather at all times. Where removal of existing roofing is necessary to accomplish the Work, have materials and workmen ready to provide adequate and temporary covering of exposed areas so as to ensure effectiveness and to prevent loss.

E. Trees: Protect trees within the Site that might be damaged during demolition and are indicated to be left in place, by a 6-foot-high fence. The fence shall be securely erected a minimum of 5 feet from the trunk of individual trees or follow the outer perimeter of branches or clumps of trees. Any tree designated to remain that is damaged during the Work shall be replaced in kind, as approved by the Engineer.

F. Facilities:

1. Protect electrical and mechanical services and utilities. Where removal of existing utilities and pavement is specified or indicated, provide

approved barricades, temporary covering of exposed areas, and temporary services or connections for electrical and mechanical utilities.

2. Floors, roofs, walls, columns, pilasters, and other structural elements that are designed and constructed to stand without lateral support or shoring, and are determined by Contractor to be in stable condition, shall remain standing without additional bracing, shoring, or lateral support until demolished, unless directed otherwise by the Engineer.
3. Protect all facility elements not scheduled for demolition.
4. Provide interior shoring, bracing, or support to prevent movement, settlement, or collapse of structure or element to be demolished and adjacent facilities.

G. Protection of Personnel:

1. During demolition, continuously evaluate the condition of the structure being demolished and take immediate action to protect all personnel working in and around the demolition site.
2. Provide temporary barricades and other forms of protection to protect Owner's personnel and the general public from injury due to demolition Work.
3. Provide protective measures as required to provide free and safe passage of Owner's personnel and the general public to occupied portions of the structure.

3.03 BURNING

A. The use of burning at the Site for the disposal of refuse and debris will not be permitted.

3.04 RELOCATIONS

A. Relocation of existing supports and equipment is not acceptable.

3.05 BACKFILL

A. Do not use demolition debris as backfill material.

B. Fill excavations, open basements and other hazardous openings to existing ground level or foundation level of new construction in accordance with Section 31 23 23, Fill and Backfill.

3.06 TITLE TO MATERIALS

A. All salvaged equipment and materials shall become the property of Contractor.

B. Title to equipment and materials resulting from demolition is vested in the Contractor upon approval by Engineer of Contractor's Demolition/Renovation Plan, and the resulting authorization by Engineer to begin demolition.

3.07 DISPOSITION OF MATERIAL

A. Do not remove equipment and materials without approval of Contractor's Demolition/Renovation Plan by Engineer.

B. Salvage equipment and material to the maximum extent possible.

C. Owner will not be responsible for the condition or loss of, or damage to, property scheduled to become Contractor's property after Engineer's authorization to begin demolition. Materials and equipment shall not be viewed by prospective purchasers or sold on the site.

D. Store salvaged items as approved by Engineer and remove them from Owner's property before completion of the Contract. Materials and equipment shall not be either viewed by prospective purchasers or sold on the Site.

3.08 UNSALVAGEABLE MATERIAL

A. Concrete, masonry, and other noncombustible material, except concrete permitted to remain in place, shall be disposed of by the Contractor according to all applicable State and Local regulations and Laws.

B. Universal Waste Lamps and Thermostats: Dispose of in strict accordance with 40 CFR 273.

3.09 CLEANUP

A. Debris and rubbish shall be removed from basement and similar excavations. Debris and rubbish shall be removed and transported in a manner that prevents spillage on streets or adjacent areas. Local regulations regarding hauling and disposal shall apply.

END OF SECTION

SECTION 02 61 00
REMOVAL AND DISPOSAL OF CONTAMINATED SOIL

PART 1 GENERAL

1.01 SUMMARY

A. This section describes the Work involved in removal, handling, testing, and disposal of contaminated soils not suitable for backfill, and water treatment where levels exceed those that can be discharged at grade encountered or generated during performance of the Work.

B. In accordance with Haley & Aldrich (H&A) Geotechnical Engineering and Environmental Report for the Wet Weather Capacity Improvement – Phase 1 East Shore Water Pollution Abatement Facility project in New Haven, Connecticut, dated September 2012, the soils at the work area located in between the existing ground surface elevation and 5 feet depth are classified as "contaminated soil/fill" and contain compounds at levels exceeding Connecticut Department of Energy and Environmental Protection (CTDEEP) Pollutant Mobility Criteria (PMC) for areas with groundwater classified as "GB" (GB PMC) by the CTDEEP and exceed the CTDEEP Industrial / Commercial Direct Exposure Criteria. Soil sample test results were also compared to Massachusetts Department of Environmental Protection (MADEP) landfill disposal criteria. The samples tested do not exceed MADEP landfill disposal.

C. The H&A Geotechnical Engineering and Environmental Report is provided as an attachment to Jacobs Geotechnical Memorandum for the Process Air Compressor System for Low Level Nitrogen Removal project, dated June 2022.

D. For bidding purposes, all excavated material will be considered contaminated and not suitable for backfill. Any excavated material shall be hauled directly offsite and disposed of to an appropriate landfill as part of the Lump Sum Bid.

E. For bidding purposes, the water pumped from dewatering operations will be considered suitable for discharge at grade with treatment only for the reduction of total suspended solids (TSS). Reduction of TSS, sampling for TSS and other contaminates throughout the dewatering operations, and discharge at grade is included in the Bid. Treatment beyond what is required to reduce TSS will be negotiated as a differing site condition and paid for from the allowance identified in the Bid Form.

F. After conducting a sample-in-place program and characterization (by the Contractor as specified in Section 31 23 16, Excavation, as part of the Bid) the Contractor shall determine an appropriate landfill for disposal, approved by

the Engineer. The Contractor shall also determine if additional treatment for dewatering operations is required. For bidding purposes, the Massachusetts Department of Environmental Protection (MADEP) landfill shall be considered. Any differences in costs from the basis of bidding will be negotiated as a differing site condition and paid for from the allowance identified in the Bid Form.

G. The stockpiling of materials to be hauled offsite will be permitted if deemed appropriate by the Engineer provided suitable segregation from other materials located in the area designated for stockpiling on the Drawings. The stockpiles must be located outside of the FEMA mapped floodplain.

1.02 DEFINITIONS

A. Clean Soil: Chemically clean natural soil as defined in the Regulations of Connecticut State Agencies, Section 22a-209-1. Clean Soil does not contain any substances above natural background levels.

B. Contaminated Soil: Treated or untreated soil and/or sediment affected by a known or suspected release and determined, or reasonably expected, to contain substances exceeding Residential Direct Exposure Criteria or GA Pollutant Mobility Criteria, as these terms are defined in the Remediation Standard Regulations (RCSA Section 22a-133k-1).

C. Wastewater: Water produced by Contractor's operation, including groundwater removed, stormwater entering excavation pits despite controls, washdown water, used decontamination water, and other water that requires handling by Contractor to accomplish the Work.

D. Reusable Regulated Soil: Reusable Regulated Soil means soil with substance concentrations above the analytical detection limit for such substance in accordance with RCSA 22a-133k-1(a)(45) and below the industrial direct exposure criteria and the GB pollutant mobility criteria as these terms are described in the Remediation Standard Regulations (RCSA 22a-133k-1 through 3), which do not contain polychlorinated biphenyls.

E. Non-Reusable Regulated Soil: Non-Reusable Regulated Soil means soil with substance concentrations exceeding Industrial Direct Exposure Criteria or GB Pollutant Mobility Criteria, as these terms are defined in the Remediation Standard Regulations (RCSA Section 22a-133k-1).

1.03 SUBMITTALS

A. Action Submittals:

1. Excavated Material Management Plan:
   a. Identification of the areas to be excavated in both plan and elevation.
   b. Classification of all areas of excavation.
   c. Identification and quantities of materials to be stockpiled for offsite disposal.
   d. Identification and quantities of materials to be hauled directly offsite for disposal.
2. Excavated Material Disposal Plan:
   a. Permits and certification for soil haulers.
   b. Permits, certification, and acceptance requirements for proposed soil disposal or treatment facilities.
   c. Material transporter's documentation of licensing and equipment capabilities.
   d. Offsite disposal and treatment facilities documentation of licensing and disposal requirements.
3. Dewatering Water Treatment Plan:
   a. Identification of equipment necessary to meet discharge permit limits.
   b. General arrangement drawing of the dewatering water treatment system.
   c. Utility requirements and media life expectancy.
   d. Operations and maintenance data.
4. Site-specific Health and Safety Plan: A written health and safety plan (HASP). Such plan must be approved by signature by the Health and Safety Manager (HSM) and provide for compliance with OSHA regulations including, as applicable 29 CFR 1910.120. All elements in 29 CFR 1910.120(b) (4) shall be addressed in the HASP.
5. The name and address of transporters to be used on the project to transport Regulated Soil.
6. Current licenses and permits to operate in all states affected by transport.
7. Written confirmation from the facility that it is permitted to accept and will accept the material to be disposed.
8. Written approval from the CT DEEP or MA DEP for disposal of Regulated Soil or use of Regulated Soil as cover soil in a solid waste disposal area at facilities located in Connecticut or in Massachusetts.
9. Receiving facility sampling frequency and analytical testing requirements.
10. All chemical analytical reports within 48 hours of Contractor's receipt.

11. During Excavation and Removal Activities:
    a. Daily job progress log detailing information on review of progress with respect to previously established milestones and schedules, major problems, corrective actions, injury reports, equipment breakdown, and sampling results.
    b. Weekly excavation plans.
    c. Copies of manifests or bills of lading, and material disposal or treatment facility receipts, including weight or volume tickets, for solid or liquid materials removed from Site and transported to disposal facilities.

1.04 QUALITY ASSURANCE

A. Contractor Qualifications:

1. Work must be performed by Contractor personnel formally trained in procedures for Regulated Soil and water removal, with proven history of successfully executing similar projects for a minimum of 5 years.
2. Work must be accomplished by Contractor with proper equipment and personnel experienced in similar work.

B. Contractor's Qualified Environmental Professional: Shall be currently licensed as a Licensed Environmental Professional (LEP) in Connecticut and, if applicable, Licensed Site Professional (LSP) in Massachusetts.

C. Contractor's Independent Analytical Laboratory:

1. Accredited by the State of Connecticut Department of Health Services.
2. Have a minimum 5 years' experience.
3. Ability to perform all analyses and provide analytical reports in accordance with the CTDEP's Reasonable Confidence Protocols.

D. Codes and Regulations:

1. Comply with federal, state, and local regulations in handling, testing, transporting, and disposing materials and in performing the Work.
2. Prior to commencing removal operations, obtain applicable local, state, and federal permits and licenses that directly impact Contractor's ability to perform the Work.

PART 2 PRODUCTS

2.01 MATERIALS

A. Stockpile Liner: The stockpile liner shall be manufactured of new, first quality product designed and manufactured specifically for the intended use and have the following properties:

1. The material shall be U.V. resistant (black in color).
2. The material shall be impervious to prevent precipitation from entering the stockpile or liquids from migrating to underlying soil.
3. The material shall be 20 mil thickness (liner under stockpile) and 10 mil thickness (liner over stockpile).

B. Spill Response Materials: Provide appropriate spill response materials including, but not limited, to the following: containers, adsorbents, shovels, and personal protective equipment. Spill response materials shall be available at all times when contaminated soil is being handled or transported. Spill response materials shall be compatible with the type of soil and contaminants being handled and detailed in the Site-Specific HASP.

C. Packaging, Labeling, Marking, and Placarding Materials: Provide all of the materials required for the packaging, labeling, marking, placarding and transportation of Regulated Soil in conformance with Department of Transportation standards. Details in this specification shall not be construed as establishing the limits of the Contractor's responsibility.

PART 3 EXECUTION

3.01 GENERAL

A. Contractor shall be responsible for the following:

1. Providing means, methods, and equipment necessary for excavating, sampling, collecting, testing, handling, processing, loading, and disposing of contaminated soil and wastewater generated as part of the Work.
2. Selecting, providing, and coordinating with qualified transporters, disposal facilities, and treatment facilities for transporting, disposing, and documenting material transportation and disposal in accordance with this specification.
3. Complying with federal, state, and local requirements for transporting solid and liquid materials from Site through applicable jurisdictions, and be responsible for associated fines, penalties, and other costs for non-compliance.
4. Obtaining and submitting acceptance letters and receipts for materials disposed at each facility.

5. Including provisions in its construction sequence and schedule for sampling, analysis, and review of sampling results.

B. Provide qualified Licensed Site Professional to oversee and supervise excavation and material handling operations at Site and to coordinate with proposed disposal and treatment facilities.

3.02 DEWATERING WATER TREATMENT

A. Perform dewatering water treatment as necessary to meet the sewer discharge permit.

3.03 MATERIAL EXCAVATION

A. Perform material excavation in accordance with requirements of Section 31 23 16, Excavation, unless otherwise specified in this section.

B. Water control shall be provided in accordance with Section 31 23 19.01, Dewatering, unless otherwise specified in this section.

C. Conduct Work in excavated area in accordance with Contractor's Site-specific safety plan.

D. Immediately stop excavation and notify Engineer upon encountering material unanticipated or outside scope of this Specification.

3.04 MATERIAL HANDLING AND DISPOSAL

A. To extent possible, schedule and coordinate Work such that excavated contaminated soil and wastewater can be loaded and removed from Site with minimal handling or storage requirements.

B. Where temporary storage or stockpiling is necessary, and as approved by the Engineer, provide and maintain adequate containment and environmental controls, including but not limited to containers, dikes, linings, covers, erosion and sediment controls, and other measures of sufficient capacity to store materials without unauthorized release of contaminants into ground, air, or surface water.

C. Temporary Stockpile:

1. Provide with perimeter dike at least 12 inches high and lined with plastic sheeting.
2. Anchor plastic sheeting with sandbags or other approved ballast over stockpile(s) at end of working day.

3. Liquid Container Storage:
    a. Provide with perimeter dike and plastic lining.
    b. Volume of lined storage area shall be at least the volume of the largest container within the area plus a minimum of 1 foot of freeboard.
4. Seams for diked area linings shall be appropriately sealed to prevent release of contaminated materials or liquids within containment area.
5. Cover systems shall be lapped or sealed as required to prevent leakage of rainwater into stockpiled materials.
6. Inspect containment areas daily, or after each rainfall event, and remove standing water.

D. Transportation:

1. Provide sealed or lined vehicles and other measures necessary to prevent spillage or tracking of contaminated materials on local streets or roads.
2. Inspect and document vehicles and containers for proper operation and covering.
3. Inspect vehicles and containers for proper markings, manifests, and other requirements for material shipment.
4. Perform and document decontamination procedures prior to leaving Site and again before leaving disposal or treatment facility.
5. Obtain and submit receipts of confirmation from disposal or treatment facilities that solid and liquid wastes were accepted for disposal or treatment, including weight tickets or other confirmation of quantities received.

3.05 SPILLS

A. Immediately notify the Engineer and CT DEEP (860-424-3338) in the event of a spill or release of a hazardous substance, pollutant, contaminant, or oil. Follow the pre-established procedures as described in HASP and spill response plan in the Excavated Material Management Plan. Immediately take containment actions to minimize the effect of any spill or leak. Cleanup shall be done in accordance with applicable federal, state, and local regulations. Perform extra sampling and testing as directed by the Engineer to verify spills have been cleaned up. Spill cleanup and testing shall be done at no additional cost to the Owner.

3.06 EQUIPMENT DECONTAMINATION

A. Decontaminate equipment that has come into contact with contaminated soil or impacted water by methods approved by Engineer.

B. Wastewater and sediment generated by decontamination activities shall be contained and treated or disposed of in accordance with provisions stated in this section.

END OF SECTION

SECTION 03 30 10
STRUCTURAL CONCRETE

PART 1 GENERAL

1.01 GENERAL

A. Work shall conform to requirements of ACI 301-20, Specifications for Structural Concrete, unless otherwise specified.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI):
   a. 117, Specifications for Tolerances for Concrete Construction and Materials.
   b. 301-20, Specifications for Structural Concrete.
   c. 305.1, Specification for Hot Weather Concreting.
   d. 306.1, Specification for Cold Weather Concreting.
   e. 308.1, Specification for Curing Concrete.
   f. 350.1, Specification for Tightness Testing of Environmental Engineering Concrete Containment Structures.
   g. SP-66, Detailing Manual.
2. ASTM International (ASTM):
   a. A185/A185M, Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
   b. A497/A497M, Standard Specification for Steel Welded Reinforcement, Deformed, for Concrete.
   c. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   d. C31/C31M, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   e. C33/C33M, Standard Specification for Concrete Aggregates.
   f. C39/C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   g. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   h. C143/C143M, Standard Test Method for Slump of Hydraulic-Cement Concrete.
   i. C150/C150M, Standard Specification for Portland Cement.
   j. C231/C231M, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
   k. C260/C260M, Standard Specification for Air-Entraining Admixtures for Concrete.
   l. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.

m. C494/C494M, Standard Specification for Chemical Admixtures for Concrete.
n. C595/C595M, Standard Specification for Blended Hydraulic Cements.
o. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
p. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
q. C920, Specification for Elastomeric Joint Sealants.
r. C989, Standard Specification for Slag Cement for Use in Concrete and Mortars.
s. C1012/C1012M, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
t. C1017/C1017M, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.
u. C1077, Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation.
v. C1218/C1218M, Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.
w. C1260, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).
x. C1293, Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction.
y. C 1315, Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.
z. C1567, Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method).
aa. C1602/C1602M, Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete.
bb. D226, Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing.
cc. D227, Specification for Coal-Tar Saturated Organic Felt Used in Roofing and Waterproofing.
dd. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
ee. D1056, Specification for Flexible Cellular Materials—Sponge or Expanded Rubber.
ff. D1751, Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
gg. D1752, Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.

hh. D2240, Standard Test Method for Rubber Property – Durometer Hardness.
ii. E329, Standard Specification for Agencies Engaged in Construction Inspection, Special Inspection, or Testing Materials Used in Construction.

3. Concrete Reinforcing Steel Institute (CRSI):
   a. Manual of Standard Practice.
   b. Recommended Practice for Placing Reinforcing Bars.
4. Corps of Engineers (COE): CRD-C-572, Corps of Engineers Specifications for Polyvinylchloride Waterstop.
5. National Ready Mixed Concrete Association (NRMCA).
6. NSF International (NSF): 61, Drinking Water System Components - Health Effects.

1.03 DEFINITIONS

A. Cold Weather: When ambient temperature is below 40 degrees F or is approaching 40 degrees F and falling.

B. Contractor's Licensed Design Engineer: Individual representing Contractor who is licensed to practice engineering as defined by statutory requirements of professional licensing laws in state or jurisdiction in which Project is to be constructed.

C. Defective Area: Surface defects that include honeycomb, rock pockets, indentations, and surface voids greater than 3/16-inch deep, surface voids greater than 3/4 inch in diameter, cracks in liquid containment structures and below grade habitable spaces that are 0.005-inch wide and wider, and cracks in other structures that are 0.010-inch wide and wider, spalls, chips, embedded debris, sand streaks, mortar leakage from form joints, deviations in formed surface that exceed specified tolerances and include but are not limited to fins, form pop-outs, and other projections. At exposed concrete, defective areas also include texture irregularities, stains, and other color variations that cannot be removed by cleaning.

D. Exposed Concrete: Concrete surface that can be seen inside or outside of structure regardless of whether concrete is above water, dry at all times, or can be seen when structure is drained.

E. Hot Weather: As defined in ACI 305.1.

F. Hydraulic Structure: Liquid containment structure.

G. New Concrete: Concrete less than 60 days old.

H. Top Bars: Horizontal bars placed such that 12 inches of fresh concrete is cast below in single placement.

1.04 DESIGN REQUIREMENTS

A. Design formwork to provide specified concrete finishes.

1.05 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Formwork and Formwork Accessories: Unless otherwise specified, conform to requirements of ACI 301.
   b. Reinforcing steel prepared in accordance with CRSI Manual of Standard Practice and ACI SP-66 Detailing Manual:
      1) Bending lists.
      2) Placing drawings.
   c. Construction Joints, Expansion Joints and Control Joints: Layout and location for each type.
2. Mix Design:
   a. Contain proportions of materials and admixtures to be used on Project, signed by mix designer.
   b. Documentation of average strength for each proposed mix design in accordance with ACI 301.
   c. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services, for the following:
      1) Portland cement.
      2) Fly ash.
      3) Slag cement.
      4) Aggregates, including specified class designation for coarse aggregate.
      5) Admixtures.
      6) Concrete producer has verified compatibility of constituent materials in design mix.
   d. Test Reports:
      1) Cement: Chemical analysis report.
      2) Supplementary Cementitious Materials: Chemical analysis report and report of other specified test analyses.
      3) Water-Soluble Chloride-Ion Content in Hardened Concrete: Unless otherwise permitted, in accordance with ASTM C1218/C1218M at an age between 28 days and 42 days.
   e. Aggregates:
      1) Percent of fine aggregate weight to total aggregate weight.
      2) Deleterious substances in fine aggregate per ASTM C33/C33M, Table 2.
      3) Deleterious substances in coarse aggregate per ASTM C33/C33M, Table 4.

4) Test Reports:
a) Alkali Aggregate Reactivity: Aggregate shall be classified as nonpotentially reactive in accordance with Article Concrete Mix Design. Include documentation of test results per applicable standards.

f. Admixtures: Manufacturer's product data sheets for each admixture used in proposed mix designs.

3. Product Data: Specified ancillary materials.
4. Samples: PVC waterstop splice, joint, and fabricated cross of each size, shape, and fitting of waterstop.
5. Letter stating compatibility between liquids being contained and materials used for waterstops and joint fillers.
6. Detailed plan for curing and protection of concrete placed and cured in cold weather. Details shall include, but not be limited to, the following:
   a. Procedures for protecting subgrade from frost and accumulation of ice or snow on reinforcement, other metallic embeds, and forms prior to placement.
   b. Procedures for measuring and recording temperatures of reinforcement and other embedded items prior to concrete placement.
   c. Methods for temperature protection during placement.
   d. Types of covering, insulation, housing, or heating to be provided.
   e. Curing methods to be used during and following protection period.
   f. Use of strength accelerating admixtures.
   g. Methods for verification of in-place strength.
   h. Documentation of embeds that must be at a temperature above freezing prior to placement of concrete.
   i. Procedures for measuring and recording concrete temperatures.
   j. Procedures for preventing drying during dry, windy conditions.
7. Detailed plan for hot weather placements including curing and protection for concrete placed in ambient temperatures over 80 degrees F. Plan shall include, but not be limited to, the following:
   a. Procedures for measuring and recording temperatures of reinforcement and other embedded items prior to concrete placement.
   b. Use of retarding admixture.
   c. Methods for controlling temperature of reinforcement and other embedded items and concrete materials before and during placement.
   d. Types of shading and wind protection to be provided.
   e. Curing methods, including use of evaporation retardant.
   f. Procedures for measuring and recording concrete temperatures.
   g. Procedures for preventing drying during dry, windy conditions.
8. Concrete repair techniques.

B. Informational Submittals:

1. Preinstallation Conference minutes.
2. Manufacturer's application instructions for bonding agent and bond breaker.
3. Manufacturer's Certificate of Compliance to specified standards:
   a. Bonding agent.
   b. Bond breaker.
   c. Repair materials.
4. Statement of Qualification:
   a. Batch Plant: Certification as specified herein.
   b. Mix designer.
   c. Installer.
   d. Mix designer.
   e. Testing agency.
5. Concrete Delivery Tickets:
   a. For each batch of concrete before unloading at Site.
   b. In accordance with ASTM C94/C94M, including requirements 14.2.1. through 14.2.10.
   c. Indicate amount of mixing water withheld and maximum amount that may be permitted to be added at Site.

1.06 QUALITY ASSURANCE

A. Qualifications:

1. Batch Plant: NRMCA Program for Certification of Ready-Mixed Concrete Production Facilities or approved equivalent program.
2. Mix Designer: Person responsible for developing concrete mixture proportions certified as NRMCA Concrete Technologist Level 2 or DOT certified mix designer in jurisdiction of the Work. Requirement may be waived if individual is Contractor's Licensed Design Engineer.
3. Flatwork Finisher: Unless otherwise permitted, at least one person on finishing crew shall be certified as an ACI Flatwork Finisher, or equivalent.
4. Testing Agency: Unless otherwise permitted, an independent agency, acceptable to authorities having jurisdiction, qualified according to ASTM C1077 and ASTM E329 for testing indicated.
   a. Where field testing is required of Contractor, personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.
   b. Personnel performing laboratory tests shall be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician - Grade I. Testing Agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician - Grade II.

B. Preinstallation Conference:

1. Required Meeting Attendees:
   a. Contractor, including pumping, placing and finishing, and curing subcontractors.
   b. Ready-mix producer.
   c. Admixture representative.
   d. Testing and sampling personnel.
   e. Engineer who authored Statement of Special Inspection Plan or Engineer's designee.
2. Schedule and conduct prior to incorporation of respective products into Project. Notify Engineer of location and time.
3. Agenda shall include:
   a. Admixture types, dosage, performance, and redosing at Site.
   b. Mix designs, test of mixes, and Submittals.
   c. Placement methods, techniques, equipment, consolidation, and form pressures.
   d. Slump or slump flow and placement time to maintain slump and slump flow.
   e. Finish, curing, and water retention.
   f. Protection procedures for weather conditions.
   g. Other specified requirements requiring coordination.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Unload, store, and handle bars in accordance with CRSI publication "Placing Reinforcing Bars."

PART 2 PRODUCTS

2.01 FORMWORK

A. Form Materials:

1. For exposed areas, use hard plastic finished plywood, overlaid waterproof particle board, or steel in "new and undamaged" condition, of sufficient strength and surface smoothness to produce specified finish.
2. For unexposed areas, use new shiplap or plywood.
3. Earth cuts may be used for forming footings.

B. Beveled Edge Corner Strips: Nonabsorbent material, compatible with form surface, fully sealed on all sides prohibiting loss of paste or water between the two surfaces.

C. Form Ties:

1. Material: Steel.
2. Spreader Inserts:
   a. Conical or spherical type.
   b. Design to maintain positive contact with forming material.
   c. Furnish units that will leave no metal closer than 1.5 inches to concrete surface when forms, inserts, and tie ends are removed.
3. Wire ties not permitted.

2.02 CONCRETE

A. Materials:

1. Cementitious Materials:
   a. Cement:
      1) Portland Cement: Unless otherwise specified, conform to requirements of ASTM C150/C150M.
      2) Blended Hydraulic Cement:
         a) Unless otherwise specified, conform to requirements of ASTM C595/C595M.
         b) Portland cement used in blended hydraulic cement; conform to requirements of ASTM C150/C150M.
      3) Furnish from one source.
   b. Supplementary Cementitious Materials (SCM):
      1) Fly Ash (Pozzolan): Class F and Class C fly ash in accordance with ASTM C618, except as modified herein:
         a) ASTM C618, Table 1, Loss on Ignition: Unless permitted otherwise, maximum 3 percent.
      2) Slag Cement: In accordance with ASTM C989, Grades 100 or 120.
2. Aggregates: Unless otherwise permitted, furnish from one source for each aggregate type used in a mix design.
   a. Aggregates:
      1) In accordance with ASTM C33/C33M, except as modified herein.
         a) Class Designation: 4S unless otherwise specified.
         b) Free of materials and aggregate types causing popouts, discoloration, staining, or other defects on surface of concrete.
         c) Alkali Silica Reactivity: See Article Concrete Mix Design.
      2) Fine Aggregates:
         a) Clean, sharp, natural sand.
         b) ASTM C33/C33M.

c) Limit deleterious substances in accordance with ASTM C33/C33M, Table 2 and as follows:
(1) Limit material finer than 75-µm (No. 200) sieve to 3 percent mass of total sample.
(2) Limit coal and lignite to 0.5 percent.

3) Coarse Aggregate:
a) Natural gravels, combination of gravels and crushed gravels, crushed stone, or combination of these materials containing no more than 15 percent flat or elongated particles (long dimension more than five times the short dimension).
b) Limit deleterious substances in accordance with ASTM C33/C33M, Table 4 for specified class designation.

3. Admixtures: Unless otherwise permitted, furnish from one manufacturer.
a. Characteristics:
1) Compatible with other constituents in mix.
2) Contain at most, only trace amount chlorides in solution.
3) Furnish type of admixture as recommended by manufacturer for anticipated temperature ranges.
b. Air-Entraining Admixture: ASTM C260/C260M.
c. Water-Reducing Admixture: ASTM C494/C494M, Type A or Type D.
d. Retarding Admixture: ASTM C 494/C 494M, Type B.
e. Accelerating Admixture: ASTM C 494/C 494M, Type C.
f. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F or Type G.
g. Plasticizing Admixture: ASTM C1017/C1017M, Type I or Type II.
h. Do not use calcium chloride as an admixture.
i. Admixtures with no standard, ASTM or other, designation may be used where permitted.

4. Water and Ice: Mixing water for concrete and water used to make ice shall be potable water, unless alternative sources of water are permitted.
a. Water from alternative sources shall comply with requirements of ASTM C1602/C1602M, and concentration of chemicals in combined mixing water shall be less than:
1) Chloride Content: 1,000 ppm.
2) Sulfate Content as SO_4: 3,000 ppm.
3) Alkalis as (Na_2O + 0.658 K_2O): 600 ppm.
4) Total Solids by Mass: Less than 50,000 ppm.

B. Concrete Mix Design:

1. General:
   a. See Supplement at the end of this section for mix design requirements for each class of concrete used on Project.
   b. Prepare design mixtures for each type and strength of concrete, selecting and proportioning ingredients in accordance with requirements of ACI 301, unless otherwise specified.
   c. Selection of constituent materials and products in mix design are optional, unless specified otherwise.
   d. Unless otherwise permitted, use water-reducing admixture or water-reducing admixture and high-range, water-reducing admixture, or plasticizing admixture in pumped concrete, in concrete with a water-cementitious materials ratio below 0.50.
   e. Unless otherwise permitted, use water-reducing admixture and high-range, water-reducing admixture, or plasticizing admixture in columns, piers, pilasters, and walls.
   f. Use water-reducing admixture or high-range, water-reducing admixture, or plasticizing admixture to achieve fresh properties that facilitate handling, placing, and consolidating of concrete, and specified hardened properties.
   g. Use water-reducing and retarding admixture when anticipated high temperatures, low humidity, or other adverse placement conditions can adversely affect fresh properties of concrete.
   h. Unless otherwise specified, desired fresh properties of concrete shall be determined by Contractor and coordinated with concrete producer. Fresh properties of concrete shall remain stable to satisfaction of Contractor, for duration of placement and consolidation, and shall remain in conformance with requirements of Contract Documents.
   i. Contractor is encouraged to consider using environmentally sustainable concrete mix design technologies such as use of supplementary cementitious materials, aggregate packing, and self-consolidating concrete.
2. Potential alkali-aggregate reactivity of concrete:
   a. Do not use aggregates known to be susceptible to alkali-carbonate reaction (ACR).
   b. Aggregates shall have been tested to determine potential alkali-aggregate reactivity in concrete in accordance with ASTM C1260/C1260M or ASTM C1567.
      1) Aggregates that indicate expansion greater than 0.10 percent at 16 days after casting shall not be used unless they have been shown to be nondeleteriously reactive in accordance with ASTM C1293, with less than 0.04 percent expansion at 1 year for cement-aggregate combinations or less than 0.04 percent expansion at 2 years for combinations with pozzolan or slag.

2) Alkali content of cement used in proposed concrete mixture shall not be greater than alkali content of cement used in test for potential alkali-aggregate reactivity.

c. Use low alkali cement and incorporate pozzolans into the concrete mixture as necessary to satisfy testing for potential alkali reactivity.

3. Proportions:
   a. Design mix to meet aesthetic, durability, and strength requirements.
   b. Where fly ash is included in mix, minimum fly ash content shall be a minimum of 15 percent of weight of total cementitious materials.
4. Slump or Slump Flow:
   a. Unless otherwise permitted, target slump value is 4 inches at point of delivery, for concrete without high-range, water-reducing admixture.
   b. Design mixes that include a high-range, water-reducing or a plasticizing admixture shall have a minimum slump of 2 inches prior to addition of admixture. Unless otherwise permitted, slump shall be 8 inches maximum at point of delivery, for concrete with a high-range, water-reducing admixture.
   c. Slump tolerance shall meet requirements of ACI 117.

C. Concrete Mixing:

1. General: In accordance with ACI 301, except as modified herein.
2. Truck Mixers:
   a. For every truck, test slump or slump flow of samples taken per ASTM C94/C94M, paragraph 12.5.1.
   b. Where specified slump is more than 4 inches, and if slump tests differ by more than 2 inches, discontinue use of truck mixer, unless causing condition is corrected and satisfactory performance is verified by additional slump tests.

2.03 REINFORCING STEEL

A. Deformed Steel Reinforcing Bars: ASTM A615/A615M, Grade 60. Welding of reinforcing bars is not permitted.

B. Fabrication: Follow CRSI Manual of Standard Practice.

2.04 ANCILLARY MATERIALS

A. Bonding Agent: Unless otherwise specified, in accordance with the following:

1. ASTM C881/C881M, Type V.
2. Two-component, moisture insensitive, 100 percent solids epoxy.

3. Consult manufacturer for surface finish, pot life, set time, vertical or horizontal application, and forming restrictions.
4. Manufacturers and Products:
    a. BASF Building Systems Inc., Shakopee, MN; Masterinject 1500.
    b. Euclid Chemical Co., Cleveland, OH; Euco # 352 Epoxy System LV.
    c. Prime Resins, Conyers, GA; Prime Bond 3000 to 3900 Series.
    d. Sika Chemical Corp., Lyndhurst, NJ; Sikadur 32 Hi-Mod.

B. Bond Breaker:

1. Nonstaining type, providing positive bond prevention.
2. Manufacturers and Products:
    a. Dayton Superior Corporation, Kansas City, KS; EDOCO Clean Lift Bond Breaker.
    b. Nox-Crete Products Group, Omaha, NE; Silcoseal Select.

C. Tie Wire:

1. Black, soft-annealed 16-gauge wire.
2. Nylon-, epoxy-, or plastic-coated wire.

D. Bar Supports and Spacers:

1. Use precast concrete bar supports and side form spacers, unless noted otherwise. Do not use other types of supports or spacers.
2. Bar supports shall have sufficient strength and stiffness to carry loads without failure, displacement, or significant deformation. Space bar supports so minimum concrete cover is maintained for reinforcing between supports.

E. Plastic Waterstop:

1. Extruded from elastomeric plastic compound of which basic resin shall be prime virgin polyvinyl chloride (PVC). Compound shall not contain scrapped material, reclaimed material, or pigment.
2. Specific Gravity: Approximately 1.37.
3. Shore Durometer Type A Hardness: Approximately 80.
4. Performance Requirements: COE Specification CRD-C-572.
5. Type Required in Contraction and Control Joints: 6 inches wide and parallel longitudinal ribs or protrusions on each side of strip center, as indicated on Drawings.
6. Type Required in Construction Joints: Flat ribbed with same dimensional properties as described above.
7. Corrugated or tapered type waterstops are not acceptable.
8. Thickness: Constant from center bulb (or center of waterstop), to outside stop edge.

9. Waterstop Weight: 1.60 pounds for 3/8 inch by 6 inches, minimum per foot.
10. Factory Fabrications: Use only factory fabrications for intersections, transitions, and changes of direction.
11. Manufacturers and Products:
    a. Center Bulb Type:
        1) Vinylex Corp., Knoxville, TN; Catalog No. 03250/VIN: No. RB6-38H (6 inches by 3/8 inch).
        2) Greenstreak Plastic Products, St. Louis, MO; Catalog No. 03150/GRD: Style 732 (6 inches by 3/8 inch).
        3) Four Seasons Industries Durajoint, Garrettsville, OH; Catalog No. CSP-162: Type 9 (6 inches by 3/8 inch).
        4) BoMetals, Carrollton, GA; Catalog No. RCB-638LB (6 inches by 3/8 inch).
        5) Dacon Plastics LLC, Portland, OR, (903) 245-0048; Catalog No. DR004 (6 inches by 3/8 inch).
    b. Flat Ribbed Profile: Use same manufacturers as bulb type.

F. Premolded Joint Filler:

1. Bituminous Type: ASTM D994 or ASTM D1751.
2. Sponge Rubber:
    a. Neoprene, closed-cell, expanded; ASTM D1056, Type 2C5, with compression deflection, 25 percent deflection (limits), 119 kPa to 168 kPa (17 psi to 24 psi) minimum.
    b. Manufacturer and Product: Monmouth Rubber and Plastics Corporation, Long Branch, NJ; Durafoam DK515IHD.

G. Curing Compound:

1. Water-based, high-solids content, nonyellowing, curing compound meeting requirements of ASTM C1315 Type I, Class A.
2. Manufacturers and Products:
    a. BASF Construction Chemicals, Shakopee, MN; Kure 1315.
    b. Euclid Chemical Co., Cleveland, OH; Super Diamond Clear VOX.
    c. WR Meadows, Inc., Hampshire, IL; VOCOMP-30.
    d. Vexcon Chemical, Inc.; Philadelphia, PA; Starseal 1315.
    e. Dayton Superior; Safe Cure and Seal 1315 EF.

H. Evaporation Retardant:

1. Optional: Fluorescent fugitive dye color tint that disappears completely upon drying.
2. Manufacturers and Products:
    a. BASF Construction Chemicals, Shakopee, MN; Confilm.
    b. Euclid Chemical Co., Cleveland, OH; Eucobar.

I. Nonshrink Grout:

1. Nonmetallic, nongas-liberating.
2. Prepackaged natural aggregate grout requiring only the addition of water.
3. Aggregate shall show no segregation or settlement at fluid consistency at specified times or temperatures.
4. Test in accordance with ASTM C1107/C1107M:
   a. Fluid consistency 20 seconds to 30 seconds in accordance with ASTM C939.
   b. Temperatures of 40 degrees F, 80 degrees F, and 100 degrees F.
5. 1 hour after mixing, pass fluid grout through flow cone with continuous flow.
6. Minimum strength of fluid grout, 3,500 psi at 1 day, 4,500 psi at 3 days, and 7,500 psi at 28 days.
7. Maintain fluid consistency when mixed in 1 yard to 9 yard loads in ready-mix truck.
8. Manufacturers and Products:
   a. BASF Building Systems, Inc., Shakopee, MN; Master Flow 928.
   b. Five Star Products Inc., Fairfield, CT; Five Star Fluid Grout 100.
   c. Euclid Chemical Co., Cleveland, OH; Hi Flow Grout.
   d. Dayton Superior Corp., Kansas City, KS; Sure Grip High Performance Grout.
   e. L & M Construction Chemicals, Inc., Omaha, NE; Crystex.

J. Repair Material:

1. Contain only trace amounts of chlorides and other chemicals that can potentially cause steel to oxidize.
2. Where repairs of exposed concrete are required, prepare mockup using proposed repair materials and methods, for confirmation of appearance compatibility prior to use.
3. Obtain Manufacturer’s Certificate of Compliance that products selected are appropriate for specific applications.
4. Repair mortar shall be Site mixed.
5. Prepare concrete substrate and mix, place, and cure repair material in accordance with manufacturer’s written recommendations.
6. Manufacturers and Products:
   a. BASF Building Systems Inc., Shakopee, MN; EMACO S-Series products.
   b. Sika Chemical Corp., Lyndhurst, NJ; SikaTop-Series.

K. Crack Repair:

1. Obtain Letter of Certification from manufacturer’s technical representative, that products selected are appropriate for the specific applications.

2. Prepare concrete substrate and mix, place, and cure repair material in accordance with manufacturer's written recommendations.
3. When crack repair is deemed by Engineer as requiring a structural repair, use part epoxy injection resin.
    a. Manufacturers:
        1) BASF Building Systems, Inc., Shakopee, MN.
        2) Euclid Chemical Co., Cleveland, OH.
        3) Prime Resins, Conyer, GA.
        4) Sika Chemical Corp., Lyndhurst, NJ.
4. Unless otherwise specified, use hydrophilic polyurethane resin.
    a. Manufacturers:
        1) Prime Resins, Conyer, GA.
        2) Sika Chemical Corp., Lyndhurst, NJ.

2.05 SOURCE QUALITY CONTROL

A. Source Quality Control Inspection: Engineer shall have access to and have right to inspect batch plants, cement mills, and supply facilities of suppliers, manufacturers, and Subcontractors, providing products included in this section.

PART 3 EXECUTION

3.01 FORMWORK

A. Form Construction:

1. Construct forms and provide smooth-form finish.
2. Form 3/4-inch bevels at concrete edges, unless otherwise shown.
3. Make joints tight to prevent escape of mortar and to avoid formation of fins.
4. Brace as required to prevent distortion during concrete placement.
5. On exposed surfaces, locate form ties in uniform pattern or as shown.
6. Construct so ties remain embedded in the member with no metal within 1 inch of concrete surface when forms, inserts, and tie ends are removed.

B. Form Removal:

1. Nonsupporting forms (walls and similar parts of Work) may be removed after cumulatively curing at not less than 50 degrees F for 24 hours from time of concrete placement if:
    a. Concrete is sufficiently hard so as not to sustain damage by form removal operations.
    b. Curing and protection operations are maintained.
2. Remove forms with care to prevent scarring and damaging the surface.
3. Prior to form removal, provide thermal protection for concrete being placed under the requirements of cold weather concreting.

3.02 PLACING REINFORCING STEEL

A. Unless otherwise specified, place reinforcing steel in accordance with CRSI Recommended Practice for Placing Reinforcing Bars.

B. Splices and Laps:

1. Lap splice reinforcing: Refer to Structural General Notes in Drawings for additional information.
2. Tie splices with 18-gauge annealed wire as specified in CRSI Standard.

3.03 INSTALLATION OF WATERSTOPS

A. General:

1. Continuous waterstop (as specified) shall be installed in all construction joints in walls and slabs of water holding basins and channels and in walls of belowgrade structures, unless specifically noted otherwise.
2. Join waterstop at intersections to provide continuous seal.
3. Center waterstop on joint.
4. Secure waterstop in correct position. Tie waterstop to reinforcing steel using grommets, “Hog Rings,” or tie wire at maximum spacing of 12 inches. Do not displace waterstop during concrete placement.
5. Repair or replace damaged waterstop.
6. Place concrete and vibrate to obtain impervious concrete in vicinity of joints.
7. Joints in Footings and Slabs:
   a. Ensure that space beneath plastic waterstop is completely filled with concrete.
   b. During concrete placement, make visual inspection of waterstop area.
   c. Limit concrete placement to elevation of waterstop in first pass, vibrate concrete under waterstop, lift waterstop to confirm full consolidation without voids, then place remaining concrete to full height of slab.
8. Plastic Waterstop:
   a. Install in accordance with manufacturer’s written instructions.
   b. Splice in accordance with waterstop manufacturer’s written instructions using Teflon-coated thermostatically controlled heating iron at approximately 380 degrees F.
      1) Allow at least 10 minutes before new splice is pulled or strained in any way.
      2) Finished splices shall provide cross section that is dense and free of porosity with tensile strength of not less than 80 percent of unspliced materials.
      3) Use only factory made waterstop fabrications for all intersections, changes of directions and transitions.

4) Field splice permitted only for straight butt welds.

c. Wire looped plastic waterstop may be substituted for plastic waterstop.

3.04 CONCRETE PLACEMENT INTO FORMWORK

A. Inspection: Notify Engineer and Special Inspector at least one work day in advance before starting to place concrete.

B. Placement into Formwork:

1. Reinforcement: Secure in position before placing concrete.
2. Place concrete as soon as possible after leaving mixer, without segregation or loss of ingredients, without splashing forms or steel above, and in layers not over 1.5 feet deep, except for slabs that shall be placed full depth. Place and consolidate successive layers prior to initial set of first layer to prevent cold joints.
3. Placement frequency shall be such that lift lines will not be visible in exposed concrete finishes.
4. Use placement devices, for example, chutes, pouring spouts, and pumps as required to prevent segregation.
5. Vertical Free Fall Drop to Final Placement:
   a. Forms 8 Inches or Less Wide: 5 feet.
   b. Forms Wider than 8 Inches: 8 feet, except as specified.
6. For placements where drops are greater than specified, use placement device such that free fall below placement device conforms to required value.
   a. Limit free fall to prevent segregation caused by aggregates hitting steel reinforcement.
7. Provide sufficient illumination in the interior of forms so concrete deposition is visible, permitting confirmation of consolidation quality.
8. Joints in Footings and Slabs:
   a. Ensure space beneath plastic waterstop completely fills with concrete.
   b. During concrete placement, make visual inspection of entire waterstop area.
   c. Limit concrete placement to elevation of waterstop in first pass, vibrate concrete under waterstop, lift waterstop to confirm full consolidation without voids, and place remaining concrete to full height of slab.
   d. Apply procedure to full length of waterstop.
9. Trowel and round off top exposed edges of walls with 1/4-inch radius steel edging tool.

C. Conveyor Belts and Chutes:

1. Design and arrange ends of chutes, hopper gates, and other points of concrete discharge throughout conveying, hoisting, and placing system for concrete to pass without becoming segregated.
2. Do not use chutes longer than 50 feet.
3. Wipe clean with device that does not allow mortar to adhere to belt.
4. Cover conveyor belts and chutes.

D. Pumping of Concrete:

1. Provide standby pump, conveyor system, crane and concrete bucket, or other system onsite during pumping, for adequate redundancy to ensure completion of concrete placement without cold joints in case of primary placing equipment breakdown.
2. Minimum Pump Hose (Conduit) Diameter: 4 inches.
3. Replace pumping equipment and hoses (conduits) that are not functioning properly.

E. Retempering: Not permitted for concrete where cement has partially hydrated.

F. Maximum Size of Concrete Placements:

1. Limit size of each placement to allow for strength gain and volume change as a result of shrinkage.
2. Locate expansion, control, and contraction, joints where shown.
3. Construction Joints: Unless otherwise shown or permitted, locate construction joints as follows:
   a. Locate construction joints as shown on Drawings or where approved in the joint location submittal.
   b. Locate expansion, control, and contraction joints where shown on Drawings.
   c. Provide vertical construction joints at maximum spacing of 40 feet unless shown or approved otherwise.
   d. When vertical expansion, contraction or control joint spacing does not exceed 60 feet, intermediate construction joints are not required.
   e. Uniformly space vertical construction joints within straight sections of walls, avoiding penetrations.
4. Consider beams, girders, brackets, column capitals, and haunches as part of floor or roof system and place monolithically with floor or roof system.
5. Should placement sequence result in cold joint located below finished water surface, install waterstop in joint.

G. Minimum Time between Adjacent Placements:

1. Construction or Control Joints: 7 days.
2. Construction joint between top of footing or slab, and column or wall: As soon as can safely be done without damaging previously cast concrete or interrupting curing thereof, but not less than 24 hours.
3. Expansion or Contraction Joints: 1 day.
4. For columns and walls with a height in excess of 10 feet, wait at least 2 hours before depositing concrete in beams, girders, or slabs supported thereon.
5. For columns and walls 10 feet in height or less, wait at least 1 hour prior to depositing concrete in beams, girders, brackets, column capitals, or slabs supported thereon.

3.05 CONSOLIDATION AND VISUAL OBSERVATION

A. Provide at least one standby vibrator in operable condition at placement Site prior to placing concrete.

3.06 COLD WEATHER PLACEMENT

A. Unless otherwise permitted, shall be in accordance with requirements of ACI 301, ACI 306.1 and as follows:

1. Cold weather requirements shall apply when ambient temperature is below 40 degrees F or approaching 40 degrees F and falling.
2. Do not place concrete over frozen earth or against surfaces with frost or ice present. Frozen earth shall be thawed to acceptance of Engineer.
3. Unless otherwise permitted, do not place concrete in contact with surfaces less than 35 degrees F; requirement is applicable to all surfaces including reinforcement and other embedded items.
4. Provide supplemental external heat as needed when other means of thermal protection are unable to maintain minimum surface temperature of concrete as specified in ACI 306.1.
5. Maintain minimum surface temperature of concrete as specified in ACI 306.1 for no less than 3 days during cold weather conditions.
6. Protect concrete from freezing until end of curing period and until concrete has attained a compressive strength of 3,500 psi or design compressive strength if less than 3,500 psi.

B. Provide maximum and minimum temperature sensors placed on concrete surfaces spaced throughout Work to allow monitoring of concrete surface temperatures representative of Work. Unless otherwise permitted, record surface temperature of concrete at least once every 12 hours during specified curing period.

C. External Heating Units: Do not exhaust heater flue gases directly into enclosed area as it causes concrete carbonation as a result of concentrated carbon dioxide.

D. Cure as specified.

3.07 HOT WEATHER PLACEMENT

A. Prepare ingredients, mix, place, cure, and protect in accordance with ACI 301, ACI 305.1, and as follows:

1. Maintain concrete temperature below 95 degrees F at time of placement or furnish test data or other proof that admixtures and mix ingredients do not produce flash set, plastic shrinkage, or cracking as a result of heat of hydration. Cool ingredients before mixing to maintain fresh concrete temperatures as specified or less.
2. Internal concrete temperature in structure shall not exceed 158 degrees F, and maximum temperature differential between center of section and external surfaces of concrete shall not exceed 35 degrees F.
3. Provide for windbreaks, shading, fog spraying, sprinkling, ice, wet cover, or other means as necessary to maintain concrete at or below specified temperature.
4. Cure as specified.

3.08 CONCRETE BONDING

A. Construction Joints at Existing Concrete:

1. Thoroughly clean and roughen existing concrete surfaces to roughness profile of 1/4 inch.
2. Saturate surface with water for 24 hours prior to placing new concrete.

3.09 PREMOLDED JOINT FILLER INSTALLATION

A. Sufficient in width to completely fill joint space where shown.

B. Drive nails approximately 1 foot 6 inches on center through filler, prior to installing, to provide anchorage embedment into concrete during concrete placement.

C. Secure premolded joint filler in forms before concrete is placed.

3.10 FINISHING FORMED SURFACES

A. Provide surface finish 2.0 (SF-2.0) in accordance with ACI 301 and as herein specified.

B. Tie Holes: Unless otherwise specified, fill with specified repair material.

1. Prepare substrate and mix, place, and cure repair material per manufacturer's written recommendations.

C. Alternate Form Ties, Through-Bolts:

1. Mechanically roughen entire interior surface of through hole.
2. Apply bonding agent to roughened surface and drive elastic vinyl plug to half depth.
3. Dry pack entire hole from both sides of plug with nonshrink grout.
4. Use only enough water to dry pack grout.
5. Dry pack while bonding agent is still tacky.
6. If bonding agent has dried, remove bonding agent by mechanical means and reapply new coat of bonding agent.
7. Compact grout using steel hammer and steel tool to drive grout to high density.
8. Cure grout per grout manufacturer's written recommendations.

D. Repair defective areas of concrete.

1. Cut edges perpendicular to surface at least 1/2 inch deep. Do not feather edges. Soak area with water for 24 hours.
2. Patch with specified repair material.
3. Repair concrete surfaces using specified materials. Select system, submit for review, and obtain approval from Engineer prior to use.
4. Develop repair techniques with material manufacturer on surface that will not be visible in final construction prior to starting actual repair work and show how finish color will blend with adjacent surfaces. Obtain approval from Engineer.
5. Obtain quantities of repair material and manufacturer's detailed instructions for use to provide repair with finish to match adjacent surface or apply sufficient repair material adjacent to repair to blend finish appearance.
6. Repair of concrete shall provide structurally sound surface finish, uniform in appearance or upgrade finish by other means until acceptable to Engineer.

E. Inject cracks that leak.

3.11 FINISHING UNFORMED SURFACES

A. General:

1. Use manual screeds, vibrating screeds, or roller compacting screeds to place concrete level and smooth.
2. Do not use "jitterbugs" or other special tools designed for purpose of forcing coarse aggregate away from surface and allowing layer of

mortar, which will be weak and cause surface cracks or delamination, to accumulate.

3. Do not dust surfaces with dry materials nor add water to surfaces.
4. Cure concrete as specified.

B. Slab Tolerances:

1. Exposed Slab Surfaces: Comprise of flat planes as required within tolerances specified.
2. Slab Finish Tolerances and Slope Tolerances: Crowns on floor surface not too high as to prevent 10-foot straightedge from resting on end blocks, nor low spots that allow block of twice the tolerance in thickness to pass under supported 10-foot straightedge.
3. Steel gauge block 5/16 inch thick.
4. Finish Slab Elevation: Slope slabs to floor drain and gutter and shall adequately drain regardless of tolerances.
5. Thickness: Maximum 1/4 inch minus or 1/2 inch plus from thickness shown. Where thickness tolerance will not affect slope, drainage, or slab elevation, thickness tolerance may exceed 1/2 inch plus.

C. Interior Slab Finish: Provide trowel finish unless specified otherwise.

D. Exterior Slab Finish:

1. Provide broom finish unless specified otherwise.
2. Finish exposed edges with steel edging tool.
3. Mark sidewalks transversely at 5-foot intervals with jointing tool.

3.12 EXPOSED METAL OBJECTS

A. Remove metal objects not intended to be exposed in as-built condition of structure including wire, nails, and bolts, by chipping back concrete to depth of 1 inch and then cutting or removing metal object.

B. Repair area of chipped-out concrete as specified for defective areas.

3.13 BLOCKOUTS AT PIPES OR OTHER PENETRATIONS

A. Where shown, install in accordance with requirements of Drawings.

3.14 PROTECTION AND CURING

A. Protect and cure concrete in accordance with requirements of ACI 301, ACI 308.1, and as follows:

1. Protect fresh concrete from direct rays of sunlight, drying winds, and wash by rain.

2. Keep concrete slabs continuously wet for a 7-day period. Intermittent wetting is not acceptable.
3. Use curing compound only where approved by Engineer.
4. Cure formed surfaces with curing compound applied in accordance with manufacturer's written instructions as soon as forms are removed, and finishing is completed.
5. Remove and replace concrete damaged by freezing.
6. Repair areas damaged by construction, using specified repair materials and approved repair methods.

3.15 NONSHRINK GROUT

A. General: Mix, place, and cure nonshrink grout in accordance with grout manufacturer's written instructions.

B. Grouting Machinery Foundations:

1. Block out original concrete or finish off at distance shown below bottom of machinery base with grout. Prepare concrete surface by sandblasting, chipping, or by mechanical means to remove any soft material.
2. Set machinery in position and wedge to elevation with steel wedges or use cast-in leveling bolts.
3. Form with watertight forms at least 2 inches higher than bottom of plate.
4. Fill space between bottom of machinery base and original concrete in accordance with manufacturer's written instructions.

3.16 BACKFILL AGAINST STRUCTURES

A. Do not backfill against walls until concrete has obtained specified 28-day compressive strength.

B. Refer to General Structural Notes on the Drawings for additional requirements, including elevated slab and diaphragm completion prior to backfill.

C. Unless otherwise permitted, place backfill simultaneously on both sides of structure, where such fill is required, to prevent differential pressures.

3.17 FIELD QUALITY CONTROL

A. General:

1. Provide adequate facilities for safe storage and proper curing of concrete test specimens onsite for first 24 hours, and for additional time as may be required before transporting to test lab.
2. Unless otherwise specified, sample concrete for testing for making test specimens, from point of delivery.

3. When concrete is pumped, sample and test air content at point of delivery and at point of placement.
4. Evaluation will be in accordance with ACI 301 and Specifications.
5. Test specimens shall be made, cured, and tested in accordance with ASTM C31/C31M and ASTM C39/C39M.
6. Frequency of testing may be changed at discretion of Engineer.
7. Pumped Concrete: Take concrete samples for slump, ASTM C143/C143M, and test specimens, ASTM C31/C31M and ASTM C39/C39M.
8. If measured air content at delivery is greater than specified limit, check test of air content will be performed immediately on a new sample from delivery unit. If check test fails, concrete has failed to meet requirements of Contract Documents. If measured air content is less than lower specified limit, adjustments will be permitted in accordance with ASTM C94/C94M, unless otherwise specified. If check test of adjusted mixture fails, concrete has failed to meet requirements of Contract Documents. Concrete that has failed to meet requirements of Contract Documents shall be rejected.

B. Concrete Strength Test:

1. Unless otherwise specified, one specimen at age of 7 days for information, and two 6-inch diameter or when permitted three 4-inch diameter test specimens at age of 28 days for acceptance.
2. If result of 7-day concrete strength test is less than 50 percent of specified 28-day strength, extend period of moist curing by 7 additional days.
3. Provide a minimum of one spare test specimen per sample. Test spare cylinder as directed by Engineer.

C. High Range Water Reducer (Superplasticizer) Admixture Segregation Test: Test each truck prior to use on Job.

1. Segregation Test Objective: Concrete shall stay together when slumped. Segregation is assumed to cause mortar to flow out of mix even though aggregate may stay piled enough to meet slump or slump flow test.
2. Test Procedure: Make slump or slump flow test and check for excessive slump or slump flow and observe to see if mortar or moisture flows from slumped concrete.
3. Reject concrete if mortar or moisture separates and flows out of mix.

D. Cold Weather Placement Tests:

1. During cold weather concreting, cast cylinders for field curing as follows. Use method that will produce greater number of specimens:
   a. Six extra test cylinders from last 100 cubic yards of concrete.
   b. Minimum three specimens for each 2 hours of placing time or for each 100 cubic yards.
2. These specimens shall be in addition to those cast for lab testing.
3. Protect test cylinders from weather until they can be placed under same protection provided for concrete of structure that they represent.
4. Keep field test cylinders in same protective environment as parts of structure they represent to determine if specified strength has been obtained.
5. Test cylinders in accordance with applicable sections of ASTM C31/C31M and ASTM C39/C39M.
6. Use test results to determine specified strength gain prior to falsework removal.

E. Slab Finish Tolerances and Slope Tolerances:

1. Support 10-foot long straightedge at each end with steel gauge blocks of thicknesses equal to specified tolerance.
2. Compliance with designated limits in four of five consecutive measurements is satisfactory, unless defective conditions are observed.

3.18 SUPPLEMENTS

A. Requirements of concrete mix designs following “End of Section,” are a part of this Specification and supplement requirements of Part 1 through Part 3 of this section:

1. Concrete Mix Design, Class 5000F1S1P0C2.
2. Concrete Mix Design, Class 4000F1S1P0C1.

END OF SECTION

CONCRETE MIX DESIGN, CLASS 5000F3S1P2C2

A. Mix Locations: Typical, unless otherwise specified.

B. Exposure Categories and Classifications: F1S1P0C2.

C. Mix Properties:

1. Limit water to cementitious materials ratio (W/Cm) in mix design to maximum value of 0.40.
2. Minimum concrete compressive strength (f'c) shall be 5,000 psi at 28 days.
3. Air-entraining admixtures are prohibited in concrete mixtures and total air content shall not be greater than 3 percent, for the following:
   a. Slabs to receive hard-troweled finish.
   b. Slabs to receive dry shake floor hardener.
   c. Slabs to receive topping placed monolithically as two-course floor on top of plastic concrete.
4. Unless otherwise specified, provide air content based on nominal maximum size of aggregate as follows:

Nominal Maximum Aggregate Size in.‡	Air Content (%)*
3/8	7.5
1/2	7.0
3/4	6.0
1	6.0
1-1/2	5.5
2§	5.0
3§	4.5

‡See ASTM C33/C33M for tolerance on oversize for various nominal maximum size designations.

*Tolerance of air content is ±1-1/2 percent.

§Air contents apply to total mixture. When testing concretes, however, aggregate particles larger than 1-1/2 inches are to be removed by sieving and air content will be measured on sieved fraction (tolerance on air content as delivered applies to this value). Air content of total mixture is computed from value measured on the sieved fraction passing the 1-1/2-inch sieve in accordance with ASTM C231/C231M.

5. Limit supplementary cementitious materials measured as a percent of weight of total cementitious materials in mix design, as follows:
    a. Fly Ash and other Pozzolans: 25 percent.
    b. Slag Cement: 50 percent.
    c. Combined Fly Ash and other Pozzolans and Slag Cement: 50 percent, with fly ash and other pozzolans not exceeding 25 percent.
    d. Total cementitious materials include ASTM C150/C150M and ASTM C595/C595M cement.
        1) Fly ash and other pozzolans in Type IP, blended cement, ASTM C595/C595M.
        2) Slag used in the manufacture of an IS blended cement, ASTM C595/C595M.
6. Provide cementitious materials in accordance with one of the following:
    a. ASTM C150/C150M Type II; inclusion of supplementary cementitious materials in design mix is optional.
    b. ASTM C150/C150M types other than Type II, plus supplementary cementitious materials in accordance with one of the following:
        1) Tricalcium Aluminate Content of Total Cementitious Materials: Maximum 8 percent by weight.
        2) Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.
    c. ASTM C595/C595M Type IP or Type IS (less than 70), tested to comply with moderate sulfate resistance option (MS).
        1) Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.
7. Unless otherwise permitted, minimum cementitious materials content in mix design shall be as follows:
    a. 515 pounds per cubic yard for concrete with 1-1/2-inch nominal maximum size aggregate.
    b. 535 pounds per cubic yard for 1-inch nominal maximum size aggregate.
    c. 560 pounds per cubic yard for 3/4-inch nominal maximum size aggregate.
    d. 580 pounds per cubic yard for 1/2-inch nominal maximum size aggregate.
    e. 600 pounds per cubic yard for 3/8-inch nominal maximum size aggregate.
    f. Unless otherwise permitted, limit cementitious materials content to 100 pounds per cubic yard greater than specified minimum cementitious materials content in mix design.

8. Limit water-soluble, chloride-ion content in hardened concrete to 0.10 percent, unless otherwise specified.
    a. Limits are stated in terms of chloride ions in percent by weight of cement.
    b. Unless otherwise permitted, provide documentation from concrete tested in accordance with ASTM C1218/C1218M at an age between 28 days and 42 days.

D. Refer to PART 1 through PART 3 of this section for additional requirements.

CONCRETE MIX DESIGN, CLASS 4000F1S1P0C1

A. Mix Locations:

1. Electrical duct banks.
2. Pipe encasements that are not cast monolithically with concrete base mats or slabs.
3. Where specified in Contract Documents.

B. Exposure Categories and Classifications: F1S1P0C1.

C. Mix Properties:

1. Limit water to cementitious materials ratio (W/Cm) in mix design to maximum value of 0.45.
2. Minimum concrete compressive strength (f'c) shall be 4,000 psi at 28 days.
3. Air-entraining admixtures are prohibited in concrete mixtures and total air content shall not be greater than 3 percent, for the following:
   a. Slabs to receive hard-troweled finish.
   b. Slabs to receive dry shake floor hardener.
   c. Slabs to receive topping placed monolithically as two-course floor on top of plastic concrete.
4. Unless otherwise specified, provide air content based on nominal maximum size of aggregate as follows:

Nominal Maximum Aggregate Size in. ‡	Air Content (%)*
3/8	6.0
1/2	5.5
3/4	5.0
1	4.5
1-1/2	4.5
2§	4.0
3§	3.5

Nominal Maximum Aggregate Size in. ‡	Air Content (%)*
‡See ASTM C33/C33M for tolerance on oversize for various nominal maximum size designations. *Tolerance of air content is ±1-1/2 percent. §Air contents apply to total mixture. When testing concretes, however, aggregate particles larger than 1-1/2 inches are to be removed by sieving and air content will be measured on the sieved fraction (tolerance on air content as delivered applies to this value). Air content of total mixture is computed from value measured on the sieved fraction passing the 1-1/2-inch sieve in accordance with ASTM C231/C231M.	

5. Provide cementitious materials in accordance with one of the following:
   a. ASTM C150/C150M Type II; inclusion of supplementary cementitious materials in design mix is optional.
   b. ASTM C150/C150M types other than Type II, plus supplementary cementitious materials in accordance with one of the following:
      1) Tricalcium Aluminate Content of Total Cementitious Materials: Maximum 8 percent by weight.
      2) Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.
      3) ASTM C595/C595M Type IP or Type IS (less than 70), tested to comply with moderate sulfate resistance option (MS).
         a) Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.
6. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent, unless otherwise specified.
   a. Limits are stated in terms of chloride ions in percent by weight of cement.
   b. Unless otherwise permitted, provide documentation from concrete tested in accordance with ASTM C1218/C1218M at an age between 28 days and 42 days.

D. Refer to PART 1 through PART 3 of this section for additional requirements.

SECTION 04 21 13.13
MASONRY VENEER

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C144, Standard Specification for Aggregate for Masonry Mortar.
   b. C150/C150M, Standard Specification for Portland Cement.
   c. C207, Standard Specification for Hydrated Lime for Masonry Purposes.
   d. C216, Standard Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale).
   e. C270, Standard Specification for Mortar for Unit Masonry.
   f. C979/C979M, Standard Specification for Pigments for Integrally Colored Concrete.
   g. D1056, Standard Specification for Flexible Cellular Materials—Sponge or Expanded Rubber.
   h. E2178, Standard Test Method for Air Permeance of Building Materials.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Manufacturer’s product information for each different item specified.
   b. Mix designs for mortar.
   c. Details for special brick shapes and assemblies.
2. Samples:
   a. Full-size units for each different exposed masonry unit required showing full range of exposed color, texture, and dimensions to be expected in completed construction. Match selected Samples at Engineer’s office or listed in Finish Schedule.
      1) Include size variation data verifying that actual range of sizes for brick falls within ASTM C216 dimension tolerances for brick where modular dimensioning is indicated.
   b. Colored masonry mortar Samples for each color required showing full range of colors expected in finished construction. Label Samples to indicate type and amount of colorant used.

B. Informational Submittals:

1. Experience record of mortar color pigment proposed for use.
2. Manufacturer's certificate of compliance for masonry units specified herein.
3. Method and materials for removal of efflorescence.

1.03 QUALITY ASSURANCE

A. Regulatory Requirements: For masonry construction meet requirements of the Connecticut State Building Code and as supplemented by these Specifications.

B. Mockups: Lay up a Sample panel for each type of masonry at the Site including reinforcing, air and water barrier, insulation, and veneer ties. Show bond pattern and method of finishing joints. Make Sample panels 8 feet high and 8 feet long, including base of wall flashing and one masonry control joint. Remove mockup after acceptance of permanent masonry Work. Acceptable Sample panel serves as a basis of color, texture, pattern, and workmanship for acceptance of the permanent construction.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage and Protection:

1. Store all masonry materials off ground and protected from precipitation.
2. Protect veneer materials from mud splatters and staining.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Temperature: Do not lay masonry when ambient temperature is below 32 degrees F on a rising temperature or below 40 degrees F on a falling temperature, or when there is a probability of such conditions occurring within 48 hours, unless express approval of Engineer is obtained. In such case, make special provisions for heating materials and protecting finished Work. Protect masonry against freezing for a minimum of 48 hours after being laid. Protect tops of walls from precipitation at all times. Cover with waterproof paper when rain or snow is imminent, and the Work is discontinued.

B. Humidity: Protect masonry construction from direct exposure to wind and sun when erected in an ambient air temperature of 99 degrees F (37 degrees C) in the shade with relative humidity less than 50 percent.

PART 2 PRODUCTS

2.01 MASONRY UNITS

A. Color, Texture, and Pattern: Match existing brick as approved by Engineer.

B. Facing Brick:

1. ASTM C2l6, Grade SW, Type FBX.
2. Minimum compressive strength for individual brick, 2,500 psi.
3. Actual Size: 3-5/8 inches by 2-1/4 inches by 7-5/8 inches.

2.02 MORTAR MATERIALS

A. Portland Cement: ASTM C150, Type I, low alkali content (0.60 percent maximum).

B. Lime: ASTM C207, Type S.

C. Mortar: ASTM C270, Type S. Consisting of one part portland cement, from 1/4 part to 1/2 part lime putty or hydrated lime, and clean well-graded sand in the proportion of three times the sum of the cementitious material; or 1/2 part portland cement, one part masonry cement, and clean well-graded sand in the proportion of three times the sum of the cementitious material.

1. If color is added, add in a consistent manner to provide final uniformity.
2. No antifreeze liquid, salts, or other substances are allowed to lower freezing point. No calcium chloride is allowed in mortar.

D. Tuck-Pointing Mortar: Prehydrated Type N, one part portland cement, one part Type S hydrated lime, and six parts sand, by volume.

E. Mortar Color:

1. Pure, concentrated mineral, pigment specially processed for mixing in to mortar; ASTM C979.
2. Manufacturer and Product:
   a. Davis Colors, True Tone Cement Colors.
   b. Solomon Colors, Mortar Colors.
3. Color: Match existing mortar as approved by Engineer.

F. Sand: ASTM C144, in addition not less than 5 percent passes the No. 100 sieve.

G. Water: Fresh, clean, and free of deleterious acids, alkalies, chlorides, and organic materials.

2.03 MORTAR PREPARATION

A. Place one-half the water and aggregate in operating mixer; add cement; add remaining aggregate and water and mix for at least 2 minutes. Add lime and continue mixing as long as needed to secure a uniform mass, but no less than 3 minutes after the addition of lime. Time the addition of admixture in strict accordance with manufacturer's instructions and the procedure used for adding it to the mix shall provide good dispersion.

B. Mix mortar in machine with mixing drums clean and free of debris and dried mortar. Use mortar before the initial setting of the cement has taken place. Do not retemper mortar in which the cement has started to set.

C. Retemper mortar boards by adding water within a basin formed with the mortar and the mortar reworked into the water. Dashing or pouring water over mortar and retempering of harsh, nonplastic mortar is not permitted.

D. Where color tinting of mortar is required, add sufficient lime-proof color-fast mineral pigment to mortar.

2.04 MASONRY CONTROL JOINTS

A. ASTM D1056, closed cell neoprene sponge, 3 inches wide by 3/8 inch thick.

2.05 COMPRESSIBLE PADS

A. ASTM D1056, closed cell neoprene sponge, 3 inches wide by 1/4 inch thick, with pressure sensitive adhesive applied on one side.

2.06 FLUID APPLIED VAPOR RETARDER

A. Air and water barrier, fluid applied, one component, vapor permeable membrane, cures on masonry or concrete surfaces to form a resilient, monolithic, fully-bonded elastomeric sheet, 40 mils minimum dry thickness, meeting requirements of ASTM E2178 for air permeance.

B. Manufacturers and Products:

1. Grace, Perma-A-Barrier Liquid VP.
2. Hohmann and Barnard, Inc.; Textroflash Liquid VP.

2.07 MASONRY VENEER ANCHORS

A. Horizontal Joint Reinforcement:

1. Stainless steel.
2. Horizontal ladder eye with seismic hook anchors and continuous wire.
3. Two parallel No. 9 wires weld connected to No. 9 perpendicular cross wire and double wire eyes at 16 inches on center.

4. Double Wire Seismic Hooks: 9-gauge stainless steel wire Pintel swaged for insertion of continuous wire.
5. Continuous Wire: 9-gauge stainless steel wire.
6. Clean and free from loose rust, scale, and any coatings that reduce bond.
7. Furnish special manufactured corner and wall intersection pieces.
8. Manufacturers and Products:
    a. Hohmann and Barnard, Inc.; 270 ML Ladder and SH Hook and Wire.
    b. Wire-Bond; Series 800 Ladder Level - Eye, Seismic Hook and Wire.

B. Dovetail Slots and Anchors:

1. Stainless steel.
2. 20-gauge stainless steel anchor slots with mating anchors.
3. 16-gauge stainless steel anchor tie. Tie length as required by 1-1/4-inch minimum width, swagged to engage 9-gauge horizontal wire.
4. Manufacturers and Products:
    a. Hohmann and Barnard, Inc.; 305 Slot and 303-SV Anchor with Wire.
    b. Wire-Bond; 1304 Slot and 2222 Anchor with Wire.

2.08 WEEP HOLES

A. Honeycomb, polypropylene; 3/8 inch by size of head joint; match color of mortar.

B. Manufacturers and Products:

1. Hohmann and Barnard; QV Quadro Vent.
2. Wire-Bond; 3601 Cell Vent.

2.09 MORTAR BLOCK

A. HDPE mesh specifically designed to trap or block mortar droppings in masonry cavity walls allowing free passage of trapped water to weep holes below; 10 inches high by thickness of wall cavity.

B. Manufacturers and Products:

1. Hohmann and Barnard; Mortar Trap.
2. Heckmann Building Products; Weep-Thru Mortar Deflector.

2.10 MASONRY ACCESSORIES AND ANCILLARY MATERIALS

A. Through Wall Flashing and Reglets: As specified in Section 07 62 00, Sheet Metal Flashing and Trim.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other specific conditions, and other conditions affecting performance of masonry veneer.

B. Examine rough-in and built-in construction to verify actual locations of piping connections prior to installation.

C. Do not proceed until unsatisfactory conditions have been corrected.

3.02 FLUID APPLIED VAPOR RETARDER

A. Cleaning of Substrate:

1. Thoroughly clean surfaces to receive membrane following membrane manufacturer's recommendations.
2. Treat as necessary to remove laitance, loose material on surface, grease, oil, and other contaminants that will affect bond of the membrane.
3. Vacuum clean or clear water wash surfaces and allow to dry completely.

B. Fill voids and control joints with sealant and overcoat with nonflow membrane material. Fill or coat visible shrinkage cracks to minimum 2 inches either side of crack.

C. Follow manufacturer's directions for application including limitations because of weather, temperature, and concrete cure time. Apply by brush or spray following manufacturer's recommended coverage and coating rates.

3.03 GENERAL INSTALLATION

A. Provide or cut special shapes for corners, jambs, lintels, and other areas as shown or as required. Match color and texture of standard units.

B. Cut masonry units with motor-driven saws to provide clean, sharp, unchipped edges. Cut units as required to provide continuous pattern and to fit adjoining construction. Use full-size units without cutting where possible.

C. Matching Existing Masonry: Match coursing, bonding, color, and texture of new masonry with existing masonry.

D. Anchoring:

1. Anchor all veneer types to structural backing wall or to structural columns as shown on Drawings and in conformance to the Connecticut State Building Code.

2. Anchor masonry veneer to concrete backing with dovetail anchor ties and to CMU backing with horizontal joint reinforcement.
3. Maintain a space not less than 1 inch wide between masonry wall and concrete members.
4. Keep space free of mortar or other rigid material to permit differential movement between backing wall and masonry.
5. Attach veneer to backing with anchor ties.
   a. Use one anchor tie for each 1.77 square feet of wall area.
   b. Maximum Space between Adjacent Ties:
      1) Vertically: 16 inches.
      2) Horizontally: 24 inches.
   c. Embed ties at least 2 inches in horizontal joint of veneer. Engage or swag a continuous horizontal wire into each anchor tie.
   d. Provide additional ties at openings:
      1) Maximum Spacing Around Perimeter: 24 inches.
      2) Install within 12 inches of opening.

3.04 MASONRY VENEER WALL CONSTRUCTION—GENERAL

A. Mortar Beds: Lay masonry with full mortar coverage on horizontal and vertical joints. Rock closures into place with head joints thrown against two adjacent units in-place. Do not pound corners or jambs to fit stretcher units after setting in-place. Where adjustment to corners or jambs must be made after mortar has started to set, remove mortar and replace with fresh mortar.

B. Horizontal and Vertical Face Joints:

1. Nominal Thickness: 3/8 inch.
2. Construct uniform joints.
3. Shove vertical joints tight.
4. Tool joints concave in exposed surfaces when thumbprint hard using jointing tool.
5. Concave tool exterior joints below grade.
6. Flush cut all joints not tooled.
7. Fill horizontal joints between top of masonry partition and underside of concrete beams with mortar.

C. Tuck-Point Joints:

1. Rake mortar joints to a depth of 1/2 inch to 3/4 inch.
2. Saturate exposed joints with clean water.
3. Fill joints solidly with pointing mortar.
4. Tool joints to match existing.

D. Movement Joints: Keep clean of all mortar and debris.

E. Masonry Control Joints:

1. Provide continuous vertical control joints in masonry as shown on Drawings.
2. Omit mortar from vertical joints. Place control joint material as wall is built.

F. Through-Wall Flashing:

1. Place flashing on bed of mortar.
2. Lap cross joints of through-wall flashing at least 2 inches.
3. Extend flashing beyond exterior face of wall and provide drip edge.
4. Cover flashing with mortar.

G. Mortar Block: Install continuously in cavity space on flashing against inside face of brick veneer, zig-zag side up. No adhesive or fasteners required. Follow manufacturer's recommendations.

H. Flashing: Clean surface of masonry smooth and free from projections that might puncture, gouge, or otherwise damage flashing material.

I. Weep Holes: Provide weep holes in head joints in first course immediately above all flashing leaving head joint free and clean of mortar. Also install weep hole vents in head joints on top of masonry veneer walls.

1. Maximum Spacing: 24 inches OC.
2. Keep weep holes and area above flashing free of mortar droppings.

J. Sealant Joints:

1. Retain sealant joints around outside perimeters of exterior doors, window frames, and other wall openings:
   a. Uniform Depth: 3/4 inch.
   b. Uniform Width: 1/4 inch.

K. Pointing: Cut out defective joints and holes in exposed masonry and repoint with mortar. Dry brush masonry surface after mortar has set at end of each day's Work and after final pointing.

3.05 BRICK VENEER INSTALLATION

A. General: Do not install cracked, broken, or chipped masonry units exceeding ASTM C216 allowances. Thoroughly wet brick just before laying except in freezing weather where bricks are laid dry. Prewetting may also be omitted if the brick at the time of laying has a rate of absorption not exceeding 0.025 ounce of water per square inch of surface after being placed in 1/8 inch of water for 1 minute.

1. Coordinate installation with backup walls, through wall flashing, and other construction. Use masonry saws to cut and fit exposed units. Lay brick plumb, true to line, with level courses accurately spaced, and do not furrow bed joints.
2. Finish horizontal run by racking back in each course; toothing not permitted. Adjust all units to final position while mortar is soft and plastic. If units are displaced after mortar has stiffened, remove, clean joints and units of mortar, and relay with fresh mortar.
3. Bond unexposed units in wythe by lapping a minimum of 2 inches. Adjust shelf angles to keep Work level at proper elevation. Provide pressure relieving joints by placing a continuous compressible pad under the shelf angle.
4. When joining fresh masonry to set or partially set masonry:
   a. Remove loose brick and mortar.
   b. Clean and lightly wet exposed surface of set masonry prior to laying fresh masonry.

B. Pattern: Lay brick in running bond.

3.06 CLEANING

A. Follow masonry and mortar color manufacturer's recommendations for use of cleaning agents.

B. Application:

1. Thoroughly wet surface of masonry on which no efflorescence appears before using cleaning agent.
2. Scrub with acceptable cleaning agent.
3. Immediately rinse with clean water.
4. Work small sections at a time.
5. Work from top to bottom.
6. Protect sash, metal lintels, and other materials, which may corrode when masonry is cleaned with acid solution.
7. Remove efflorescence in accordance with masonry manufacturer's recommendations.

C. Leave Work area and surrounding surfaces clean and free of mortar spots, droppings, and broken masonry.

3.07 FIELD QUALITY CONTROL AND QUALITY CONTROL

A. At least once a week while installation of masonry veneer is in progress, take mortar Samples for testing. Continue on that basis for duration of installation of masonry veneer at discretion of Engineer.

B. Take Samples in accordance with ASTM C270.

C. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in Statement of Special Inspections Plan in Supplement located at end of Section 01 45 33, Special Inspection, Observation, and Testing. Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection, Observation, and Testing.

D. Contractor-Furnished Quality Control: Inspect and test as required in Section 01 45 16.13, Contractor Quality Control.

3.08 PROTECTION

A. Wall Covering: During erection, cover top of wall with strong waterproof membrane at end of each day or shutdown and as follows:

1. Cover partially completed walls when Work is not in progress.
2. Extend cover minimum of 24 inches down both sides.
3. Hold cover securely in-place.

B. Protect sills, ledges, and offsets from mortar drippings or other damage during construction. Remove misplaced mortar immediately. Protect face materials against staining. Protect the door jambs and corners from damage during construction.

END OF SECTION

SECTION 04 22 00
CONCRETE UNIT MASONRY

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A82/A82M, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
   b. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   c. C33, Standard Specification for Concrete Aggregates.
   d. C90, Standard Specification for Loadbearing Concrete Masonry Units.
   e. C140, Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units.
   f. C144, Standard Specification for Aggregate for Masonry Mortar.
   g. C150, Standard Specification for Portland Cement.
   h. C207, Standard Specification for Hydrated Lime for Masonry Purposes.
   i. C270, Standard Specification for Mortar for Unit Masonry.
   j. C404, Standard Specification for Aggregates for Masonry Grout.
   k. C476, Standard Specification for Grout for Masonry.
   l. C618 12 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
   m. C744, Standard Specification for Prefaced Concrete and Calcium Silicate Masonry Units.
   n. C979, Pigments for Integrally Colored Concrete.
   o. C989, Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars.
   p. C1314, Standard Test Method for Compressive Strength of Masonry Prisms.
   q. C1403, Standard Test Method for Rate of Water Absorption of Masonry Mortars.
   r. E514/E514M, Standard Test Method for Water Penetration and Leakage through Masonry.
2. The Masonry Society (TMS):
   a. TMS 402/ACI 530/ASCE 5; Building Code Requirements for Masonry Structures and Companion Commentaries. (MSJC Code and Commentary).
   b. TMS 602/ACI530.1/ASCE6; Specification for Masonry Structures.

c. 602/American Concrete Institute ACI 530.1/ASCE 6, Specification for Masonry Structures and Companion Commentaries. (Masonry Standards Joint Committee Specifications and Commentary).

3. International Code Council (ICC):
   a. International Building Code (IBC).
   b. ICC Evaluation Service (ICC-ES) Reports.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings.
2. Data Sheets:
   a. Horizontal joint reinforcement.
   b. Preformed control joint materials.
   c. Grout mix design.
   d. Mortar proportions. Prebagged mortar properties and data sheets.
   e. Grout sand gradation in accordance with ASTM C404.
3. Samples:
   a. Two of each type of masonry unit to be used on Project from the proposed manufacturer.
   b. Mortar colors for color selection.

B. Informational Submittals:

1. Method and Location of Placing Grout: High lift or low lift.
2. Mix design test results.
3. Certifications:
   a. Units comply with ASTM C55 and ASTM C90.
   b. Grout test results conform to ASTM C1019.
   c. Grout aggregates conform to requirements of ASTM C33, including nonreactivity.
   d. Mortar sand conform to requirements of ASTM C144.
4. Test results of Project samples from masonry unit manufacturer stating that units comply with ASTM C90. Documentation of material testing shall be one less than 1 year old.
5. Test results of proposed grout mix deign stating that units comply with ASTM C1019. Documentation of material testing shall be 1 year old or less.
6. Test reports stating aggregates for mortar meet requirements of ASTM C144.
7. Test reports or letter of certification stating aggregates for grout meet requirements of ASTM C404.
8. Method and materials for removal of efflorescence.

9. Field test results to qualify materials.
    a. Grout tests in accordance with ASTM C1019.

1.03 QUALITY ASSURANCE

A. Mockups:

1. Lay up Sample panel for each type of masonry at Site.
2. Dimensions: Minimum 4 feet high by 4 feet long.
3. Use approved materials and procedures.
4. May be part of permanent construction.
5. Approved panels shall serve as basis of color, texture, bond, quality of finished joints, surface applied finishes, and for acceptance of permanent construction.
6. Demonstrate ability to keep grout isolated and in certain cells during any sequence of placement, and to demonstrate materials will be restricted to cells and bond beams intended to receive grout.
7. Construction shall show areas required to receive mortar, including webs on each side of each grouted cell to prevent grout from entering adjacent cells or courses.
8. Where bond beams are to be used, demonstrate proper placement of grout to bond beam level, and proper placement of bond beam prior to placement of grout above bond beam level.
9. Demonstrate proper use of running bond.
10. Compliance Requirements: For masonry finish and appearance, dimension tolerances, tolerances of construction, joint tolerances, and wall plumb tolerances, comply with the requirements and criteria of NCMA, ASTM C90, and TMS 602.1.

B. Preinstallation Conference:

1. Required Meeting Attendees:
    a. Masonry subcontractor, including masonry foreman.
    b. Ready-mix producer.
    c. Admixture representative.
    d. Testing and sampling personnel.
2. Schedule and conduct prior to start of masonry construction.
3. Notify Engineer of location and time.
4. Agenda shall include:
    a. High lift and low lift procedures.
    b. Mortar, grout, unit, and reinforcing submittals.
    c. Types and locations of rebar splices.
    d. Joint tooling.
    e. Admixture types, dosage, performance, and redosing at Site.
    f. Mix designs and test of mix.
    g. Placement methods, techniques, equipment, consolidation, and reconsolidation.

h. Protection procedures for environmental conditions.
i. Other specified requirements requiring coordination.

5. Submit conference minutes as specified in Section 01 31 19, Project Meetings.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage and Protection: Keep units and mortar/grout cementitious ingredients, including lime, dry.

PART 2 PRODUCTS

2.01 COMPRESSIVE STRENGTH OF MASONRY ASSEMBLAGE

A. Minimum 28-Day Specified Compressive Strength (f'm) of Masonry: 2,000 psi.

2.02 CONCRETE MASONRY UNITS (CMU)

A. ASTM C90: Normal weight.

1. Net Area Compressive Strength: 2,800 psi minimum, in accordance with TMS 602, Table 2.
2. Nominal Size:16 inches long by 8 inches high by thickness shown on Drawings.
3. Color of Units: Natural.
4. Surface Texture on Exposed Surfaces: Smooth.
5. Surface Texture: Smooth on interior, concealed exterior, and surface 1 foot below finished grade.

B. General Concrete Masonry Unit (CMU) Requirements:

1. Furnish or cut special shapes for corners, jambs, lintels, and other areas shown or required.
2. Special units shall match color and texture of standard units.
3. Where units are placed so end of unit is exposed, such as at a corner or intersection, exposed end of that block shall have surface to match color and texture of sides of other units.
4. Furnish sound, dry, clean units free of cracks, prior to placing in structure.
5. Vertical Cells to be Grouted: Capable of alignment sufficient to maintain clear, unobstructed continuous vertical cell dimensions in accordance with TMS 602, Table 7.
6. Masonry unit size and shape shall allow for all placement patterns. Use vertical grout dams to prevent materials, such as grout, from escaping from cell being filled to adjacent cells where material is not intended to be placed.

2.03 MORTAR MATERIALS

A. Portland Cement-Lime Mortar:

1. ASTM C270.
2. Cement: ASTM C150, Type I and Type II portland cement.
3. Lime: ASTM C207, Type S hydrated.
4. Aggregates:
   a. Non-reactive in accordance with ASTM C33, Appendix X1.
   b. Mortar: ASTM C144, sand.

B. Water: Fresh, clean, and potable.

C. Mortar Color Admixture:

1. Meet the requirements of ASTM C979.
2. Manufacturer and Product: Davis Colors, Los Angeles, CA; True Tone Mortar Color.
3. Color shall be selected by Architect.

2.04 GROUT MATERIALS

A. Cement: ASTM C150, Type I and Type II portland cement.

B. Fly Ash: Fly Ash (Pozzolan): Class F and Class C fly ash in accordance with ASTM C618.

C. Slag Cement: In accordance with ASTM C989, Grade 100 or Grade 120.

D. Lime: ASTM C207, Type S hydrated.

E. Aggregates:

1. ASTM C404, fine and coarse.
2. Non-reactive in accordance with ASTM C33, Appendix X1.

F. Water: Fresh, clean, and potable.

2.05 REINFORCEMENT

A. Reinforcement: Clean and free from loose rust, scale, and coatings that reduce bond.

B. Deformed Bars: As specified in Section 03 30 10, Structural Concrete.

C. Horizontal Joint Reinforcement:

1. Two parallel, ASTM A82/A82M, No. 9 wires, galvanized in accordance with ASTM A153/A153M, weld connected to No. 9 perpendicular or diagonal cross wire at 16 inches, maximum, center.
2. Furnish special manufactured corner and wall intersection pieces.
3. Manufacturer: Dayton Superior/Dur-O-Wal, Dayton, OH.

2.06 PREFORMED CONTROL JOINTS

A. Solid rubber cross-shape extrusions as manufactured by:

1. Dayton Superior/Dur-O-WalDayton, OH; DA 2001 Control Joint Regular Rubber.
2. Hohmann and Barnard, Inc, Hauppauge, NY; #RS-Standard.

2.07 MORTAR MIXES

A. In accordance with ASTM C270, Type S and MSJC Specifications.

B. Mix Method:

1. Proportion Method: Proportion per Table 1 of ASTM C270.

2.08 GROUT MIXES

A. Compressive Strength Property:

1. Minimum 2,000 psi at 28 days. Grout strength shall not exceed two times the minimum specified strength.

B. Mix Design:

1. Proportions:
   a. Design mix to meet property/strength requirements.
   b. Where fly ash or slag is included in mix, fly ash or slag content shall be a minimum of 25 percent and a maximum of 40 percent of weight of total cementitious materials.
2. Slump: 8-inch minimum, 11-inch maximum.

C. Mixing:

1. Do not use water reducers, air entrainment, plasticizing, high-range water reducers, or other non-specified admixtures in grout mixes.
2. Transit-Mixed Grout: Meet requirements of ASTM C476.
3. For high lift grouting, add approved grout expansion admixture in accordance with manufacturer’s recommendations.
4. Fluid consistency suitable for placing without segregation with a slump of 8 inches to 11 inches.

PART 3 EXECUTION

3.01 GENERAL

A. Meet requirements of 2021 IBC, Chapter 21 and 2013 The Masonry Society (TMS) 602/American Concrete Institute (ACI)530.1/ASCE 6, Specification for Masonry Structures and Companion Commentaries (MSJC), Part 3, Execution, except as modified in this section.

B. Moisture Protection:

1. Keep units dry while stored on Site.
2. Do not wet units prior to laying.

C. Provide measures to prevent moisture from entering incomplete walls and open cells.

D. Cold Weather: Meet requirements of MSJC Specification Section “Cold Weather Construction”.

E. Hot Weather: Meet requirements of MSJC Specification Section “Hot Weather Construction”.

F. After construction during cold weather, maintain newly constructed masonry temperature above 32 degrees F for a minimum of 24 hours using MSJC or other approved cold weather methods.

G. After construction and during hot weather, fog spray newly constructed masonry in accordance with MSJC hot weather construction requirements.

3.02 PREPARATION

A. Concrete Foundations: Meet tolerance requirements of ACI 117 prior to starting any masonry work.

B. Prepare surface contact area of foundation concrete for initial mortar placement by removing laitance, loose aggregate, and other materials, and anything that would prevent mortar from bonding to foundation.

C. Patch or grind out-of-tolerance foundation surfaces to receive mortar prior to starting masonry work.

D. Clean reinforcement dowels and projecting embeds by removing laitance, spillage, or items that will adversely affect grout bond.

E. Prevent surface damage to foundation concrete that will be exposed to view outside of contact area.

3.03 LAYING MASONRY UNITS

A. General:

1. Finish Tolerances (Measured on Interior Surfaces): Meet requirements of “Site Tolerance” requirements of Part 3, Execution, of the MSJC Specifications.
2. Place units with chipped edges or corners such that chipped area is not exposed to view.

B. Wall Units:

1. General:
   a. If necessary to move a unit after once set in-place, remove from wall, clean, and set in fresh mortar.
   b. Toothing of masonry units is not permitted.
2. Running Bond:
   a. Unless otherwise shown, lay up walls in straight, level, and uniform courses using a running bond pattern.
   b. Place units for continuous vertical cells and mortar joints to prevent materials, such as grout, from escaping from cell being filled to adjacent cells where material is not intended to be placed.
   c. Corners: Lay standard masonry bond for overlapping units and grout solid.
   d. Intersecting Walls: Half unit appearance shall not extend and be visible on exterior side of intersecting wall. Provide hooked corner bars in bond beam units and joint reinforcement as shown on Drawings.
3. Special Shapes:
   a. Provide and place such special units as corner block, doorjamb block, lintel block fillers, and similar blocks as may be required.
   b. Use required shapes and sizes to work to corners and openings, maintaining proper bond throughout wall.

3.04 BUILT-IN ITEMS

A. Position door frames, windows, vents, louvers, and other items to be built in wall, and construct wall around them.

B. Install masonry anchors to secure items to wall.

C. Fill spaces around items with grout except use mortar at mortar joints.

D. Do not place electrical, instrumentation, or water conduits in a cell containing parallel reinforcement, unless approved in writing by Engineer. Additionally, pipes, sleeves, and conduits shall meet requirements of TMS 402/ACI 530/ASCE 5, Building Code Requirements for Masonry Structures (MSJC Code) and MSJC specification construction requirements.

3.05 MORTAR JOINTS

A. General:

1. Meet masonry erection requirements of MSJC, Part 3, Execution, 3.3B.
2. As units are laid, remove excess mortar from grout space of cells to be filled. Final grout space, including any remaining mortar projections, shall be as required by MSJC Table “Grout Space Requirements”.
3. Place mortar before initial setting of cement takes place. Retemper only as required for it to remain plastic. Retempering of colored mortar is not allowed.

B. Exposed Joints:

1. Tool joints exposed to view after final construction, unless otherwise noted or shown.
2. Cut joints flush and as mortar takes its initial set; tool to provide a concave joint.
3. Perform tooling with tool that compacts mortar, pressing excess mortar out.
4. Perform tooling when mortar is partially set, but still sufficiently plastic to bond rather than dragging it out.
5. Rake out joints that are not tight at time of tooling, point, and then tool.
6. Rake and tool joints at split-face surfaces, interior and exterior.

C. Concealed Joints: Strike flush with no further treatment required.

3.06 CONTROL JOINTS

A. Preformed Control Joints:

1. Omit mortar from vertical joints.
2. Place in units fabricated to receive rubber control joint material as wall is built.
3. After wall is grouted, cured, and cleaned, install backing rod and sealant as specified in Section 07 92 00, Joint Sealants.
4. Place and tool sealant to match depth of typical joint.

3.07 REINFORCING

A. Foundation Dowels:

1. Locate first foundation dowel at end of wall in center of first cell; typically 4 inches from end of wall.
2. Locate at each side of control joints and openings and below beam and joist seats, and then locate at maximum required spacing between these bars.

3. Size, number, and location of foundation dowels shall match all typical and additional vertical wall reinforcing, unless otherwise noted.
4. When foundation dowel does not line up with vertical core, do not slope more than 1 horizontal to 6 vertical to bring it into alignment.

B. Vertical Reinforcing:

1. Use deformed bars.
2. Hold in position near ends of bars by wire ties to dowels or by reinforcing positioners.
3. For high lift grouting, hold in position at maximum intervals of 160 bar diameters by reinforcing positioners.
4. Lap reinforcing bars as shown or approved.
5. Wire tie splices together.
6. Minimum Bar Clearance: 1/2-inch from masonry for coarse grout 1/4-inch from masonry for fine grout, from formed surfaces, and from parallel bars in same grout space.

C. Horizontal Reinforcing:

1. Use deformed bars.
2. Lay on webs of bond beam units and place as wall is built. Increase web depth to ensure 1/2-inch cover over top of rebar.
3. Lap reinforcing bars where spliced and wire tie together.
4. Minimum Bar Clearance: 1/2 inch from masonry for coarse grout 1/4 inch from masonry for fine grout, from formed surfaces, and from parallel bars in same grout space.
5. Terminate reinforcing bars 2 inches clear from control joints except horizontal bars at roof and floor courses shall be continuous through joints.

D. Horizontal Joint Reinforcement:

1. Use where indicated on Drawings.
2. Space maximum16 inches apart, vertically.
3. Lap ends 16 inches minimum.
4. Terminate reinforcing 2 inches clear from control joints except reinforcement at roof and floor courses shall be continuous through joints.
5. Use manufactured corner and other wall intersection pieces.

3.08 MORTAR PRODUCTION

A. Mix bulk materials in accordance with MSJC Specification.

B. Mix prebagged materials with water to produce a workable consistency.

C. Remix or retemper to maintain workability. Discard mortar that has begun to stiffen or is not used within 2-1/2 hours after initial mixing.

3.09 GROUT PLACEMENT

A. Do not mix, convey, or place with equipment constructed of aluminum.

B. Secure vertical and horizontal reinforcement, ties, bolts, anchors, and other required embedments in place; inspect and verify before placing grout.

C. Grout beams over openings in one continuous operation.

D. Maintain vertical alignment in accordance with ACI 530.1, Table 7:

1. Place grout within 1-1/2 hours of addition of water to mix.
2. Use reinforcing positioners to secure vertical reinforcement.

E. Grouting Requirements:

1. Partial grout all walls as shown.
   a. Slump: 8 inches to 11 inches.
   b. Do not start grouting until wall mortar has cured for 24 hours, minimum.
2. Fully embed horizontal steel with grout in an uninterrupted pour.
3. Do not construct wall more than one course above top of grout pour prior to placing grout.
4. Partial Grouting Requirements:
   a. Fill cells containing reinforcing steel, anchor bolts, and other embedded items as shown with grout.
   b. Construct cells to be filled to confine grout within cell.
   c. Cover tops of unfilled vertical cells under a bond beam with metal lath to confine grout fill to bond beam section.
   d. Form horizontal construction joints between pours by stopping grout pour 1-1/2 inches below a mortar joint, except at a bond beam; stop pour 1/2 inch below top of masonry unit.

F. Vibration:

1. Use internal “pencil” type, low energy vibrator to thoroughly consolidate grout and reduce amount of air voids. Do not use concrete vibrators.
2. After initial water loss and settlement has occurred, but before it has taken any set, reconsolidate grout.
3. Waiting period for reconsolidation will vary depending upon weather conditions and block absorption rates, but under “normal” weather conditions with average masonry units the waiting period should be between 30 minutes and 60 minutes.

G. Cleanouts:

1. Construct in accordance with MSJC specification.
2. Provide for grout pours heights over 5 feet 4 inches in accordance with the 2015 IBC.
3. Provide of sufficient size to permit cleaning of cell, positioning of reinforcing, and inspection at bottom of every vertical cell containing reinforcing and maximum of 32 inches on center.
4. Location: Concealed from view after final construction, unless otherwise approved by Engineer.
5. After wall has been inspected and approved and prior to grouting, cap cleanouts in a manner that will seal them from grout leakage and provide a flush finish.

3.10 FIELD QUALITY CONTROL

A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan in Supplement located at end of Section 01 45 33, Special Inspection, Observation, and Testing. Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection, Observation, and Testing.

B. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

C. Masonry shall be tested by testing agency retained by Owner.

D. Provide adequate facilities for safe storage and proper curing of masonry prisms, mortar samples, and grout samples, as applicable, onsite for first 24 hours, and for additional time as may be required before transporting to test lab.

E. Masonry Testing:

1. Masonry strength shall be determined using unit strength method as shown.
2. Unit Strength Method:
   a. Method and frequency for mortar, grout, and masonry unit sampling and testing shall be as shown.
   b. Provide masonry units for test samples required.

F. Corrective Action:

1. If compressive strength tests made prior to construction of permanent structure fail to meet Specifications, adjustments shall be made to mix designs for mortar, or grout, or both, as needed to produce specified strength.

2. If strength tests performed on materials representative of in-place construction fail to meet Specifications, prisms or cores shall be cut from constructed walls in sufficient locations to adequately determine strength in accordance with IBC 2105.3.

3.11 CLEANING

A. Immediately after completion of grouting, clean masonry surfaces of excess mortar, grout spillage, scum, stains, dirt, and other foreign substances using clean water and fiber brushes.

B. Clean walls not requiring painting or sealing so there are no visible stains.

3.12 PROTECTION OF INSTALLED WORK

A. Do not allow grout and mortar stains to dry on face of exposed masonry.

B. Protect tops of walls at all times. Cover tops of walls with waterproof paper when rain or snow is imminent and when the Work is discontinued.

C. Adequately brace walls until walls and roof are completed.

D. Provide sufficient bracing to protect walls against damage from elements, including wind and snow.

E. Protect masonry against freezing for minimum 72 hours after being laid.

F. Protect masonry from damage until final acceptance of the Work. Damaged units will not be accepted.

END OF SECTION

SECTION 05 05 19
POST-INSTALLED ANCHORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI):
   a. 318, Building Code Requirements for Structural Concrete.
   b. 355.2, Qualification of Post-Installed Mechanical Anchors in Concrete.
   c. 355.4, Qualification of Post-Installed Adhesive Anchors in Concrete.
2. American Iron and Steel Institute (AISI): Stainless Steel Type 316.
3. American National Standards Institute (ANSI).
4. ASTM International (ASTM):
   a. A123/A123M, Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   b. A143, Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.
   c. A153/A153M, Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   d. A193/A193M, Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.
   e. A194/A194M, Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both.
   f. A380, Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   g. A385, Practice for Providing High-Quality Zinc Coatings (Hot-Dip).
   h. A563, Specification for Carbon and Alloy Steel Nuts.
   i. A780, Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
   j. A967, Specification for Chemical Passivation Treatments for Stainless Steel Parts.
   k. E488, Standard Test Methods for Strength of Anchors in Concrete Elements.
   l. F436, Specification for Hardened Steel Washers.
   m. F468, Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use.
   n. F568M, Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners.

o. F593, Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
p. F594, Specification for Stainless Steel Nuts.
q. F1554, Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.

5. International Association of Plumbing and Mechanical Officials Uniform ES (IAPMO-UES): Evaluation Reports for Concrete and Masonry Anchors.
6. International Code Council Evaluation Service (ICC-ES):
   a. Evaluation Reports for Concrete and Masonry Anchors.
   b. AC01, Acceptance Criteria for Expansion Anchors in Masonry Elements.
   c. AC70, Acceptance Criteria for Fasteners Power-driven into Concrete, Steel and Masonry Elements.
   d. AC106, Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry Elements.
   e. AC193, Acceptance Criteria for Mechanical Anchors in Concrete Elements.
   f. AC308, Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements. Evaluation Reports for Concrete and Masonry Anchors.
7. NSF International (NSF): 61, Drinking Water System Components - Health Effects.
8. Specialty Steel Industry of North America (SSINA):
   a. Specifications for Stainless Steel.
   b. Design Guidelines for the Selection and Use of Stainless Steel.
   c. Stainless Steel Fabrication.
   d. Stainless Steel Fasteners.

1.02 DEFINITIONS

A. Corrosive Area: Containment area or area exposed to delivery, storage, transfer, or use of chemicals.

B. Exterior Area: Location not protected from weather by a building or other enclosed structure to include buried roof structures.

C. Interior Dry Area: Location inside building or structure where floor is not subject to liquid spills or wash down, and where wall or roof slab is not common to a water-holding or earth-retaining structure.

D. Interior Wet Area: Location inside building or structure where floor is sloped to floor drains or gutters and is subject to liquid spills or wash down, or where wall, floor, or roof slab is common to a water-holding or earth-retaining structure.

E. Submerged: Location at or below top of wall of open water-holding structure, such as a basin or channel, or wall, ceiling, or floor surface inside a covered water-holding structure, or exterior below grade wall or roof surface of water-holding structure, open or covered.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Specific instructions for concrete anchor installation, including drilled hole size and depth, preparation, placement, procedures, and instructions for safe handling of anchoring systems.

B. Informational Submittals:

1. Concrete and Masonry Anchors:
   a. Manufacturer's product description and installation instructions.
   b. Current ICC-ES or IAPMO-UES Report for each type of post-installed anchor to be used.
   c. Adhesive Anchor Installer Certification.
2. Passivation method for stainless steel members.

1.04 QUALITY ASSURANCE

A. Qualifications: Installers of adhesive anchors horizontally or upwardly inclined to support sustained tension loads shall be certified by an applicable certification program. Certification shall include written and performance tests in accordance with the ACI/CRSI Adhesive Installer Certification Program or equivalent.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Package stainless steel items in a manner to provide protection from carbon impregnation.

B. Protect hot-dip galvanized finishes from damage as a result of metal banding and rough handling.

PART 2 PRODUCTS

2.01 GENERAL

A. Unless otherwise indicated, meet the following requirements:

Item	**ASTM Reference**
Stainless Steel:	
Threaded Rods	F593, AISI Type 316, Condition CW

Item	ASTM Reference
Nuts*	F594, AISI Type 316, Condition CW
Carbon Steel:	
Threaded Rods	F1554, Grade 36 or F568M Class 5.8
Flat and Beveled Washers (Hardened)	F436
Nuts*	A194/A194M, Grade 2H
Galvanized Steel:	
All	A153/A153M
*Nuts of other grades and styles having specified proof load stresses greater than specified grade and style are also suitable. Nuts must have specified proof load stresses equal to or greater than minimum tensile strength of specified threaded rod.	

B. Bolts, Washers, and Nuts: Use stainless steel, hot-dip galvanized steel, and zinc-plated steel material types as indicated in Fastener Schedule at end of this section.

2.02 POST-INSTALLED CONCRETE ANCHORS

A. General:

1. AISI Type 316 stainless, hot-dip galvanized or zinc-plated steel, as shown in Fastener Schedule at end of this section.
2. Post-installed anchor systems used in concrete shall be approved by ICC Evaluation Services Report or equivalent for use in cracked concrete and for short-term and long-term loads including wind and earthquake.
3. Mechanical Anchors: Comply with the requirements of ICC-ES AC193 or ACI 355.2.
4. Adhesive Anchors: Comply with the requirements of ICC-ES AC308 or ACI 355.4.
5. Acceptable for use in potable water structures by EPA and local health agencies or NSF 61.

B. Torque-Controlled Expansion Anchors (Wedge Anchors):

1. Manufacturers and Products:
   a. Hilti, Inc., Tulsa, OK; Kwik-Bolt –TZ (KB-TZ) Anchors (ESR-1917).
   b. DeWalt/Powers Fasteners, Brewster, NY; Power-Stud +SD1 , +SD2, +SD4, or +SD6 Anchors (ESR-2502 and ESR-2818).

c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Strong-Bolt 2 Anchors (ESR-1771 and ESR-3037).

C. Self-Tapping Concrete Screw Anchors:

1. Manufacturers and Products:
   a. DeWalt/Powers Fasteners, Brewster, NY; Wedge-Bolt+ (ESR-2526).
   b. DeWalt/Powers Fasteners, Brewster, NY; Vertigo+ Rod Hanger Screw Anchor (ESR-2989).
   c. DeWalt/Powers Fasteners, Brewster, NY; Snake+ Flush Mount Screw Anchor (ESR-2272).
   d. Hilti, Inc., Tulsa, OK; HUS-EZ Screw Anchor (ESR-3027).
   e. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Titen HD Screw Anchor (ESR-2713).

D. Adhesive Anchors and Dowels:

1. Threaded Rod:
   a. Diameter as shown on Drawings.
   b. Length as required to provide minimum depth of embedment indicated and thread projection required.
   c. Clean and free of grease, oil, or other deleterious material.
2. Reinforcement:
   a. Diameter and embedment as shown on Drawings.
3. Adhesive:
   a. Two-component, insensitive to moisture, designed to be used in adverse freeze/thaw environments.
   b. Cure Temperature, Pot Life, and Workability: Compatible for intended use and anticipated environmental conditions.
4. Packaging and Storage:
   a. Disposable, self-contained system capable of dispensing both components in proper mixing ratio and fitting into a manually or pneumatically operated caulking gun.
   b. Store adhesive on pallets or shelving in a covered storage area.
   c. Package Markings: Include manufacturer's name, product name, batch number, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.
   d. Dispose of When:
      1) Shelf life has expired.
      2) Stored other than in accordance with manufacturer's instructions.

5. Manufacturers and Products:
    a. Hilti, Inc., Tulsa, OK; HIT Doweling Anchor System, HIT RE 500 V3 (ESR-3814), or HIT-HY 200 (ESR-3187).
    b. Simpson Strong-Tie Co., Inc., Pleasanton, CA; SET-XP Epoxy Adhesive Anchors (ESR-2508), or AT-XP Adhesive Anchors (IAPMO UES-263).
    c. DeWalt/Powers Fasteners, Brewster NY; Pure 110+ Epoxy adhesive anchor system (ESR-3298).

E. Adhesive Threaded Inserts:

1. Type 316 stainless steel, internally threaded inserts.
2. Manufacturer and Product: Hilti, Inc., Tulsa, OK; HIS-RN Insert with HIT-RE 500-V3 or HIT-HY 200 adhesive.

2.03 POST-INSTALLED MASONRY ANCHORS

A. General: AISI Type 316 stainless, hot-dip galvanized, or zinc-plated steel, as shown in Fastener Schedule at end of section.

B. Current ICC Evaluation Report indicating acceptance for anchors at structural applications in masonry.

C. Manufacturers and Products:

1. Hilti, Inc., Tulsa, OK; Kwik-Bolt-3 (KB-3) (ESR-1385), for grout-filled masonry, HIT-HY 70 (ESR-2682) for grout filled CMU, hollow CMU, or unreinforced masonry.
2. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Strong-Bolt 2 (IAPMO ER 240) for grout filled CMU, Titen-HD (ESR-1056) for grout filled or hollow CMU, AT-XP (IAPMO ER-281) for grout filled CMU.
3. DeWalt/Powers Fasteners, Brewster NY; Power-Stud+ SD1 (ESR-2966) for grout-filled masonry, Wedgebolt+ (ESR-1678) for grout-filled masonry.

PART 3 EXECUTION

3.01 CONCRETE AND MASONRY ANCHORS

A. Begin installation only after concrete or masonry to receive anchors has attained design strength.

B. Locate existing reinforcing with Ground Penetrating Radar or other method approved by Engineer prior to drilling. Coordinate with Engineer to adjust anchor locations where installation would result in hitting reinforcing.

C. Install in accordance with written manufacturer’s instructions.

D. Provide minimum embedment, edge distance, and spacing as indicated on Drawings.

E. Use only drill type and bit type and diameter recommended by anchor manufacturer.

F. Clean hole of debris and dust per manufacturer's requirements.

G. When unidentified embedded steel, rebar, or other obstruction is encountered in drill path, slant drill to clear obstruction. If drill must be slanted more than indicated in manufacturer's installation instructions to clear obstruction, notify Engineer for direction on how to proceed.

H. Adhesive Anchors:

1. Unless otherwise approved by Engineer and adhesive manufacturer:
   a. Do not install adhesive anchors when temperature of concrete or masonry is below 40 degrees F or above 100 degrees F.
   b. Do not install prior to concrete attaining an age of 21 days.
   c. Remove any standing water from hole with oil-free compressed air. Inside surface of hole shall be dry.
   d. Do not disturb anchor during recommended curing time.
   e. Do not exceed maximum torque as specified in manufacturer's instructions.
2. For hollow-unit masonry, install screen tube in accordance with manufacturer's instructions.

3.02 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan in Supplement located at end of Section 01 45 33, Special Inspection, Observation, and Testing. Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection, Observation, and Testing.

B. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

3.03 MANUFACTURER'S SERVICES

A. Adhesive Anchors: Conduct Site training of installation personnel for proper installation, handling, and storage of adhesive anchor system. Notify Engineer of time and place for sessions.

3.04 FASTENER SCHEDULE

A. Unless indicated otherwise on Drawings, provide fasteners as follows:

Service Use and Location	Product	Remarks
1. Post-Installed Anchors for Metal Components to Cast-in-Place Concrete (such as, Ladders, Handrail Posts, Electrical Panels, Platforms, and Equipment)		
Interior Dry Areas	Anchor material type to match material being anchored (for example, stainless steel anchors to anchor stainless steel equipment, zinc-plated anchors to anchor painted equipment, galvanized anchors to anchor galvanized equipment).	Verify product acceptability and manufacturer's requirements if anchor installation will occur in an overhead application
Submerged, Exterior, Interior Wet, and Corrosive Areas	Stainless steel adhesive anchors	Verify product acceptability and manufacturer's requirements if anchor installation will occur in an overhead application
2. Anchors in Grout-Filled Concrete Masonry Units		
Interior Dry Areas	Anchor material type to match material being anchored (for example, stainless steel anchors to anchor stainless steel equipment, zinc-plated anchors to anchor painted equipment, galvanized anchors to anchor galvanized equipment).	

Service Use and Location	Product	Remarks
Submerged, Exterior, Interior Wet, and Corrosive Areas	Stainless steel adhesive anchors	
3. Anchors in Hollow Concrete Masonry Units		
Interior Dry Areas	Anchor material type to match material being anchored (for example, stainless steel anchors to anchor stainless steel equipment, zinc-plated anchors to anchor painted equipment, galvanized anchors to anchor galvanized equipment).	Adhesive anchors shall be installed with screen tubes.
Exterior, Interior Wet, and Corrosive Areas	Stainless steel adhesive anchors	Adhesive anchors shall be installed with screen tubes.
4. All Others		
All service uses and locations	Stainless steel fasteners	

B. Antiseizing Lubricant: Use on all stainless steel threads.

C. Do not use adhesive anchors to support fire-resistive construction or where ambient temperature will exceed 120 degrees F.

END OF SECTION

SECTION 05 05 23
WELDING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
   a. BPVC SEC V, Nondestructive Examination.
   b. BPVC SEC IX, Welding and Brazing Qualifications.
2. American Society of Nondestructive Testing (ASNT): SNT-TC-1A, Personnel Qualification and Certification in Nondestructive Testing.
3. ASTM International (ASTM): A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products.
4. American Welding Society (AWS):
   a. A2.4, Standard Symbols for Welding, Brazing, and Nondestructive Examination.
   b. A3.0, Standard Welding Terms and Definitions.
   c. D1.1/D1.1M, Structural Welding Code—Steel.
   d. D1.2/D1.2M, Structural Welding Code—Aluminum.
   e. D1.3/1.3M, Structural Welding Code—Sheet Steel.
   f. D1.6/D1.6M, Structural Welding Code—Stainless Steel.
   g. QC1, Standard for AWS Certification of Welding Inspectors.

1.02 DEFINITIONS

A. CJP: Complete Joint Penetration.

B. CWI: Certified Welding Inspector.

1. Contractor's Welding Inspector: Contractor's CWI acts for, and on behalf of, the Contractor for all inspection and quality matters within the scope of the Contract Documents. Contractor is required to provide a welding inspector to oversee welding operations and be responsible for visual inspection and necessary correction of all deficiencies in materials and workmanship required to meet referenced welding codes. This type of Quality Control Inspection is not classified as Special Inspection.
2. Verification Inspector: This independent inspection is the prerogative of the Owner, who may employ their own, independent CWI, or waive this supplementary, independent CWI inspection.

C. MT: Magnetic Particle Testing.

D. NDE: Nondestructive Examination.

E. NDT: Nondestructive Testing.

F. PJP: Partial Joint Penetration.

G. PQR: Procedure Qualification Record.

H. PT: Liquid Penetrant Testing.

I. Special Inspection: Nondestructive examination including MT, PT, UT, and RT. Special Inspection personnel report to, and are retained by the Owner. See additional requirements in Section 01 45 33, Special Inspection, Observation, and Testing.

J. RT: Radiographic Testing.

K. UT: Ultrasonic Testing.

L. VT: Visual Inspection/Testing.

M. WPQ: Welder/Welding Operator Performance Qualification Record.

N. WPS: Welding Procedure Specification.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Shop and field WPSs and PQRs.
   b. NDT procedure specifications prepared in accordance with ASME BPVC SEC V.
   c. Welding Data (Shop and Field): Submit welding data together with Shop Drawings as a complete package.
      1) Show on Shop Drawings, or on a weld map, complete information regarding base metal ASTM specifications, and location, type, size, and length of all welds.
      2) Identify WPS to be used, and NDE requirements in tail of welding symbols as indicated in AWS A2.4.
      3) Clearly distinguish between shop and field welds.
      4) Indicate, by welding symbols or sketches, details of welded joints and preparation of base metal. Provide complete joint welding details showing bevels, groove angles, and root openings for welds.
      5) Welding and NDE Symbols shall be in accordance with AWS A2.4. Welding terms and definitions shall comply with AWS A3.0.

B. Informational Submittals:

1. WPQs.
2. CWI credentials.
3. Testing agency personnel credentials.
4. CWI visual inspection (VT) reports.
5. Welding Documentation: Submit on forms provided in referenced welding codes.

1.04 QUALIFICATIONS

A. WPSs: In accordance with AWS D1.1/D1.1M (Annex J Forms) for shop or field welding; or ASME BPVC SEC IX (Forms QW-482 and QW-483) for shop welding only.

B. WPQs: In accordance with AWS D1.1/D1.1M (Annex J Forms); or ASME BPVC SEC IX (Form QW-484).

C. CWI: Certified in accordance with AWS QC1 and having prior experience with specified welding codes. Alternate welding inspector qualifications require prior approval by Engineer.

D. Testing Agency: Personnel performing tests shall be NDT Level II certified in accordance with ASNT SNT-TC-1A.

1.05 SEQUENCING AND SCHEDULING

A. Unless otherwise specified, Submittals required in this section shall be submitted and approved prior to commencement of welding operations.

PART 2 PRODUCTS

2.01 SOURCE QUALITY CONTROL

A. Fabricator's CWI shall be present whenever shop welding is performed. CWI shall perform inspection at suitable intervals, prior to assembly, during assembly, during welding, and after welding. CWI shall perform inspections as required in AWS D1.1/D1.1M or referenced welding code and as follows:

1. Verify conformance of specified job materials and proper storage.
2. Monitor conformance with approved WPSs.
3. Monitor conformance of WPQs.
4. Inspect weld joint fit-up and perform in-process inspections.
5. Provide 100 percent visual inspection of completed welds.
6. Coordinate with nondestructive testing personnel and review NDE results.

7. Maintain records and prepare reports documenting that results of CWI VT and required NDE complies with the Work and referenced welding codes.

PART 3 EXECUTION

3.01 GENERAL

A. Welding and Fabrication by Welding: Conform to governing welding codes referenced in attached Welding and Nondestructive Testing Table.

3.02 NONDESTRUCTIVE WELD TESTING REQUIREMENTS

A. Quality Control Inspection:

1. All Welds: 100 percent VT by Contractor's CWI.
2. Acceptance Criteria:
   a. Structural Pipe and Tubing: AWS D1.1/D1.1M, Paragraph 10.24.
   b. All Other Structural Steel: AWS D1.1/D1.1M, Paragraph 8.9, Visual Inspection, Statically Loaded Nontubular Connections.

B. Nondestructive Testing Requirements:

1. NDT Procedures and Acceptance Criteria:
   a. Nontubular Connections: Acceptance criteria per AWS D1.1/D1.1M, Paragraph 8.9, Visual Inspection, Statically Loaded Nontubular Connections.

3.03 FIELD QUALITY CONTROL

A. The Contractor's CWI shall be present whenever field welding is being done and shall perform inspection, at suitable intervals, prior to assembly, during assembly, during welding, and after welding. CWI shall perform inspections as required in AWS D1.1/D1.1M or referenced welding code and as follows:

1. Verify conformance of specified job materials and proper storage.
2. Monitor conformance with approved WPS.
3. Monitor conformance of WPQ.
4. Inspect weld joint fit-up and perform in-process inspection.
5. Provide 100 percent visual inspection of all welds in accordance with Paragraph Quality Control Inspection.
6. Coordinate with nondestructive testing personnel and review test results.
7. Maintain records and prepare reports confirming results of inspection and testing comply with the Work.

3.04 WELD DEFECT REPAIR

A. Repair and retest rejectable weld defects until sound weld metal have been deposited in accordance with appropriate welding codes.

3.05 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification.

1. Welding and Nondestructive Testing Table.

END OF SECTION

Welding and Nondestructive Testing						
Specification Section	**Governing Welding Codes or Standards**	**Submit WPS**	**Submit WPQ**	**Onsite CWI Required?**	**Submit Written NDT Procedure Specifications**	**NDT Requirements**
05 12 00 Structural Steel Framing	AWS D1.1/D1.1M, Structural Welding Code—Steel	Yes	Yes	Yes	No	100% VT; also see Section 05 12 00
05 50 00 Metal Fabrications	AWS D1.1/D1.1M, Structural Welding Code–Steel or AWS D1.2/D1.2M, Structural Welding Code—Aluminum or AWS D1.6/D1.6M, Structural Welding Code—Stainless Steel	Yes	Yes	Yes	**No**	100% VT; also see Section 05 50 00
40 27 00 Process Piping—General	ASME BPV Code, Section IX; and ASME B31.3 Normal Fluid Service Category	Yes	Yes	Yes	Yes	100% VT and 5% RT; also see Section 40 27 00

SECTION 05 12 00
STRUCTURAL STEEL FRAMING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Galvanizers Association (AGA): Quality Assurance Manual.
2. American Institute of Steel Construction (AISC):
   a. 201, Certification Program for Structural Steel Fabricators.
   b. 206, Certification Program for Structural Steel Erectors—Standard for Structural Steel Erectors.
   c. 303, Code of Standard Practices for Steel Buildings and Bridges.
   d. 325, Steel Construction Manual.
   e. 326, Detailing for Steel Construction.
   f. 360, Specification for Structural Steel Buildings.
   g. 420, Certification Standard for Shop Application of Complex Protective Coating Systems.
3. American Welding Society (AWS):
   a. D1.1/D1.1M, Structural Welding Code—Steel.
4. ASTM International (ASTM):
   a. A6/A6M, Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.
   b. A36/A36M, Standard Specification for Carbon Structural Steel.
   c. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
   d. A123/123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   e. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   f. A325, Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
   g. A384/A384M, Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.
   h. A385/A385M, Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip).
   i. A490, Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength.
   j. A500/A500M, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
   k. A563, Standard Specification for Carbons and Alloy Steel Nuts.

l. A572/A572M, Standard Specification for High-Strength Low Alloy Columbium-Vanadium Structural Steel.
m. A780/A780M, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
n. A992/A992M, Standard Specification for Structural Steel Shapes.
o. B695, Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
p. A1085/A1085M, Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS).
q. F436, Standard Specification for Hardened Steel Washers.
r. F959, Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners.
s. F1136, Standard Specification for Zinc/Aluminum Corrosion Protective Coatings for Fasteners
t. F1852, Standard Specification for "Twist Off" Type Tension Control Structural Bolt/Nut/Washer Assemblies, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
u. F2280, Standard Specification for "Twist Off" Type Tension Control Structural Bolt/Nut/Washer Assemblies, Steel, Heat Treated, 150 ksi Minimum Tensile Strength.
v. F3125, Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi (830 MPa) and 150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions.

5. Occupational Safety and Health Administration (OSHA).
6. Research Council on Structural Connections (RCSC): Specification for Structural Joints using High-Strength Bolts.

1.02 SUBMITTALS

A. Action Submittals:

1. Provide Shop Drawing details showing:
a. Erection plans.
b. Members, including piece numbers, sizes, grades, dimensions, cambers, and connection details.
c. Anchor bolt layouts.
d. Hardened washer details.
e. Connection material specifications.
f. Indicate type, size, and length of bolts.
g. Joint details for complete penetration welds.
h. Indicate welds by standard AWS symbols, distinguishing between shop and field welds and show size, length, and type of each weld. Show backing bars that are to be removed and supplemental fillet welds where backing bars are to remain.
2. Product specifications, including primer and other coatings.
3. Identify pretensioned and slip-critical high strength bolted connections.

4. Locations of Class A, or higher, faying surfaces.
5. Weld access hole dimensions, surface profile, and finish requirements.
6. Locations and dimensions of protected zones.
7. Gusset plates drawn to scale when they are detailed to accommodate inelastic rotation.
8. Nondestructive testing (NDT) where performed by the fabricator.

B. Informational Submittals:

1. Name and address of manufacturer(s).
2. Mill Certificates of tests made in accordance with ASTM A6/A6M.
3. Manufacturers' testing procedures and standards.
4. Preparation and installation or application instructions, as appropriate.
5. Proposed method to resolve misalignment between anchor bolts and bolt holes in steel members.
6. High-Strength Bolts:
    a. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, that products meet specified chemical and mechanical requirements.
    b. Manufacturer's inspection test report results for production lot(s) furnished to include:
        1) Tensile strength.
        2) Yield strength.
        3) Reduction of area.
        4) Elongation and hardness.
    c. Certified Mill Test Reports for Bolts and Nuts:
        1) Name and address of manufacturer.
        2) Bolts correctly marked.
        3) Marked bolts and nuts used in required mill tests and manufacturer's inspection tests.
7. Direct Tension Indicators (DTIs): Manufacturer's test report meeting requirements of ASTM F959.
8. Twist-Off-Type Tension-Control (TC) Bolts: Manufacturer's test report meeting requirements of ASTM F1852.
9. Welding Procedures, Qualifications, and Inspection Reports: As specified in Section 05 05 23, Welding.
10. Hot-Dip Galvanizing: Certificate of compliance signed by galvanizer with description of material processed and ASTM standard used for coating.

1.03 QUALITY ASSURANCE

A. Qualifications:

1. Welding qualifications as specified in Section 05 05 23, Welding.

2. Galvanized Coating Applicator: Company specializing in hot-dip galvanizing after fabrication and following procedures of AGA's Quality Assurance Manual.

B. Certifications:

1. Mill identification marks, heat number, size of section, and length in accordance with ASTM A6/A6M.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Load structural members in such a manner that they will be transported and unloaded without damage to coatings and without being excessively stressed, deformed, or otherwise damaged.

B. Storage:

1. Store materials to permit easy access for inspection and identification. Store in a dry area and keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from corrosion and deterioration.
   a. Do not store materials in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials as directed.
2. Store fasteners in a protected place in sealed containers with manufacturer's labels intact.
   a. Fasteners may be repackaged provided testing and inspecting agency observes repackaging and sealing of containers.
   b. Clean and lubricate bolts and nuts that become dry or rusty before use.
   c. Comply with manufacturer's written recommendations for cleaning and lubricating fasteners and for retesting fasteners after lubrication.

C. Handle materials to avoid distortion or damage to members or supporting structures.

PART 2 PRODUCTS

2.01 MATERIALS

A. Rolled Plates, Shapes except W-Shapes and Bars: ASTM A36/A36M or A572/A572M, Grade 50, unless indicated otherwise.

B. W-Shapes: ASTM A992/A992M, unless indicated otherwise on Drawings.

C. Steel Pipe: ASTM A53/A53M, Grade B.

D. Round Hollow Structural Sections (HSS): ASTM A500/A500M, Grade C (Fy equals 46 ksi).

E. Square and Rectangular Hollow Structural Sections (HSS): ASTM A500/A500M, Grade C (Fy equals 50 ksi).

2.02 FASTENERS

A. Anchor Bolts: As specified in Section 05 50 00, Metal Fabrications.

B. Post-Installed Anchors: As specified in Section 05 05 19, Post-Installed Anchors.

C. High-Strength Bolts:

1. ASTM A325, Type 1, hot-dip galvanized Zn/Al Inorganic, per ASTM F1136, Grade 3 or ASTM A490, bolt Type 1, Zn/Al Inorganic, per ASTM F1136, Grade 3.
2. Bolt Length and Thread Length: As required for connection type shown, with hardened washers as required.

D. Direct Tension Indicators (DTIs) or Load Indicator Washers:

1. ASTM F959, coating type to match bolt finish.
2. Type A325 or A490, to match bolt type.
3. Manufacturers and Products:
   a. TurnaSure LLC, Langhorne, PA; DTIs.
   b. Applied Bolting Technology Products, Ludlow, VT; DTIs, regular or Squirter type.

E. Twist-Off-Type Tension-Control (TC) Bolts:

1. High-strength, ASTM F1852, bolt Type 1, mechanically galvanized or Type 1, Zn/Al Inorganic, per ASTM F1136 Grade 3.
2. Manufacturers:
   a. LeJeune Bolt Company, Burnsville, MN.
   b. Nucor Fastener, Saint Joe, IN.
   c. Haydon Bolts, Philadelphia, PA.
   d. Vermont Fasteners Manufacturing, Swanton, VT.

F. Nuts: ASTM A563, type to match bolt type and finish.

G. Hardened Steel Flat and Beveled Washers: ASTM F436, type to match bolt finish.

H. Stud Shear Connectors: As specified in Section 05 50 00, Metal Fabrications.

2.03 ANCILLARY MATERIALS

A. Surface Preparation and Primer: As specified in Section 09 90 00, Painting and Coating.

2.04 FABRICATION

A. General:

1. Fabricate as shown and in accordance with AISC 360 and AISC 303.
2. Columns: Full-length members without splices, unless shown otherwise or approved by Engineer.
3. Mark and match mark materials for field assembly.
4. Complete assembly, including bolting and welding of units, before start of finishing operations.
5. Fabricate to agree with field measurements.
6. Fabricate beams with rolling camber up.
7. Sheared and flame-cut edges shall be free from rough corners and projections.

B. Connections:

1. Shop Connections: Weld or bolt as shown on Drawings.
2. Meet requirements of AISC 325 for bolted double-angle shear connections, unless indicated otherwise.
3. Meet OSHA requirements for one independent bolt at beams framing in to column web connections.

C. Welded Construction:

1. As specified in Section 05 05 23, Welding.
2. Groove and Butt Joint Welds: Complete penetration, unless otherwise indicated.

D. Interface with Other Work:

1. Holes:
   a. As necessary or as indicated for securing other Work to structural steel framing, and for passage of other Work through steel framing members shall be approved by Engineer.
   b. No flame-cut holes are permitted without prior approval of Engineer.
2. Weld threaded nuts to framing members, and other specialty items to receive other Work.

2.05 FINISHES

A. Shop Paint Primer:

1. Surface Preparation and painting as specified in Section 09 90 00, Painting and Coating.
2. Do not shop prime the following surfaces, unless indicated otherwise:
   a. Within 2 inches of field-welded connections.
   b. Steel members to be completely encased in reinforced concrete or coated with cementitious fireproofing.
3. Apply shop primer to top flange surfaces of composite steel beams, unless indicated otherwise.

B. Galvanizing:

1. Fabricate steel to be galvanized in accordance with ASTM A143/A143M, ASTM A384/A384M, and ASTM A385/A385M. Avoid fabrication techniques that could cause distortion or embrittlement of steel.
2. Remove welding slag, splatter, burrs, grease, oil, paint, lacquer, and other deleterious material prior to delivery for galvanizing.
3. Remove, by blast cleaning or other methods, surface contaminants and coatings not removable by normal chemical cleaning process in galvanizing operation.
4. Hot-dip galvanize steel members, fabrications, and assemblies after fabrication in accordance with ASTM A123/A123M.
5. Hot-dip galvanize ASTM A325 bolts, nuts, washers, and hardware components in accordance with ASTM A153/A153M. Oversize holes to allow for zinc alloy growth. Shop-assemble bolts, nuts, and washers with special lubricant and test in accordance with ASTM A325 and ASTM A563.
6. Mechanically zinc coat ASTM F1852 twist-of-type tension-control (TC) bolts, nuts, and washers in accordance with ASTM F1852 and ASTM B695, Class 50.
7. Coat ASTM F2280 twist-off-type tension-control (TC) bolts, nuts, and washers in accordance with ASTM F1136.
8. Galvanize components of bolted assemblies separately before assembly.

2.06 SOURCE QUALITY CONTROL

A. Welding:

1. Contractor’s Certified Welding Inspector (CWI): Inspect and test fabrication welds as specified in Section 05 05 23, Welding.
2. Visually inspect fabrication welds in accordance with AWS D1.1/D1.1M, Section 6 and Table 6.1, Visual Inspection Acceptance Criteria.

3. An independent testing agency will be retained by Owner to perform the inspection and testing of fabrication welds as specified in Section 05 05 23, Welding.
4. Repair and retest defective welds as specified in Section 05 05 23, Welding.

PART 3 EXECUTION

3.01 ERECTION

A. General:

1. Meet requirements of AISC 360 and AISC 303, with exceptions as specified.
2. Install Contractor-designed temporary construction bracing to provide necessary support until components are in place and construction is complete.
3. Provide additional field connection material as required by AISC 303.
4. Splice members only where indicated and accepted on Shop Drawings.

B. Field Assembly:

1. Clean bearing surfaces and other surfaces that will be in permanent contact before assembly.
2. Set structural frames accurately to lines and elevations shown.
3. Align and adjust various members forming a part of a complete frame or structure before permanently fastening.
4. Level and plumb individual members of structure within tolerances shown in AISC 303.
5. Establish required leveling and plumbing measurements on mean operating temperature of structure. Make allowances for difference between temperature at time of erection and mean temperature at which structure will be completed and in service.
6. Perform necessary adjustments to compensate for minor discrepancies in elevations and alignment.

C. Setting Baseplates and Bearing Plates:

1. Clean concrete and masonry bearing surfaces of bond reducing materials and roughen to improve bond to surfaces.
2. Clean bottom surface of baseplates and bearing plates.
3. Set loose and attached baseplates and bearing plates for structural members on wedges, shims, leveling nuts, or other adjustable devices. Use leveling plates where indicated.
4. Tighten anchor bolts after supported members have been positioned and plumbed. Do not remove wedges or shims, but if protruding, cut off flush with edge of base or bearing plate prior to placing grout. Weld plate washer to baseplate where indicated.

5. Grout Under Baseplate: As specified in Section 03 30 10, Structural Concrete, prior to placing loads on structure.

D. Anchor Bolts:

1. Coordinate installation of anchor bolts and other connectors required for securing structural steel to in-place work.
2. Provide templates and other devices for presetting bolts and other anchors to accurate locations.
3. Projection of anchor bolts beyond face of concrete and threaded length shall be adequate to allow for full engagement of threads of hold-down nuts, adjustment of leveling nuts, washer thicknesses, and construction tolerances, unless indicated otherwise.
4. Placement Tolerances:
   a. As required by AISC 303, unless indicated otherwise.
   b. Embedded anchor bolts shall not vary from dimensions shown on Drawings by more than the following:
      1) Center-to-Center of Any Two Bolts Within an Anchor Group: 1/8 inch.
      2) Center-to-Center of Adjacent Anchor Bolt Groups: 1/4 inch.
      3) Variation from Perpendicular to Theoretical Bearing Surface: 1:50.

E. Connections:

1. High-Strength Bolted:
   a. Tighten in accordance with RCSC Specification for Structural Joints Using High-Strength Bolts.
   b. Pretension all bolts unless noted otherwise on Drawings.
   c. Hardened Washers:
      1) Provide at locations required by Washer Requirements section of RCSC Specification for Structural Joints Using High Strength Bolts, to include pretensioned and slip critical connections using slotted or oversized holes or ASTM A490 bolts.
      2) Use beveled style and extra thickness where required by RCSC Specification.
      3) Use square or rectangular beveled washers at inner flange surfaces of American Standard beams and channels.
      4) Do not substitute DTIs for hardened flat washers required at slotted and oversize holes.
   d. For snug-tightened connections (N, X), tighten to snug tight condition. Use hardened washer over slotted or oversize holes in outer plies.
2. Pretensioned Bolted:
   a. Use DTIs or twist-off-type tension-control (TC) bolts at slip critical (SC) and pretensioned bearing-type connections.

b. DTIs:
1) Position within bolted assembly in accordance with ASTM F959.
2) Install bolts, with DTIs plus hardened washers as required, in holes of assembly and tighten until plies are in firm contact and fasteners are uniformly snug tight.
c. Final tightening bolts begin at most rigid part of bolted connection and progress toward free edges until final twist-off-type tension-control (TC) bolts or until DTIs have been compressed to an average gap equal to or less than shown in ASTM F959, Table 2.

3. Welded:
a. As specified in Section 05 05 23, Welding.
b. Groove and Butt Joint Welds: Complete penetration, unless otherwise indicated.

3.02 MISFITS

A. At Bolted Connections:

1. Immediately notify Engineer for approval of one of the following methods of correction:
a. Ream holes that must be enlarged to admit bolts and use oversized bolts.
b. Plug weld misaligned holes and redrill holes to admit standard size bolts.
c. Drill additional holes in connection, conforming to AISC for bolt spacing and end and edge distances, and add additional bolts.
d. Reject member containing misfit, incorrect sized, or misaligned holes and fabricate new member to ensure proper fit.
2. Do not enlarge incorrectly sized or misaligned holes in members by burning or by use of drift pins.

B. At Anchor Bolts:

1. Resolve misalignments between anchor bolts and bolt holes in steel members in accordance with approved Shop Drawing.
2. Do not flame cut to enlarge holes without prior approval of Engineer.

C. Gas Cutting:

1. Do not use gas cutting torches in field for correcting fabrication errors in structural framing.
2. Secondary members not under stress and concealed in finished structure may be corrected by gas cutting torches, if approved by Engineer.
3. Finish flame-cut sections equivalent to sheared and punched appearance.

3.03 REPAIR AND CLEANING

A. Clean shop primer from field welds, bolted connections, and abraded areas immediately after erection.

B. Remove and grind smooth tack welds, fit-up-lugs, and weld runoff tabs.

C. Remove weld back-up bars and grind smooth where indicated on Drawings.

D. Apply touchup paint primer by brush or spray of same thickness and material as that used in shop application and as specified in Section 09 90 00, Painting and Coating.

E. Hot-Dip Galvanized Coating Repair:

1. Conform to ASTM A780/A780M.
2. For minor repairs at abraded areas, use sprayed zinc conforming to ASTM A780/A780M.
3. For flame cut or welded areas, use zinc-based solder, or zinc sticks, conforming to ASTM A780/A780M.
4. Use magnetic gauge to determine thickness is equal to or greater than base galvanized coating.

3.04 FIELD FINISH

A. Field finish in accordance with Section 09 90 00, Painting and Coating.

3.05 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in Statement of Special Inspections Plan in Supplement located at end of Section 01 45 33, Special Inspection, Observation, and Testing. Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection, Observation, and Testing.

B. Contractor-Furnished Quality Control: Inspect and test as required in Section 01 45 16.13, Contractor Quality Control.

C. High-Strength Bolted Connections:

1. An independent testing agency will be retained by Owner to perform the following inspection and testing in accordance with the RCSC Specification for Structural Joints Using High-Strength Bolts:
   a. Marking identification and conformance to ASTM standards.
   b. Alignment of bolt holes.
   c. Placement, type, and thickness of hardened washers.
   d. Tightening of bolts.

2. Snug-Tightened Connections (N, X): Snug tight condition with plies of joint in firm contact.
3. Pretensioned Bearing and Slip Critical (SC) Connections:
   a. Conduct preinstallation test.
   b. Monitor installation and tightening of DTIs or TC bolts.
   c. Monitor condition of faying surfaces for slip critical connections.
4. Preinstallation Test:
   a. Conduct test in accordance with Specification for Structural Joints Using ASTM A325 or ASTM A490 bolts prior to using bolt tension measuring device.
   b. Select representative sample of not less than three bolts of each diameter, length, and grade.
   c. Include DTIs and flat hardened washers as required to match actual connection assembly.
5. Nondestructive Testing (NDT): Inspect bolted connections and perform corrections as required to meet code acceptance criteria per RCSC Specification for Structural Joints Using ASTM A325 or ASTM A490 Bolts.
6. Defective Connections: Correct and reinspect defective and improperly tightened high-strength bolted connections. Retest pretensioned bolts as necessary to demonstrate compliance of completed work.

D. Welding:

1. Contractor's Certified Welding Inspector (CWI): Inspect and test field welds as specified in Section 05 05 23, Welding.
2. Visually inspect field welds in accordance with AWS D1.1/D1.1M, Section 6 and Table 6.1, Visual Inspection Acceptance Criteria.
3. An independent testing agency will be retained by Owner to perform inspection and testing of field welds as specified in Section 05 05 23, Welding.
4. Repair and retest defective welds as specified in Section 05 05 23, Welding.

END OF SECTION

SECTION 05 31 00
STEEL DECKING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Iron and Steel Institute (AISI): Specifications for the Design of Cold Formed Steel Structural Members.
2. American Welding Society (AWS): D1.3, Structural Welding Code - Sheet Steel.
3. ASTM International (ASTM):
   a. A611, Standard Specification for Structural Steel (SS), Sheet, Carbon, Cold-Rolled.
   b. A653, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   c. A780, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
   d. A924, Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process.
4. Steel Deck Institute (SDI):
   a. Design Manual for Composite Decks, Form Decks and Roof Decks.
   b. Diaphragm Design Manual.
5. Factory Mutual (FM):
   a. Factory Mutual Approval Guide.
   b. FM Research Corporation (FMRC): Approval Requirements for Steel Roof Deck Construction.
6. International Code Council Evaluation Service, Inc. (ICC-ES): Evaluation Reports for Deck Fasteners.
7. Underwriters Laboratories, Inc. (UL): Fire Resistance Directory.

1.02 SUBMITTALS

A. Action Submittals:

1. Plan view layout of decking showing type and section properties of deck panels, reinforcing channels, pans, special jointing, and accessories.
2. Location of openings, deck laps, and deck attachment details.

B. Informational Submittals:

1. Decking manufacturer’s installation requirements.
2. Operation manuals for mechanical fastener installation tools.

3. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.

1.03 QUALITY ASSURANCE

A. General: For metal decking section properties, meet requirements of AISI Specifications for Design of Cold-Formed Steel Structural Members.

B. FM Requirements:

1. Steel Roof Deck: Listed in Factory Mutual "Approval Guide" for Class 1 fire rating and Class 1-90 wind uplift rating.
2. Mechanical Fasteners: Packing containers shall show name of manufacturer and product and FMRC approval mark.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Protect steel deck from corrosion, deformation, and other damage during delivery, storage, and handling.

B. Store deck bundles on platforms or pallets, with one end elevated to provide drainage.

C. Protect bundles against condensation with a ventilated waterproof covering.

D. Stack bundles so there is no danger of tipping, sliding, rolling, shifting or material damage.

PART 2 PRODUCTS

2.01 METAL DECKING

A. Provide metal deck as shown in the following schedule:

STEEL DECK SCHEDULE

Type	Depth (in)	Panel Width (in)	Design Thickness (in)	Min. Yield Strength Fy (ksi)	Min. (+) S (in^3/ft)	Min. I (in^4/ft)	Minimum Diaphragm Shear Capacity (lbs/ft)	Finish
Composite Roof Deck	3	36	0.0358	33	0.53	0.90	500 (strength level)	Galv, G-90

B. Materials and Finishes:

1. Galvanized Deck:
   a. Sheet steel for galvanized deck and accessories shall conform to ASTM A653 Structural Quality Grade 33 or higher, as shown in Steel Deck Schedule.
   b. Galvanizing shall conform to ASTM A924 with coating class of G60 or G90 as defined in ASTM A653 and as shown in Steel Deck Schedule.

C. Manufacturers:

1. Vulcraft Division of Nucor Co., Brigham City, UT.
2. BHP Steel Building Products, USA, Inc., West Sacramento, CA.
3. Verco Manufacturing, Inc., Phoenix, AZ.
4. United Steel Deck, Inc., Summit, NJ.

2.02 ACCESSORIES

A. Provide pour stops, end closures, cover plates, girder fillers, ridge and valley plates, finish strips, reinforcing channels, and other accessories as required for complete installation.

B. Accessories shall be minimum 22-gauge, except edge forms shall be sized as required by the deck manufacturer, unless shown otherwise on the Drawings.

2.03 MECHANICAL FASTENERS

A. Self-Drilling Screws:

1. Self-drilling, self-tapping screws with hexagonal washer head and corrosion-resistant finish.
2. Manufacturers and Products:
   a. ITW Buildex, Itasca, IL; ICH Traxx Self-Drilling Fasteners with Climaseal Coating and Autotraxx Standup Installation Tool.
   b. Hilti, Inc., Tulsa, OK; Kwik-Pro HWH Self-Drilling Screws with Kwik-Cote Treatment and Kwik-Tapper Screwdriver.

B. Powder Driven Fasteners:

1. Knurled shank, minimum 1/2-inch diameter steel washer, corrosion-resistant coating.
2. Pin diameter and length to suit deck type and flange thickness of steel support member.

3. Manufacturers and Products:
    a. ITW Buildex, Itasca, IL; Buildex BX14 pins with yellow dichromate galvanizing and BX900 Installation Tool.
    b. Hilti, Inc., Tulsa, OK; ENP-series fasteners with electroplated zinc coating and DX-750 Installation Tool.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine supporting framing and field conditions for compliance with requirements for installation tolerances and other conditions affecting performance of steel deck.

3.02 INSTALLATION

A. Locate deck bundles to prevent overloading of support framing members.

B. Install at right angles to supporting members in a three span minimum lay-up, unless shown otherwise, and in accordance with Specification and manufacturer's installation recommendation.

C. Bearing: 1-1/2 inches, minimum.

D. Endlaps: Minimum of 2 inches and located over supports.

E. Do not stretch sidelaps.

F. Closure Plates:

1. Install closure and cover plate accessories as recommended by the metal deck manufacturer, unless shown otherwise on the Drawings.
2. Deck Closures:
    a. Fasten cell closures, and zee closures to deck to provide tight fitting closures at open ends of ribs and sides of decking.
    b. Fasten cell closures at changes of direction of deck units unless otherwise indicated.

G. Holes and Openings

1. Cut and fit around roof openings and other work projecting through or adjacent to decking.
2. Locate holes and openings as shown to clear structural framing and bracing members.
3. Reinforcement around openings:
    a. Composite Roof Deck and Form Deck: Reinforce openings as indicated on Drawings.

H. Protect deck areas from heavy concentrated loads or wheel traffic with planking or other approved means.

I. Install temporary shoring, if required, to meet strength and deflection limitations, before placing any concrete topping on deck panels.

J. Completed Deck: Free from buckles and irregularities, and in accordance with FM and UL requirements.

3.03 DECK ATTACHMENT

A. Fasten panels as shown in the following schedule:

STEEL DECK ATTACHMENT SCHEDULE							
		At Perpendicular Supports		At Parallel Supports		At Sidelaps	
Type	Depth (in.)	Type	No. Per Sheet	Type	Spacing (in.)	Type	Spacing
Composite Roof Deck	3	Power driven fasteners	4	Power driven fasteners	12.	Button-punch	3 per span

B. Mechanical Fasteners:

1. Self-Drilling Screws:
   a. Install screws in accordance with manufacturer's written instructions and with special installation tool. Do not over-torque.
   b. Remove and redrive screws at sidelaps where upper sheet is not drawn tightly against lower sheet.
2. Powder Driven Fasteners:
   a. Install fasteners in accordance with manufacturer's written instructions and with special installation tool.
   b. Minimum Sidelap Edge Distance: 3/8 inch.
   c. Minimum End/End Lap Distance: 1 inch.
   d. Head Projection: As specified by manufacturer for correct penetration into flange of steel support member.

3.04 TOUCHUP PAINTING

A. Immediately following erection, remove unused deck edge trimmings, screws, fasteners, welding washers, butt ends of welding rods, and debris from completed installation.

B. Clean field welds, bolted connections, rust spots, and abraded areas.

C. Repair damaged painted surfaces as specified in Section 09 90 00, Painting and Coating.

D. Repair damaged galvanized surfaces with zinc-rich spray paint in accordance with ASTM A780; color to match galvanized deck.

E. Use magnetic gauge to determine that thickness of repair is equal to or greater than base painted or galvanized coating.

3.05 FIELD QUALITY CONTROL

A. An independent testing agency will be retained by Owner to perform following inspections.

1. Mechanical Fasteners: Visually inspect, in accordance with manufacturer's instructions, for each type of fastener.

B. Repair or replace defective fasteners.

END OF SECTION

SECTION 05 50 00
METAL FABRICATIONS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. The Aluminum Association, Inc. (AA): The Aluminum Design Manual.
2. American Galvanizers Association (AGA):
   a. Inspection of Hot-Dip Galvanized Steel Products.
   b. Quality Assurance Manual.
3. American Iron and Steel Institute (AISI): Stainless Steel Types.
4. American Ladder Institute (ALI): A14.3, Ladders - Fixed - Safety Requirements.
5. American National Standards Institute (ANSI).
6. American Welding Society (AWS):
   a. D1.1/D1.1M, Structural Welding Code - Steel.
   b. D1.2/D1.2M, Structural Welding Code - Aluminum.
   c. D1.6/D1.6M, Structural Welding Code - Stainless Steel.
7. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A48/A48M, Specification for Gray Iron Castings.
   c. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   d. A108, Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished.
   e. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   f. A143/A143M, Standard for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.
   g. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   h. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   i. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   j. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   k. A276, Standard Specification for Stainless Steel Bars and Shapes.

l. A283/A283M, Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
m. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
n. A325, Standard Specification for Structural Bolts, Steel, Heat Treated 120/105 ksi Minimum Tensile Strength.
o. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
p. A384/A384M, Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.
q. A385/A385M, Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip).
r. A489, Standard Specification for Carbon Steel Lifting Eyes.
s. A500/A500M, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
t. A501, Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
u. A563, Standard Specification for Carbon and Alloy Steel Nuts.
v. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
w. A780/A780, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
x. A786/A786M, Standard Specification for Hot-Rolled Carbon, Low-Alloy, High-Strength Low-Alloy, and Alloy Steel Floor Plates.
y. A793, Standard Specification for Rolled Floor Plate, Stainless Steel.
z. A967, Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
aa. A992/A992M, Standard Specification for Structural Steel Shapes.
bb. A1085, Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS).
cc. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
dd. B308/B308M, Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
ee. B429/B429M, Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
ff. B632/B632M, Standard Specification for Aluminum-Alloy Rolled Tread Plate.
gg. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
hh. D1056, Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber.

ii. F436, Standard Specification for Hardened Steel Washers.
jj. F468, Standard Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use.
kk. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
ll. F594, Standard Specification for Stainless Steel Nuts.
mm. F844, Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use.
nn. F1554, Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.

8. Occupational Safety and Health Administration (OSHA):
   a. 29 CFR 1910.27, Fixed Ladders.
   b. 29 CFR 1926.502, Fall Protection Systems Criteria and Practices.
9. Specialty Steel Industry of North America (SSINA):
   a. Specifications for Stainless Steel.
   b. Design Guidelines for the Selection and Use of Stainless Steel.
   c. Stainless Steel Fabrication.
   d. Stainless Steel Fasteners.

1.02 DEFINITIONS

A. Anchor Bolt: Cast-in-place anchor; concrete or masonry.

B. Corrosive Area: Containment area or area exposed to delivery, storage, transfer, or use of chemicals.

C. Exterior Area: Location not protected from weather by building or other enclosed structure.

D. Interior Dry Area: Location inside building or structure where floor is not subject to liquid spills or washdown, nor where wall or roof slab is common to a water-holding or earth-retaining structure.

E. Interior Wet Area: Location inside building or structure where floor is sloped to floor drains or gutters and is subject to liquid spills or washdown, or where wall, floor, or roof slab is common to a water-holding or earth-retaining structure.

F. Submerged: Location at or below top of wall of open water-holding structure, such as basin or channel, or wall, ceiling or floor surface inside a covered water-holding structure, or exterior belowgrade wall or roof surface of water-holding structure, open or covered.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Metal fabrications, including welding and fastener information.

B. Informational Submittals:

1. Pre-engineered Ladders: Letter of certification that ladder meets OSHA 29 CFR 1910.27 requirements.
2. Passivation method for stainless steel members.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Insofar as practical, factory assemble specified items. Package assemblies, which have to be shipped unassembled to protect materials from damage and tag to facilitate identification and field assembly.

B. Package stainless steel items to provide protection from carbon impregnation.

C. Protect painted coatings and hot-dip galvanized finishes from damage as a result of metal banding and rough handling. Use padded slings and straps.

D. Store fabricated items in dry area, not in direct contact with ground.

PART 2 PRODUCTS

2.01 GENERAL

A. Unless otherwise indicated, meet the following requirements:

Item	ASTM Reference
Steel Wide Flange Shapes	A992/992M
Other Steel Shapes and Plates	A36/A36M or A572/A572M, Grade 50 or A992/A992M for other steel shapes
Steel Pipe	A500, Grade B
Hollow Structural Sections (HSS)	A500/A500M, Grade C
Aluminum:	
Aluminum Plates	B209, Alloy y6061-T6
Aluminum Structural Shapes	B308/B308M, Alloy 6061-T6

Item	ASTM Reference
Stainless Steel:	
Bars and Angles	A276, AISI Type 316 (316L for welded connections)
Shapes	A276, AISI Type 304 (304L for welded connections)
Steel Plate, Sheet, and Strip	A240/A240M, AISI Type 316 (316L for welded connections)
Bolts, Threaded Rods, Anchor Bolts, and Anchor Studs	F593, AISI Type 316, Group 2, Condition SH
Nuts	F594, AISI Type 316, Condition CW
Steel Bolts and Nuts:	
Carbon Steel	A307 bolts, with A563 nuts
High-Strength	A325, Type 1 bolts, with A563 nuts
Anchor Bolts and Rods	F1554, Grade 36, with weldability supplement S1.
Eyebolts	A489
Threaded Rods	A36/A36M
Flat Washers (Unhardened)	F844
Flat and Beveled Washers (Hardened)	F436
Thrust Ties for Steel Pipe:	
Threaded Rods	A193/A193M, Grade B7
Nuts	A194/A194M, Grade 2H
Plate	A283/A283M, Grade D
Aluminum Bolts and Nuts	F468, Alloy 2024-T4
Cast Iron	A48/A48M, Class 35

B. Bolts, Washers, and Nuts: Use stainless steel, hot-dip galvanized steel, zinc-plated steel, and aluminum material types as indicated in Fastener Schedule at end of this section.

2.02 ANCHOR BOLTS AND ANCHOR BOLT SLEEVES

A. Cast-In-Place Anchor Bolts:

1. Headed type, unless otherwise shown on Drawings.
2. Material type and protective coating as shown in Fastener Schedule at end of this section.

2.03 POST-INSTALLED CONCRETE AND MASONRY ANCHORS

A. See Section 05 05 19, Post-Installed Anchors.

2.04 STEEL LINTELS AND SHELF ANGLES

A. ASTM A36/A36M, hot-dip galvanize after fabrication in accordance with ASTM A123/A123M.

2.05 LADDERS

A. Fabricate ladders with rails, rungs, landings, and cages to meet applicable requirements of OSHA, CFR Part 1910.27, and ALI A14.3.

1. Design ladder for concentrated load of 250 pounds imposed by user concentrated at points that will cause maximum stress in structural member being considered.
2. Include weight of ladder and attached appurtenances together with live load in design of rails and fastenings.
3. Self-closing gates at landings.

B. Aluminum Pre-engineered Pipe Ladder:

1. Rungs:
   a. Aluminum extrusions of Alloy 6063-T6.
   b. Nonslip grip surface, 1-inch wide flat top, and semicircular bottom with mill finish.
   c. Diamondback, finish to match rails, as manufactured by Alcoa Building Products, Inc., Sidney, OH.
2. Side Rails: ASTM B429/B429M, Alloy 6063-T6, 1-1/2 inches, Schedule 40 pipe with anodized finish, AA M32-C22-A41.
3. Ladder Attachments and Cage Assembly Fasteners: Stainless steel.
4. Welded, pop riveted, or glued construction is not acceptable.
5. Fabricate to longest length as practical but not to exceed 24 feet.
6. Furnish support attachments to side rails at 6 feet maximum spacing.
7. Manufacturer: Thompson Fabricating Co. Inc., Tarrant, AL.

C. Ladder Safety Post:

1. Telescoping tubular, spring balanced and automatically locking in raised position, with release lever for unlocking.
2. Post: Aluminum.
3. Hardware: Stainless steel, AISI Type 316.
4. Furnish dissimilar metal protective coatings at connections.
5. Manufacturer and Product: Bilco Co., New Haven, CT; "Ladder Up" to fit ladder rungs.

2.06 SAFETY CLIMB DEVICE

A. General:

1. Conforms to ALI A14.3 and OSHA CFR Part 1910.27.
2. Belt and harness shall withstand minimum drop test of 250 pounds in 6-foot free fall.
3. Fall Prevention System Material: Aluminum 6061-T6.

B. Components and Accessories:

1. Main Components: Sleeve or trolley, safety harness, and carrier or climbing rail.
2. Ladder rung clamps with aluminum or stainless steel, AISI Type 316, mounting brackets and hardware.
3. Removable extension kit with tiedown rod or trolley gate, mandrel, and carrier rail for ladders under manholes and hatches.

C. Manufacturers and Products:

1. Miller by Honeywell, Franklin, PA; Miller Saf-T-Climb.
2. TS Products, Cambridge, Ontario, Canada; TS Safety Rail System.

2.07 ACCESSORIES

A. Antiseizing Lubricant for Stainless Steel Threaded Connections:

1. Suitable for potable water supply.
2. Resists washout.
3. Manufacturers and Products:
   a. Bostik, Middleton, MA; Neverseez.
   b. Saf-T-Eze Div., STL Corp., Lombard, IL; Anti-Seize.

B. Neoprene Gasket:

1. ASTM D1056, 2C1, soft, closed-cell neoprene gasket material, suitable for exposure to sewage and sewage gases, unless otherwise shown on Drawings.

2. Thickness: Minimum 1/4 inch.
3. Furnish without skin coat.
4. Manufacturer and Product: Monmouth Rubber and Plastics Corporation, Long Branch, NJ; Durafoam DK1111LD.

2.08 FABRICATION

A. General:

1. Finish exposed surfaces smooth, sharp, and to well-defined lines.
2. Furnish necessary rabbets, lugs, and brackets so work can be assembled in neat, substantial manner.
3. Conceal fastenings where practical; where exposed, flush countersink.
4. Drill metalwork and countersink holes as required for attaching hardware or other materials.
5. Grind cut edges smooth and straight. Round sharp edges to small uniform radius. Grind burrs, jagged edges, and surface defects smooth.
6. Fit and assemble in largest practical sections for delivery to Site.

B. Materials:

1. Use steel shapes, unless otherwise noted.
2. Steel to be hot-dip galvanized: Limit silicon content to less than 0.04 percent or to between 0.15 percent and 0.25 percent.
3. Fabricate aluminum in accordance with AA Specifications for Aluminum Structures–Allowable Stress Design.

C. Welding:

1. Weld connections and grind exposed welds smooth. When required to be watertight, make welds continuous.
2. Welded fabrications shall be free from twisting or distortion caused by improper welding techniques.
3. Steel: Meet fabrication requirements of AWS D1.1/D1.1M, Section 5.
4. Aluminum: Meet requirements of AWS D1.2/D1.2M.
5. Stainless Steel: Meet requirements of AWS D1.6/D1.6M.
6. Welded Anchor Studs: Prepare surface to be welded and weld with stud welding gun in accordance with AWS D1.1/D1.1M, Section 7, and manufacturer’s instructions.
7. Complete welding before applying finish.

D. Painting:

1. Shop prime with rust-inhibitive primer as specified in Section 09 90 00, Painting and Coating, unless otherwise indicated.
2. Coat surfaces of galvanized steel and aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as

specified in Section 09 90 00, Painting and Coating, unless indicated otherwise.

3. Do not apply protective coating to galvanized steel anchor bolts or galvanized steel welded anchor studs, unless indicated otherwise.

E. Galvanizing:

1. Fabricate steel to be galvanized in accordance with ASTM A143/A143M, ASTM A384/A384M, and ASTM A385/A385M. Avoid fabrication techniques that could cause distortion or embrittlement of the steel.
2. Provide venting and drain holes for tubular members and fabricated assemblies in accordance with ASTM A385/A385M.
3. Remove welding slag, splatter, burrs, grease, oil, paint, lacquer, and other deleterious material prior to delivery for galvanizing.
4. Remove by blast cleaning or other methods surface contaminants and coatings not removable by normal chemical cleaning process in the galvanizing operation.
5. Hot-dip galvanize steel members, fabrications, and assemblies after fabrication in accordance with ASTM A123/A123M.
6. Hot-dip galvanize bolts, nuts, washers, and hardware components in accordance with ASTM A153/A153M. Oversize holes to allow for zinc alloy growth. Shop assemble bolts and nuts.
7. Galvanized steel sheets in accordance with ASTM A653/A653M.
8. Galvanize components of bolted assemblies separately before assembly. Galvanizing of tapped holes is not required.

F. Electrolytic Protection: Coat surfaces of galvanized steel and aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as specified in Section 09 90 00, Painting and Coating, unless indicated otherwise.

G. Fitting: Where movement of fabrications is required or shown, cut, fit, and align items for smooth operation. Make corners square and opposite sides parallel.

H. Accessories: Furnish as required for a complete installation. Fasten by welding or with stainless steel bolts or screws.

2.09 SOURCE QUALITY CONTROL

A. Visually inspect all fabrication welds and correct deficiencies.

1. Steel: AWS D1.1/D1.1M, Section 6 and Table 6.1, Visual Inspection Acceptance Criteria.
2. Aluminum: AWS D1.2/D1.2M.
3. Stainless Steel: AWS D1.6/D1.6M.

PART 3 EXECUTION

3.01 INSTALLATION OF METAL FABRICATIONS

A. General:

1. Install metal fabrications plumb and level, accurately fitted, free from distortion or defects.
2. Install rigid, substantial, and neat in appearance.
3. Install manufactured products in accordance with manufacturer's recommendations.
4. Obtain Engineer approval prior to field cutting steel members or making adjustments not scheduled.

B. Aluminum:

1. Do not remove mill markings from concealed surfaces.
2. Remove inked or painted identification marks on exposed surfaces not otherwise coated after installed material has been inspected and approved.
3. Fabrication, mechanical connections, and welded construction shall be in accordance with the AA Aluminum Design Manual.

C. Pipe Sleeves:

1. Provide where pipes pass through concrete or masonry.
2. Holes drilled with a rotary drill may be provided in lieu of sleeves in existing walls.
3. Provide center flange for water stoppage on sleeves in exterior or water-bearing walls.
4. Provide rubber caulking sealant or a modular mechanical unit to form watertight seal in annular space between pipes and sleeves.

D. Steel Lintels and Shelf Angles: Provide as required for support of masonry and other construction not attached to structural steel framing, unless otherwise shown on Drawings.

3.02 CAST-IN-PLACE ANCHOR BOLTS

A. Locate and hold anchor bolts in place with templates at time concrete is placed.

B. Use anchor bolt sleeves for location adjustment and provide two nuts and one washer per bolt of same material as bolt.

C. Minimum Bolt Size: 1/2-inch diameter by 12 inches long, unless otherwise shown.

3.03 ELECTROLYTIC PROTECTION

A. Aluminum and Galvanized Steel:

1. Coat surfaces of galvanized steel and aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as specified in Section 09 90 00, Painting and Coating, unless indicated otherwise.
2. Do not apply protective coating to galvanized steel anchor bolts or galvanized steel welded anchor studs, unless indicated otherwise.
3. Allow coating to dry before installation of the material.
4. Protect coated surfaces during installation.
5. Should coating become marred, prepare and touch up in accordance with paint manufacturer's written instructions.

B. Stainless Steel:

1. During handling and installation, take necessary precautions to prevent carbon impregnation of stainless steel members.
2. After installation, visually inspect stainless steel surfaces for evidence of iron rust, oil, paint, and other forms of contamination.
3. Remove contamination using cleaning and passivation methods in accordance with requirements of ASTM A380 and ASTM A967.
4. Brushes used to remove foreign substances shall utilize only stainless steel or nonmetallic bristles.
5. After treatment, visually inspect surfaces for compliance.

3.04 PAINTING

A. Painted Galvanized Surfaces: Prepare as specified in Section 09 90 00, Painting and Coating.

B. Repair of Damaged Hot-Dip Galvanized Coating:

1. Conform to ASTM A780/A780M.
2. For minor repairs at abraded areas, use sprayed zinc conforming to ASTM A780/A780M.
3. For flame cut or welded areas, use zinc-based solder, or zinc sticks, conforming to ASTM A780/A780M.
4. Use magnetic gauge to determine thickness is equal to or greater than base galvanized coating.

C. Field Painting of Shop Primed Surfaces: Prepare surfaces and field finish in accordance with Section 09 90 00, Painting and Coating.

3.05 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Owner-Furnished Quality Assurance:

1. In accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan in Supplement located at end of Section 01 45 33, Special Inspection, Observation, and Testing.
2. Contractor responsibilities and related information on special inspection, observation, and testing are included in Section 01 45 33, Special Inspection, Observation, and Testing.

B. Contractor-Furnished Quality Control:

1. Inspection and testing required in Section 01 45 16.13, Contractor Quality Control.
2. Manufacturer's Certificate of Compliance per Section 01 61 00, Common Product Requirements, for test results, or calculations, or drawings that ensure material and equipment design and design criteria meet requirements of Section 01 61 00, Common Product Requirements and Section 01 88 15, Anchorage and Bracing.

3.06 FASTENER SCHEDULE

A. Unless indicated otherwise on Drawings, provide fasteners as follows:

Service Use and Location	**Product**	**Remarks**
1. Anchor Bolts Cast Into Concrete for Structural Steel, Metal Fabrications and Castings		
Interior Dry Areas	Hot-dip galvanized steel headed anchor bolts, unless indicated otherwise	
Exterior and Interior Wet Areas	Stainless steel headed anchor bolts	
Submerged and Corrosive Areas	Stainless steel headed anchor bolts with fusion bonded coating	See Section 09 90 00, Painting and Coating
2. Anchor Bolts Cast Into Concrete for Equipment Bases		
Interior Dry Areas	Hot-dip galvanized steel headed anchor bolts, unless otherwise specified with equipment	

Service Use and Location	Product	Remarks
Submerged, Exterior, Interior Wet, and Corrosive Areas	Stainless steel headed anchor bolts with fusion bonded coating, unless otherwise specified with equipment	See Section 09 90 00, Painting and Coating
3. Post-Installed Anchors: See Section 05 05 19, Post-Installed Anchors		
4. Anchors Cast in Grout-Filled Concrete Masonry Units		
Dry Areas	Hot-dip galvanized steel headed anchor bolts	
Exterior and Interior Wet Areas	Hot-dip galvanized steel headed anchor bolts	
5. Connections for Structural Steel Framing		
Exterior and Interior Wet and Dry Areas	High-strength steel bolted connections	Use hot-dipped galvanized high-strength bolted connections for galvanized steel framing members.
6. Connections of Aluminum Components		
Submerged, Exterior and Interior Wet and Dry Areas	Stainless steel bolted connections, unless otherwise specified with equipment	
7. All Others		
Exterior and Interior Wet and Dry Areas	Stainless steel fasteners	

B. Antiseizing Lubricant: Use on stainless steel threads.

END OF SECTION

SECTION 05 52 16
ALUMINUM RAILINGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Aluminum Association, Incorporated (AA): DAF45, Designation System for Aluminum Finishes.
2. American Concrete Institute (ACI) 318, Building Code Requirements for Structural Concrete.
3. American Iron and Steel Institute (AISI).
4. ASTM International (ASTM):
   a. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   b. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   c. E894, Standard Test Method for Anchorage of Permanent Metal Railing Systems and Rails for Buildings.
   d. E935, Standard Test Methods for Performance of Permanent Metal Railing Systems and Rails for Buildings.
   e. E985, Standard Specification for Permanent Metal Railing Systems and Rails for Buildings.
5. International Code Council (ICC): International Building Code (IBC).
6. Occupational Safety and Health Act (OSHA): 29 CFR 1910, Code of Federal Regulations.

1.02 DEFINITIONS

A. ICC Evaluation Services Report: ICC report on evaluation of manufactured concrete anchor systems.

B. Railings: This term includes guardrail systems, handrail systems, platform railing systems, ramp-rail systems, and stair-rail systems. Railings may be comprised of a framework of vertical, horizontal, or inclined members, grillwork or panels, accessories, or combination thereof.

C. Special Inspection: As defined by the ICC IBC.

D. Toeboards: Vertical barrier at floor level usually erected on railings along exposed edges of floor or wall openings, platforms, or ramps to prevent miscellaneous items from falling through.

1.03 DESIGN REQUIREMENTS

A. Structural Performance of Railing Systems: Design, test, fabricate, and install railings to withstand the following structural loads without exceeding allowable design working stress or allowable deflection. Apply each load to produce maximum stress and deflection in railing system components.

1. Railing System: Capable of withstanding the following load cases applied:
   a. Concentrated load of 200 pounds applied at any point and in any direction in accordance with ICC IBC and OSHA.
   b. Uniform load of 50 pounds per linear foot applied in any direction in accordance with ICC IBC.
   c. Concentrated load need not be assumed to act concurrently with uniform loads in accordance with ICC IBC.
2. Calculated lateral deflection at top of posts shall not exceed 1 inch.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Project-specific scaled plans and elevations of railings and detail drawings. Include railing profiles, sizes, connections, anchorage, size and type of fasteners, and accessories.
   b. Manufacturer’s literature and catalog data of railing and components.
   c. Design Data: Calculations or test data using specified design performance loads and including the following:
      1) Bending stress in, and deflection of, posts in accordance with ASTM E985 as modified herein.
      2) Design of post base connection.
      3) Documentation that concrete anchors have been designed in accordance with one of the following:
         a) ACI 318, Chapter 17.
         b) ICC Evaluation Services Report for selected anchor.
2. Samples:
   a. Rail sections, 6 inches long showing each type of proposed connection, proposed finish, and workmanship.
   b. Each fitting including wall brackets, castings, toeboard, and rail expansion joints.

B. Informational Submittals:

1. Manufacturer’s assembly and installation instructions.
2. Special Inspection: Manufacturer’s instructions for Special Inspection of post-installed anchors.

3. Test Reports: Test data may supplement load calculations providing data covers complete railing system, including anchorage:
    a. Test data for railing and components showing load and deflection as a result of load, in enough detail to prove railing is strong enough and satisfies national, state, local standards, regulations, code requirements, and OSHA 29 CFR 1910, using design loads specified. Include test data for the following:
        1) Railing and post connections.
        2) Railing wall connections.
        3) Railing expansion joint connections.
        4) Railing system gate assembly, including latch, gate stop, and hinges. Both gate latch and stop to support required loads applied independent of each other.
    b. Testing of anchorages shall be in accordance with ASTM E894 and ASTM E935 using applied loads in accordance with ICC IBC.
    c. Deflection Criteria: In accordance with ASTM E985 and design loads specified, except as follows: maximum calculated lateral deflection at top of posts shall not exceed 1 inch.
    d. Aluminum Rail Piping: Test data showing yield strength of pipe as delivered equals or exceeds specified values.
4. Manufacturer's written recommendations describing procedures for maintaining railings including cleaning materials, application methods, and precautions to be taken in use of cleaning materials.

1.05 QUALITY ASSURANCE

A. Qualifications: Calculations required for design data shall be stamped by a registered civil or structural engineer licensed in state where Project will be constructed.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Package and wrap railings to prevent scratching and denting during shipment, storage, and installation. Maintain protective wrapping to the extent possible until railing is completely installed.

B. Delivery:

1. Shop assemble into practical modules of lengths not exceeding 24 feet for shipment.
2. Deliver toeboards loose for field assembly.
3. Deliver clear anodized railing pipe and posts with protective plastic wrap.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Thermal Movements: Allow for thermal movement resulting from the following maximum range in ambient temperature in design, fabrication, and

installation of railings to prevent buckling, opening up of joints, over stressing of components, connections and other detrimental effects. Base design calculation on actual surface temperature of material as a result of both solar heat gain and night time sky heat loss. Temperature change is difference between high or low temperature and installation temperature.

1. Temperature Change Range: 70 degrees F, ambient; 100 degrees F, material surfaces.

PART 2 PRODUCTS

2.01 ALUMINUM RAILINGS

A. General:

1. Furnish pre-engineered and prefabricated railing systems as shown on Drawings.
2. Railing systems using pop rivets or glued railing construction are not permitted.
3. Sand cast accessories and components are not permitted.
4. Fasteners shall be AISI Type 316 stainless steel, unless otherwise noted.

B. Rails, Posts, and Formed Elbows:

1. Extruded Alloy 6105-T5, 6061-T6, or equivalent.
2. Tensile Strength: 38,000 psi, minimum.
3. Yield Strength: 35,000 psi, minimum.
4. Wall Thickness: 0.145 inch, minimum.
5. Posts and railings shall be nominal 1-1/2-inch diameter (1.90-inch outside diameter).

C. Accessories:

1. Fittings and Accessories:
   a. Extruded, machined bar stock, permanent mold castings, or die castings of sufficient strength to meet load requirements.
   b. Gauge metal components are not acceptable for load-resisting components.
   c. Fittings shall match color of pipe in railings.
2. Miscellaneous Extruded Aluminum Parts: Alloys 6063-T6, 6061-T6, or 6105 T5 aluminum, or equivalent, and of adequate strength for all loads.
3. Castings for Railings:
   a. Cast Al-mag with sufficient strength to meet load and test requirements.
   b. Anodizable grade finish with excellent resistance to corrosion when subjected to exposure of sodium chloride solution intermittent spray and immersion.

4. Post Anchorages:
    a. Refer to standard details for types of post anchorages and minimum requirements.
    b. Bolts at anchorages shall be minimum 1/2-inch diameter.
5. Wall Brackets: Adjustable wall fitting, with provision for minimum three 3/8-inch diameter AISI Type 316 stainless steel bolts or concrete anchors.
6. Rail Terminals (including Wall Returns): Aluminum wall fitting with provision for three 3/8-inch Type 304 fasteners.
7. Railing System Gate:
    a. Extruded aluminum rail components.
    b. Hardware Manufacturers and Products:
        1) Julius Blum & Co., Inc., Carlstadt, NJ; No. 782/3 gate hinges with springs, and No. 784 gate latch and stop.
        2) CraneVeyor Corp., South El Monte, CA; No. C4370b gate hinges with spring, No. C4369 gate latch, and No. C4368 gate stop.
        3) Moultrie Manufacturing Co., Moultrie, GA; Part No. W60006.
8. Toeboards:
    a. Molded or extruded Alloy 6063-T6 or 6061-T6 aluminum.
    b. Provide slotted holes for expansion and contraction where required.
9. Fasteners: Stainless steel.

D. Finishes:

1. Pipe and Post: In accordance with AA DAF45, designation AA-M32-C22-A41.
2. Cast Fittings and Toeboards: In accordance with AA DAF45, designation AA-M10-C22-A41.

2.02 ANCHOR BOLTS, FASTENERS, AND CONCRETE ANCHORS

A. Locknuts, Washers, and Screws:

1. Elastic Locknuts, Steel Flat Washers, Round Head Machine Screws (RHMS): AISI Type 316 stainless steel.
2. Flat Washers: Molded nylon.

B. Bolts and Nuts for Bolting Railing to Metal Beams: ASTM A193/A193M and ASTM A194/A194M, Type 316 stainless steel.

C. Concrete Anchors:

1. Stainless steel, AISI Type 316.
2. Post-installed anchors in accordance with Section 05 50 00, Metal Fabrications, unless otherwise specified herein.
3. Bolt Diameter: 1/2-inch, minimum.

2.03 FABRICATION

A. Shop Assembly:

1. Post Spacing: Maximum 6-foot horizontal spacing.
2. Railing Posts Bolted to Metal or Concrete:
   a. In lieu of field cutting, provide approved fitting with sufficient post overlap, containing provisions for vertical adjustment.
   b. Field fit-up is required.
3. Free of burrs, nicks, and sharp edges when fabrication is complete.
4. Welding is not permitted.

B. Shop/Factory Finishing:

1. Use same alloy for uniform appearance throughout fabrication for railings.
2. Railing and Post Fittings: Match fittings with color of pipe in railing.

C. Shop Assembly:

1. Shop assemble rails, posts, and formed elbows with a close tolerance for tight fit.
2. Fit dowels tightly inside posts.

D. Repair of Defective Work: Remove stains and replace defective Work.

PART 3 EXECUTION

3.01 GENERAL

A. Field fabrication of aluminum railing systems is not permitted.

B. Where required, provide railing posts longer than needed and field cut to exact dimensions required in order to satisfy vertical variations on actual structure.

C. Install railing with base that provides plus or minus 1/4-inch vertical adjustment inside base fitting. If adjustment is required in field and exceeds plus or minus 1/4-inch, reduce post length not to exceed beyond bottom of lowest set-screw or bolt in base fitting.

D. Modification to supporting structure is not permitted where railing is to be attached.

E. Protection from Entrapped Water: Make provisions in exterior and interior installations subject to high humidity to drain water from railing system.

1. For posts mounted in concrete, bends, and elbows occurring at low points, drill weep holes of 1/4-inch diameter at lowest possible elevations, one hole per post or rail. Drill hole in plane of rail.

3.02 RAILING INSTALLATION

A. Assembly and Installation: Perform in accordance with manufacturer's written recommendations for installation.

B. Expansion Joints:

1. Maximum intervals of 54 feet on center and at structural joints.
2. Slip joint with internal sleeve extending 2 inches beyond each side of joint. Provide 1/2-inch slip joint gap to allow for expansion.
3. Fasten to one side using 3/8-inch diameter set-screw. Place set-screw at bottom of pipe.
4. Locate joints within 12 inches of posts. Locate expansion joints in rails that span expansion joints in structural walls and floors supporting the posts.

C. Posts and Rails:

1. Surface Mounted Posts:
   a. Bolt post baseplate connectors firmly in place.
   b. Shims, wedges, grout, and similar devices for railing post alignment not permitted.
2. Set posts plumb and aligned to within 1/8 inch in 12 feet.
3. Set rails horizontal or parallel to slope of steps to within 1/8 inch in 12 feet.
4. Install posts and rails in same plane.
5. Remove projections or irregularities and provide a smooth surface for sliding hands continuously along top rail.
6. Use offset rail for use on stairs and platforms if post is attached to web of stringers or structural platform supports.
7. Support 1-1/2-inch rails directly above stairway stringers with offset fittings.

D. Wall Brackets:

1. Support wall rails on brackets spaced maximum 5 feet on centers as measured on the horizontal projection.

E. Toeboard:

1. Provide at railings, except where 4-inch or higher concrete curbs are installed, at gates, or at stairways unless shown otherwise.
2. Accurately measure in field for correct length; after railing post installation cut and secure to posts.
3. Dimension between bottom of toeboard and walking surface not to exceed 1/4 inch.
4. Install plumb and aligned to within 1/8 inch in 12 feet.

F. Railing System Gate: Install in accordance with manufacturer's installation instructions.

3.03 FIELD FINISHING

A. Corrosion Protection: Prevent galvanic action and other forms of corrosion caused from direct contact with concrete and dissimilar metals by coating metal surfaces as specified in Section 09 90 00, Painting and Coating.

3.04 FIELD QUALITY CONTROL

A. Post-installed anchors supporting railing systems require special inspection.

B. Owner-Furnished Quality Assurance, in accordance with ICC IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan and Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection, Observation, and Testing.

C. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

3.05 CLEANING

A. Wash railing system thoroughly using clean water and soap. Rinse with clean water.

B. Do not use acid solution, steel wool, or other harsh abrasive.

C. If stain remains after washing, restore in accordance with railing manufacturer's recommendations or replace stained railings.

END OF SECTION

SECTION 05 53 00
METAL GRATINGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A666, Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
   b. B221, Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
2. National Association of Architectural Metal Manufacturers (NAAMM):
   a. MBG 531, Metal Bar Grating Manual.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Grating: Show dimensions, weight, size, and location of connections to adjacent grating, supports, and other Work.
   b. Grating Anchorage: Show details of anchorage to supports to prevent displacement from traffic impact.
   c. Product data for grating, grating clips, anchors, accessories, and other manufactured products specified herein.
   d. Manufacturer's specifications, including coatings, surface treatment, and finishes.

B. Informational Submittals:

1. Special handling and storage requirements.
2. Installation instructions.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Insofar as is practical, factory assemble items.

B. Package and clearly tag parts and assemblies that are, due to necessity, shipped unassembled.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Alabama Metal Industries Corporation (AMICO), Birmingham, AL.
2. HARSCO Industrial IKG, Houston, TX.
3. Ohio Gratings, Inc., Canton, OH.

2.02 GRATING MATERIALS

A. Aluminum: Provide alloy and temper as designated below.

1. Bearing Bars and Banding: ASTM B221 alloy 6061-T6 or 6063-T6.
2. Swaged Crossbar Rods: ASTM B221 alloy 6061 or 6063, or ASTM B210 alloy 3003.
3. Finish: Mill.

2.03 METAL BAR GRATING

A. General Requirements:

1. Maximum Service Load:
   a. Light Duty (Type A): 100 psf uniformly distributed load.
2. Maximum Deflection: Span/240 or 1/4 inch, whichever is less.
3. Bearing Bar Spacing:
   a. Light Duty: 1-3/16 inch maximum, center-to-center.
4. Cross Bar Spacing: 4 inches maximum, center-to-center.
5. Bearing Bars, Cross Bars and Banding: Minimum thickness as specified in NAAMM MBG 531 or as shown on Drawings.

B. Grating Materials:

1. Aluminum, pressure-locked rectangular bar grating fabricated by pressing crossbars between rectangular bearing bars.

C. Surface: Plain.

D. Stair Treads:

1. Material and Type: Same as grating material and grating type as furnished for connecting walkway or work surface.
2. Nosings: Integral ribbing and serrated edge on one long axis of tread, or nonslip abrasive on each tread along one long edge.
3. Carrier Plate or Angle: Furnish at each end for connection to stair stringers.

E. Grating Clamps:

1. Use at flanged beam and bolted angle frame supports.
2. Removable from above grating walkway surface.
3. Provide hat bracket, recessed bolt, and bottom clamp of same material as grating.
4. Manufacturers and Products:
   a. Direct Metals Company, LLC, Kennesaw, GA; Grating Clamp.
   b. Grating Fasteners, Inc., Harvey, LA; G-Clip.

F. Anchor Stud and Saddle Clip:

1. Use at embedded angle frame supports with stud anchor and nut recessed below top of grating surface.
2. Removable from above grating walkway surface.
3. Provide Type 316 stainless steel welded threaded stud anchor, nut, washer, and saddle clip.
4. Manufacturers and Products:
   a. Welded Stud Anchor:
      1) Nelson Stud Welding, Inc., Elyria, OH.
      2) Stud Welding Associates, Inc. Elyria, OH.
   b. Saddle Clip:
      1) Direct Metals Company, LLC, Kennesaw, GA; Saddle Clip.
      2) Grating Fasteners, Inc., Harvey, LA; Saddle Clip.
      3) Struct-Fast, Inc., Baltimore, MD; Gratefast.

PART 3 EXECUTION

3.01 PREPARATION

A. Electrolytic Protection:

1. Protect aluminum surfaces in contact with dissimilar metals, or embedded or in contact with masonry, grout, or concrete as specified in Section 09 90 00, Painting and Coating.
2. Allow paint to dry before installation of material.

3.02 INSTALLATION

A. Until grating sections are securely fastened in place, area shall be appropriately barricaded or flagged to alert people working in the area of potential fall hazard.

B. Install manufactured products in accordance with manufacturer's recommendations.

C. Install supports such that grating sections have a solid bearing on both ends, and that grating sections will not rock or wobble under design loads.

D. Install grating supports plumb and level as applicable.

E. Install sections of welded frames with anchors to straight plane without offsets.

F. Field locate and install fasteners to fit grating layout.

G. Anchor grating securely to supports using minimum of four fastener clips and bolts per grating section.

H. Each grating or plank section shall be easily removable and replaceable.

I. Completed installation shall be rigid and neat in appearance.

J. Protect painted and galvanized surfaces during installation.

K. Repair damaged coatings as specified in Section 09 90 00, Painting and Coating.

END OF SECTION

SECTION 07 21 00
THERMAL INSULATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C578, Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.
   b. C665, Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing.
   c. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Manufacturer's product literature identifying products proposed for use.

1.03 DELIVERY, STORAGE, AND HANDLING

A. On packaging clearly identify manufacturer, contents, brand name, applicable standard, and R-value.

B. Store materials off ground and keep them dry. Protect against weather, condensation, and damage.

PART 2 PRODUCTS

2.01 RIGID INSULATION

A. Rigid Insulation:

1. ASTM C578, Type IV extruded polystyrene foam.
2. Flame Spread: Less than 25 when tested in accordance with ASTM E84.
3. Thickness: As shown on Drawings.
4. R-Value of 5 per inch minimum.
5. Manufacturers and Products:
   a. DuPont; Styrofoam.
   b. Owens Corning; Foamular 150.

B. Adhesives: As recommended by insulation manufacturer and compatible with vapor retarder.

C. Joint Sealant: As recommended by insulation manufacturer.

2.02 SPRAY-ON INSULATION

A. Cellulose Fiber:

1. Thermal Conductivity ("K") Value: 0.22, maximum.
2. Flame Spread: 25 or less when tested in accordance with ASTM E84.
3. Fuel Contribution: 10 or less.
4. Smoke Developed Rating: 0.
5. Color: White with minimum light reflectance of 70 percent where exposed.
6. Manufacturers and Products:
   a. International Cellulose Corp.; K-13.
   b. International Cellulose Corp.; ThermoCon spray-on insulation.

2.03 BATT INSULATION

A. Fiberglass or Mineral Wool Batts:

1. ASTM C665, Type I, with no vapor retarder.
2. Manufacturers:
   a. CertainTeed Corp.
   b. Owens-Corning Insulating Systems.
   c. Johns Manville.

PART 3 EXECUTION

3.01 RIGID INSULATION

A. Install in accordance with the following:

1. Install boards in location and in thickness and R-value as shown on Drawings.
2. Cut insulation with saw, knife, or other sharp tool to fit tightly around obstructions.
3. Butt insulation boards together tightly at joints.
4. Where thickness required exceeds 1-1/2 inches, install two layers of boards.
5. Apply to masonry or concrete with adhesive recommended by insulation manufacturer:
   a. Follow manufacturer's recommendations for preparing surfaces and applying adhesive.
   b. Seal joints.

3.02 SPRAY-ON INSULATION

A. Surface Preparation: Free of dirt, grease, oil, loose paint, excessive rust scale, or other foreign material, which would prevent adequate adhesion.

B. Ambient Temperature: Between 40 degrees F and 155 degrees F throughout application process.

C. Application:

1. Mix, apply, and finish in accordance with manufacturer's instructions for monolithic blanket of uniform texture.
2. Blanket Thickness: As shown on Drawings.

3.03 BATT INSULATION

A. Install in accordance with manufacturer's instructions and as specified below:

1. Fit tightly to ensure continuous seal.
2. Remove and replace damaged material.

END OF SECTION

SECTION 07 40 00
ALUMINUM INSULATED PANELS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM): B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Layouts of panels on walls and roofs including details of edge conditions, joints, corners, panel profiles, supports, anchorages, trim, flashings, and closures. Distinguish between factory and field assembly work.
2. Product data including manufacturer's product specifications, and general recommendations, as applicable to materials and finishes for each component and for total panel system.

B. Informational Submittals: Certificate of Proper Installation per Section 01 43 33, Manufacturer's Field Services (or alternately, test results or calculations), that assure items and its anchorage's design criteria meets requirements of Section 01 88 15, Anchorage and Bracing, for loads provided in General Structural Notes on Drawings.

C. Samples: For initial selection purposes, submit manufacturer's color charts or chips showing full range of colors, textures, and patterns available for roof and wall panels with factory-applied finishes.

D. Quality Control Submittals: Manufacturer's recommended installation instructions.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Deliver panels and other components so they will not be damaged or deformed. Protect panel coating either by application of removable film or by packing plastic film or other suitable material between panels to properly protect the finish. Package wall and roof panels for protection against transportation and handling damage.

B. Stack materials on platforms or pallets, covered with tarpaulins or other suitable weathertight ventilated covering. Store metal wall and roof panels so

that they will not accumulate water. Do not store panels in contact with other materials resulting in staining, denting, or other surface damage.

C. Exercise care in unloading, storing, and erecting wall and roof covering panels to prevent bending, warping, twisting, and surface damage.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Aluminum-Faced Factory-Assembled Insulated Panels:

1. Alply, Inc.
2. Columbia Architectural Products, Inc. (CAP).
3. H.H. Robertson Co.

2.02 MATERIALS

A. Face Sheet Materials:

1. Aluminum Sheets: In accordance with ASTM B209 for Alclad Alloy 3003 or 3004 with temper to suit forming operations.
   a. Cladding: Except as otherwise indicated, where aluminum sheets are exterior exposed without supplied coatings, provide special aluminum alloy-clad sheet known as “Alclad.”
   b. Thickness: 0.040 inch minimum.
2. Metal Finishes: Apply coatings either before or after forming and fabricating panels. Furnish air-drying spray finish in matching color for touchup.
   a. Architectural Class I anodic coating in 0.70-mil thickness; dark bronze color.

B. Core Materials:

1. Poured-In-Place Urethane: Modified isocyanurate foam with minimum 90 percent closed cell structure and the following characteristics:
   a. Density: 2.2 pcf to 2.6 pcf.
   b. Compressive Strength: 20 psi minimum.
   c. Tensile Strength: 30 psi minimum.
   d. Humid Aging: 250 hours at 122 degrees F, 100 percent humidity, 6 percent maximum increase.
   e. Heat Aging: 250 hours at 180 degrees F, 100 percent humidity, 4 percent maximum increase.
   f. R-Value: 14 minimum.

2.03 ALUMINUM INSULATED PANELS FABRICATION

A. Metal wall system consists of nonstructural manufactured panels of the following type: Factory-assembled insulated preformed metal wall panels with manufacturer's standard concealed fasteners, and gasketed seam system.

B. General: Fabricate and finish panels and accessories at the factory to greatest extent possible, by manufacturer's standard procedures and processes. Comply with indicated profiles and dimensional and structural requirements.

C. Fabricate panel joints with captive gaskets or separator strips, which provide a tight seal and prevent metal-to-metal contact in a manner that will minimize noise from movements within panel system.

D. Face Sheets: Fabricate wall and roof panel face sheets to the profile or configuration shown from aluminum sheets.

E. Insulated Aluminum Wall Panels: Fabricate wall panels that will eliminate condensate on the interior side. Joints between panels to form weathertight seals.

1. Factory-assemble wall panel units consisting of required core material laminated or securely bonded to metal interior and exterior face sheets.
2. Panel Size: As shown on Drawings.
3. Flat exterior face with smooth profile.

F. Fabricate and finish panels and accessories at the factory to greatest extent possible by manufacturer's standard procedures and processes.

2.04 ACCESSORIES

A. Fasteners:

1. Self-tapping screws, bolts, nuts, self-locking rivets, self-locking bolts, end-welded studs, and other suitable fasteners designed to withstand design loads.
2. Exposed: Factory-applied coating, or plastic caps for fastener heads; color to match panel.
3. Washer: Metal-backed neoprene washers.
4. Stainless steel.

B. Closure Strips: Closed-cell, self-extinguishing, expanded cellular rubber or cross-linked polyolefin foam flexible closure strips. Cut or premold to match configuration of roof and wall panels.

C. Sealing Tape: Pressure-sensitive 100 percent solids polyisobutylene compound sealing tape with release paper backing, permanently elastic, nonsag, nontoxic, nonstaining tape.

D. Joint Sealant: Polyurethane sealant as specified in Section 07 92 00, Joint Sealants.

E. Bituminous Coating: As Specified in Section 09 90 00, Painting and Coating Paint System No. 27.

PART 3 EXECUTION

3.01 GENERAL

A. Panel Supports and Anchorage: Install girts, purlin, and other secondary panel support members and anchorage in accordance with AISC Manual of Steel Construction "Code of Standard Practice."

B. Apply bituminous coating on panel surfaces where panels would otherwise be in direct contact with different materials of structure that are noncompatible or could result in corrosion or deterioration of either material or finishes.

C. Except as specified in other sections, provide components as needed for a complete preformed roof and wall panel system, including but not limited to trim, copings, fascias, gravel stops, mullions, sills, corner units, ridge closures, clips, seam covers, battens, flashings, gutters, gaskets, and fillers. Match materials and finishes of panels.

3.02 PANEL INSTALLATION

A. Comply with manufacturers' instructions and recommendations for installation. Anchor panels and other components of the Work securely in place, with provisions for thermal and structural movement.

1. Field cutting of exterior panels by torch is not permitted.
2. Install panels with concealed fasteners.

B. Accessories: Install components required for a complete wall panel system.

C. Joint Sealers: Install gaskets, joint fillers, and joint sealants required for weatherproofing of panel systems. Weather seal under ridge cap. Flash and seal roof panels at eave and rake with rubber, neoprene, or other closures to exclude weather.

D. Aluminum Insulated Panels: Apply joint sealant continuously between metal base channel (sill angle) and concrete and elsewhere as necessary to ensure weathertight conditions. Handle and apply sealant and backup in accordance with the sealant manufacturer's recommendations.

1. Align bottom of wall panels and fasten panels with blind rivets, bolts, or self-tapping screws. Fasten flashings and trim around openings and similar elements with self-tapping screws.

2. Locate and space exposed fasteners in true vertical and horizontal alignment. Use proper tools to obtain controlled uniform compression for positive seal without rupture of neoprene washer.
3. Install screw fasteners to compress neoprene washer tightly without damage to washer, screw threads, or panels. Install screws in predrilled holes.
4. Provide weathertight escutcheons for pipe and conduit penetrating exterior walls.

E. Installation Tolerances: Shim and align panel units within installed tolerance of 1/4 inch in 20 feet and within 1/8-inch offset of adjoining faces, and of alignment of matching profiles.

3.03 CLEANING

A. Remove temporary protective coverings and removable films as each panel is installed. Upon completion of panel installation, clean finished surfaces as recommended by panel manufacturer, and maintain in a clean and undamaged condition during construction.

END OF SECTION

SECTION 07 52 16
SBS-MODIFIED BITUMINOUS MEMBRANE ROOFING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Wood Preservers' Association (AWPA): C2, Lumber, Timbers, Bridge Ties, and Mine Ties-Preservative Treatment by Pressure Processes.
2. ASTM International (ASTM):
   a. C728, Standard Specification for Perlite Thermal Insulation Board.
   b. C1289, Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board.
   c. D41, Standard Specification for Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing.
   d. D312, Standard Specification for Asphalt Used in Roofing.
   e. D1227, Standard Specification for Emulsified Asphalt Used as a Protective Coating for Roofing.
   f. D4586, Standard Specification for Asphalt Roof Cement, Asbestos Free.
   g. D4601, Standard Specification for Asphalt-Coated Glass Fiber Base Sheet Used in Roofing.
   h. D6162, Standard Specification for Styrene Butadiene Styrene (SBS) Modified Bituminous Sheet Materials Using a Combination of Polyester and Glass Fiber Reinforcements.
   i. D6164, Standard Specification for Styrene Butadiene Styrene (SBS) Modified Bituminous Sheet Materials Using Polyester Reinforcements.
3. Factory Mutual (FM): Loss Prevention Data.
   a. 1-28, Insulated Steel Deck.
   b. 1-28S, Wind Uplift Pressure on Roofs.
4. National Roofing Contractors Association (NRCA): Handbook of Accepted Roofing Knowledge (HARK).

1.02 SUBMITTALS

A. Action Submittals:

1. Project-specific details of roof edges and penetrations.
2. Mechanical fastening diagram for rigid insulation, where applicable.
3. Layout drawings for tapered insulation, showing slopes and thicknesses.

4. List of materials proposed for use including roofing materials, insulation**,** composition flashing, and fasteners.
5. Roofing materials manufacturer's specifications selected for use.
6. Description of complete system, from deck up, proposed for use.

B. Informational Submittals:

1. Manufacturer's installation instructions.
2. A letter from roofing materials manufacturer stating roofer is approved by manufacturer to apply roof.
3. Manufacturer's Certificate of Proper Installation and inspection reports per Section 01 43 33, Manufacturers' Field Services.
4. Test results or calculations that assure anchorage design criteria meets requirements of Section 01 88 15, Anchorage and Bracing, for loads provided on the General Structural Notes in the Drawings.
5. Sample copy of special guarantee to be provided.
6. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
7. Test reports, in triplicate, of field test cuts of roofing system.
8. Written notice when roofing installation is ready for final inspection.
9. Record of Preroofing Conference.
10. Record drawings for tapered insulation.

1.03 QUALITY ASSURANCE

A. Materials, including insulation, used in a roofing system shall be furnished by, or approved by, manufacturer whose roofing system is selected for use.

B. Roofer Qualifications:

1. Trained and approved by roofing system manufacturer.
2. Have a minimum of 5 years of experience in the installation of roofing and flashing specified.

C. Preroofing Conference:

1. Attendees: Conduct preroofing conference with Engineer, roof deck installer, roofing system materials manufacturer's representative roofer, mechanical equipment installer and other subcontractors likely to be on roof.
2. Agenda: Follow outline in NRCA, HARK including acceptability of deck, roofing system materials manufacturer's specification selected, flashing details, roof guarantee, and protection of finished roofing system.
3. Record: Discussions and agreements and furnish copy to each participant and entity invited.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in manufacturer's original, unopened containers and rolls with labels intact and legible. Labels on bitumen shall show composition, softening point (SP) range, minimum flashpoint (FP), minimum finished blowing temperature (BT), and equiviscous temperature (EVT) range.

B. Handle roll goods so as to prevent damage to edge or ends. Store roll goods on end.

C. Store rigid roof insulation materials on clean, raised platforms.

D. Protect materials against direct sunlight, wetting, moisture absorption, mud, dust, sand, oil, grease, dirt, and construction traffic.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Temperature:

1. Apply roofing only in dry weather and when ambient temperature is above 40 degrees F.
2. When temperature is below 45 degrees F, application must be approved by, and under supervision of, roofing materials manufacturer.

1.06 SPECIAL GUARANTEE

A. Product: Furnish manufacturer's extended guarantee, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction or, at the option of the Owner, removal and replacement of Work specified in this Specification section found defective during a period of 20 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in the General Conditions.

B. Coverage and Conditions:

1. No dollar limit (NDL) for repairs required to maintain roofing system, composition flashing, and expansion joint covers in watertight condition.
2. Natural deterioration of roofing system due to ordinary wear and tear by the elements; and
3. Defects due to faulty materials or workmanship during application.

PART 2 PRODUCTS

2.01 MODIFIED BITUMEN SHEET ROOFING SYSTEM

A. Description: Single-ply SBS modified bitumen sheet membrane with mineral granule surface, applied to rigid roof insulation.

B. Membrane and Flashing Materials: Approved for use in UL Class A rated assemblies.

1. Thickness: Not less than 3.5 mm.
2. Weight: Not less than 100 pounds per square.
3. Reinforcing: Polyester or polyester and fiberglass fabrics.
4. Surface: Reflective ultra-white mineral granular surface with a SRI of 78 minimum.

C. Manufacturers and Products:

1. Firestone Building Products; Ultrawhite SBS Premium FR.
2. Johns Manville; DynaKap FR CR.
3. GAF; Ruberoid EnergyCap SBS30FR.

2.02 ROOFING MATERIALS

A. Sheet Membrane: ASTM D6162 or D6164, Grade G, Type II.

B. Primer: ASTM D41 asphalt.

C. Bitumen: ASTM D312, Type IV, special steep asphalt.

D. Plastic Roof Cement: ASTM D4586, Type II, asphalt plastic cement.

E. Base Felt: ASTM D4601, Type II, asphalt-coated glass fiber mat.

F. Flashing sheet combining SBS polymer modified bitumen, polyester reinforcement, and mineral surfacing for application in hot asphalt.

G. Wall Flashing: Flashing sheet combining SBS polymer modified bitumen, polyester reinforcement, and mineral surfacing for application in hot asphalt designed for application on parapets walls as shown on the Drawings.

H. Fasteners:

1. Into Wood: Zinc-coated, 12-gauge roofing nails with 1-inch diameter metal caps or heads and deformed shanks.
2. Into Insulation and Fiberboard: Tube-Loc nail with 1-inch diameter cap.
   a. Manufacturers and Products:
      1) Simplex Nail and Manufacturing Co.
      2) E. G. Building Fasteners Corp.; Insuldeck Loc-Nail.
3. Into Insulating Concrete:
   a. Manufacturers and Products:
      1) W. R. Grace; Zono-Tite.
      2) Simplex Nail and Manufacturing Co.; Tube-Loc nail, with 1-inch diameter cap.

I. Treated Wood Nailers:

1. Waterborne salt preservatives; AWPA C2.
2. Apply two brush coats of same preservative used in original treatment to all sawed or cut surfaces of treated lumber.
3. Minimum Grade: Standard or Better, or Stud Grade.
4. Conforms to FM Global Loss Prevention Data 1-49.
5. Creosote and asphaltic preservatives are not acceptable.

2.03 ROOF WALKWAYS

A. Roof walkways may consist of an additional layer of specified cap sheet.

B. Slip-resistant asphalt plank, minimum size 1/2 inch thick by 1 foot by 2 feet, surfaced with ceramic granules in pastel gray color.

2.04 RIGID ROOF INSULATION

A. Average Aged R-Value for Total Thickness of Rigid Roof Insulation: Minimum R=30.

B. At Contractor's option, either Polyisocyanurate Foam Board with Expanded Perlite Board cover or Composite Board may be used on this Project provided roofing materials manufacturer approves insulation used and will guarantee roofing system:

1. Perlite Board: ASTM C728, minimum size 2 feet by 4 feet, as manufactured by:
   a. Firestone Building Products; ISOGARD HD.
   b. GAF; EnergyGuard Perlite.
   c. Johns Manville; Fesco Board.

2. Polyisocyanurate Foam Board: ASTM C1289, Type II, with Factory Mutual Class I approval, minimum size 2 feet by 4 feet, as manufactured by:
   a. Firestone Building Products; ISO 95+.
   b. GAF; EnergyGuard Ultra Polyiso.
   c. Johns Manville; ENRGY 3.
3. Composite Board: Of polyisocyanurate or polyurethane foam core bonded to 1/2-inch perlite fiberboard minimum size 3 feet by 4 feet, as manufactured by:
   a. Firestone Building Products; ISOGARD HD Composite.
   b. GAF; EnergyGuard Composite Board Polyiso.
   c. Johns Manville; Fesco Foam.
4. Tapered Board System:
   a. Factory precut or field tapered insulation board, minimum 1-inch thick, with top surface cut to a uniform, continuous slope of 1/4 inch per foot minimum.
   b. Fabricate miters and edges to match abutting blocks.
   c. Manufacturers and Products: As specified for composite board.

2.05 TAPERED EDGE, CRICKETS, AND CANT STRIPS

A. Use Preformed Shapes:

1. Bitumen-coated on all sides, expanded perlite.
2. Wood treated in accordance with AWPA C2 for waterborne salts and dried to 19 percent moisture content or less after treatment.

PART 3 EXECUTION

3.01 PREPARATION

A. Notify Engineer and manufacturer’s representative at least 48 hours before beginning installation of roofing system.

B. Deck shall be firm, dry, free of foreign materials, and smooth.

1. Differential height between adjacent roof deck members of more than 1/8 inch is not acceptable.
2. Report immediately to the Engineer cracks, breaks, holes, or other unusual irregularities in the surface.

3.02 APPLICATION

A. General: Do not phase application of roofing system.

1. Install all components of an assembly over that area that is covered in 1 day.

2. Seal off edges of system at the end of the day with one layer of mopped-in felt.

B. Bitumen:

1. Maintain kettle temperature so as not to exceed the flashpoint of the bitumen.
2. Apply bitumen at the equiviscous temperature, plus or minus 25 degrees F.
3. Do not exceed the finish blowing temperature.
4. Moppings Between Layers: 15 pounds to 20 pounds per square.

C. Vapor Retarder:

1. Install under rigid roof insulation.
2. Apply vapor retarder consisting of a minimum of two layers of roofing felt mopped-in with hot bitumen in accordance with the roofing materials manufacturer's specifications.

D. Insulation:

1. Keep insulation dry before and during application.
2. Apply rigid insulation to R-value indicated, in strict accordance with the insulation and roofing materials manufacturer's specifications.
3. On Concrete Decks: Apply insulation to deck with bitumen in quantity recommended by roofing materials manufacturer.
4. Insulation Layers:
   a. Stagger joints from layer below.
   b. Secure second layer to previous layer with bitumen specified in quantity as recommended by insulation manufacturer.
   c. Place insulation immediately into applied bitumen and then press into place to ensure embedment.
   d. Lay tapered insulation, where applicable, in accordance with the insulation manufacturer's layout drawings and instructions.

E. Roofing System on Decking or Insulation:

1. Apply base sheet, modified bitumen sheet roofing membrane system, and flashing following with roofing materials manufacturer's specifications for roofing system selected.
2. Membrane may be torched or mopped down as recommended by the manufacturer.
3. Set membrane in-place with minimum 3-inch sidelaps and 4-inch endlaps.

3.03 FIELD QUALITY CONTROL

A. Concrete Deck Dryness Test:

1. Test for dryness before applying vapor retarder.
2. Should rain occur during application, retest for dryness before continuing roof application.
3. Perform the following tests for dryness:
   a. Foaming:
      1) Heat one pint of specified bitumen to 350 degrees F to 400 degrees F.
      2) Pour on surface to receive roofing felts.
      3) If bitumen foams, deck is not dry enough to roof.
   b. Strippability:
      1) Cool bitumen poured on deck to ambient temperature.
      2) Strip from surface.
      3) If any portion strips clean from deck or insulation, surface is not dry enough to roof.

3.04 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance and training of Owner's personnel for maintaining specified system.

3.05 CLEANING

A. Upon completion of the roofing installation:

1. Clean up waste material and debris resulting from roofing operation.
2. Dispose of waste material off the Site.
3. Remove spots and smears of asphalt or other material from flashing, gravel stops, and other surfaces not intended to be coated with such material.
4. During removal, ensure that no damage will be done to the surfaces.
5. Use solvents, if necessary, to satisfactorily clean the materials.

END OF SECTION

SECTION 07 62 00
SHEET METAL FLASHING AND TRIM

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A666, Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
   b. B32, Standard Specification for Solder Metal.
   c. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   d. C920, Standard Specification for Elastomeric Joint Sealants.
   e. C1311, Standard Specification for Solvent Release Sealants.
   f. D4586/D4586M, Standard Specification for Asphalt Roof Cement, Asbestos-Free.
2. FM Global (FM): Loss Prevention Data Sheet 1-49, Perimeter Flashing.
3. Sheet Metal and Air Conditioning Contractors National Association (SMACNA): 1793, Architectural Sheet Metal Manual.

1.02 PERFORMANCE REQUIREMENTS

A. General: Sheet metal flashing and trim shall withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failing, rattling, leaking, and fastener disengagement.

B. Fabricate and install roof edge flashing capable of resisting the following forces according to recommendations in FM Loss Prevention Data Sheet 1-49.

C. Thermal Movements: Provide sheet metal flashing and trim that allows for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures for preventing buckling, opening of joints, hole elongation, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects.

D. Water Infiltration: Provide sheet metal flashing and trim that does not allow water infiltration to building interior.

1.03 QUALITY ASSURANCE

A. Sheet Metal Flashing and Trim Standard: Comply with SMACNA 1793. Conform to dimensions and profiles shown, unless more stringent requirements are indicated.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Show joints, types and location of fasteners, and special shapes.
   b. Catalog data for stock manufactured items.
2. Samples: Color Samples for items to be factory finished.

1.05 DELIVERY, HANDLING, AND STORAGE

A. Inspect for damage, dampness, and wet storage stains upon delivery to Site.

B. Remove and replace damaged or permanently stained materials that cannot be restored to like-new condition.

C. Carefully handle to avoid damage to surfaces, edges, and ends.

D. Do not open packages until ready for use.

E. Store materials in dry, weathertight, ventilated areas until immediately before installation.

PART 2 PRODUCTS

2.01 METAL

A. Aluminum Flashing: ASTM B209, Alloy 5005-H34, 0.032 inch thick, unless otherwise shown, with Architectural Class I anodic coating in 0.70-mil thickness; dark bronze color.

B. Stainless Steel Flashing: ASTM A666, Type 304 or Type 316, soft temper; No. 2D, dull finish, 0.018 inch thick, unless otherwise shown.

2.02 REGLETS AND COUNTERFLASHING

A. For Masonry:

1. Stainless steel, 0.015 inch.
2. Manufacturers and Products:
   a. Fry Reglet Corp.; Fry Springlok Type MA and Springlok Flashing.
   b. Cheney Flashing Co.; Type B reglet and Snap Lock Cap Flashing.

B. For Concrete:

1. Stainless steel, 0.015 inch.
2. Manufacturers and Products:
   a. Fry Reglet Corp.; Fry Springlok Type CO and Springlok Flashing.
   b. Cheney Flashing Co.; Type A reglet and Snap Lock Cap Flashing.

2.03 PREFABRICATED METAL SYSTEMS

A. Coping System:

1. Snap-on system, stucco embossed pattern aluminum, 0.050-inch minimum thickness.
2. Include ancillary items, such as mitered and welded corners, and end caps, where shown and as required for complete system.
3. Manufacturers and Products:
   a. W.P. Hickman Co.; Permasnap Coping.
   b. IMETCO; ES-C Sloped Coping.
   c. Johns Manville; Presto Lock Coping System.

B. Finish: Factory finished with Architectural Class I anodic coating in 0.70-mil thickness and in dark bronze color.

2.04 THROUGH WALL AND ROOF FLASHING

A. Stainless steel flashing as specified where shown on Drawings.

2.05 EXPOSED FLASHING

A. Aluminum flashing as specified where shown on Drawings, including scuppers and downspouts.

2.06 ANCILLARY MATERIALS

A. Solder: ASTM B32, alloy composition Sn 60 for stainless steel.

B. Soldering Flux: ASTM B32, Type RA.

C. Burning Rod for Lead: Same composition as lead sheet.

D. Sealing Tape: Polyisobutylene sealing tape specifically manufactured for setting flanges on bituminous roofing.

E. Isolation Paint: As specified in Section 09 90 00, Painting and Coating, Paint System No. 27.

F. Isolation Tape: Butyl or polyisobutylene, internally reinforced, or 20-mil thick minimum polyester.

G. Plastic Roof Cement: ASTM D4586/D4586M, Type II.

H. Elastomeric Sealant: ASTM C920, elastomeric silicone polymer sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.

I. Butyl Sealant: ASTM C1311, single-component, solvent-release butyl rubber sealant, polyisobutylene plasticized, heavy bodied for hooked-type expansion joints with limited movement.

J. Fasteners:

1. Aluminum Work: Stainless steel or aluminum; reglet fasteners may be galvanized or cadmium-plated steel.
2. Stainless Steelwork: Stainless steel.
3. Nails: Roofing nailhead, 10-gauge spiral or ring shank, lengths as required to penetrate wood at least 3/4 inch or as required in Article Performance Requirements.

2.07 FABRICATION OF FLASHING

A. Field measure prior to fabrication.

B. Fabricate in accordance with SMACNA 1793 that applies to design, dimensions, metal, and other characteristics of item indicated.

C. Fabricate sheet metal flashing and trim in thickness or weight needed to comply with performance requirements, but not less than that specified for each application and metal.

D. Fabricate sheet metal flashing and trim without excessive oil canning, buckling, and tool marks and true to line and levels indicated, with exposed edges folded back to form hems.

E. Seams:

1. Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.
2. Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.

F. Reinforcements and Supports: Provide same material as flashing, unless other material is shown. Steel, where shown or required, shall be galvanized or stainless.

G. Rigid Joints and Seams: Make mechanically strong. Seal aluminum joints with sealant. Solder stainless steel metal joints. Do not use solder to transmit stress.

H. Sealed Joints: Form nonexpansion but movable joints in metal to accommodate elastomeric sealant to comply with SMACNA recommendations.

I. Expansion Provisions: Where lapped or bayonet-type expansion provisions in the Work cannot be used, form expansion joints of intermeshing hooked flanges, not less than 1-inch deep, filled with butyl sealant concealed within joints.

J. Fabricate sheet metal in 10-foot maximum lengths, unless otherwise indicated.

K. Provide watertight closures at exposed ends of counterflashing.

L. Fabricate corners in one-piece with legs extending 30 inches each way to field joint. Lap, rivet, or solder corner seams watertight. Apply sealant if necessary.

M. Neutralize soldering flux.

N. Solvent clean sheet metal. Surfaces to be in contact with roofing or otherwise concealed shall be coated with isolation paint.

O. Pipe Penetrations through Roof**:** As specified in Section 07 70 01, Roof Specialties and Accessories, and as shown on Drawings.

P. Conceal fasteners and expansion provisions where possible on exposed-to-view sheet metal flashing and trim, unless otherwise indicated.

Q. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal.

1. Thickness: As recommended by SMACNA 1793 and FM Loss Prevention Data Sheet 1-49 for application, but not less than thickness of metal being secured.

2.08 FABRICATION OF SCUPPERS AND DOWNSPOUTS

A. Downspouts:

1. Form downspouts in maximum lengths as practicable is sizes and shapes as indicated on Drawings.
2. Telescope end joints 1-1/2 inches and lock longitudinal joints of downspouts.
3. Fit downspouts into cast iron boots or drainpipes as indicated on Drawings; neatly caulk or cement joints.

B. For scuppers and conductor heads to shapes and sizes indicated on Drawings.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify roof openings, curbs, pipes, sleeves, ducts, or vents through roof are solidly set and cant strips and reglets in place.

B. Verify nailing strips and blocking are properly located.

C. Verify membrane termination and base flashings are in place, sealed, and secure.

3.02 INSTALLATION

A. Flashing:

1. General:
   a. Install sheet metal roof flashing and trim to comply with performance requirements and SMACNA 1793.
   b. Provide concealed fasteners where possible, set units true to line, and level as indicated.
   c. Install work with laps, joints, and seams that will be permanently watertight.
2. Roof Edge Flashing: Anchor to resist uplift and outward forces according to recommendations in FM Loss Prevention Data Sheet 1-49 for specified wind zone and as indicated.
   a. Interlock bottom edge of roof edge flashing with continuous cleats anchored to substrate at 16-inch centers.
3. Isolate metal from wood and concrete and from dissimilar metal with isolation tape or two coats of isolation paint.
4. Use only stainless steel fasteners to connect isolated dissimilar metals.
5. Joints: 10-foot maximum spacing and 2-1/2 feet from corners, butted with 3/16-inch space centered over matching 8-inch-long backing plate with sealing tape in laps.
6. Set flanges of flashings and roof accessories on continuous sealing tape or in plastic roof cement on top of envelope ply of roofing. Nail flanges through sealing tape and at 3-inch maximum spacing. Touch up isolation paint on flanges.
7. Joints, Fastenings, Reinforcements, and Supports: Sized and located as required to preclude distortion or displacement as a result of thermal expansion and contraction.
8. Provide continuous holddown clips at counterflashing and gravel stops.
9. Conceal fastenings wherever possible.
10. Set flashing and sheet metal to straight, true lines with exposed faces aligned in proper plane without bulges or waves.

B. Prefabricated Metal Systems:

1. Follow system manufacturer's printed instructions.
2. Place color variations in pieces so no extremes are next to each other.

C. Scuppers and Downspouts: Anchor downspouts to wall with straps of same material as downspouts. Install scuppers and conductors head as indicated on Drawings.

3.03 FINISH

A. Exposed Surfaces of Flashing and Sheet Metalwork: Free of dents, scratches, abrasions, or other visible defects, and clean and ready for painting where applicable.

3.04 CLEANING AND PROTECTION

A. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.

B. Clean and neutralize flux materials. Clean off excess solder and sealants.

C. Remove temporary protective coverings and strippable films as sheet metal flashing and trim are installed. On completion of installation, clean finished surfaces, including removing unused fasteners, metal filings, pop rivet stems, and pieces of flashing. Maintain in a clean condition during construction.

D. Replace sheet metal flashing and trim that have been damaged or that have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION

SECTION 07 70 01
ROOF SPECIALTIES AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM): D4586, Standard Specification for Asphalt Roof Cement, Asbestos-Free.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings of each item specified showing materials, details, flashing, anchorage, and relation to adjacent structure.
2. Catalog cuts of each item specified item.

B. Informational Submittals: Manufacturer's Certificate of Compliance per Section 01 61 00, Common Product Requirements, (or alternately, test results or calculations) that assure items and its anchorage's design criteria meets requirements of Section 01 88 15, Anchorage and Bracing, for loads provided in General Structural Notes on Drawings**.**

1.03 SEQUENCING AND SCHEDULING

A. Coordination: Schedule and coordinate work of this section with work of Section 07 52 16, SBS-Modified Bituminous Membrane Roofing, and Section 07 62 00, Sheet Metal Flashing and Trim.

PART 2 PRODUCTS

2.01 ROOF CURBS

A. Prefabricated Galvanized Steel: Minimum 18-inch-high curb with treated wood nailer**,** liner panel, and factory installed insulation as required for conditions shown on Drawings.

B. Metal Gauge and Reinforcement: To suit imposed loads of equipment to be supported.

C. Fabricate curbs to fit roof slope.

D. Manufacturers and Products:

1. Pate Co.; PC-2.
2. ThyCurb; Model TC-3.
3. RPS Corporation; RC-2A.

2.02 EQUIPMENT SUPPORT CURBS

A. Prefabricated Galvanized Steel: Minimum 18-inch-high curb with counterflashing, factory installed insulation, and treated wood nailer as required for conditions shown on Drawings.

B. Metal Gauge and Reinforcement: To suit imposed loads of equipment to be supported.

C. Fabricate curbs to fit roof slope.

D. Manufacturers and Products:

1. Pate Co.; ES-2.
2. ThyCurb; Model TEMS-3.
3. RPS Corporation; ER-2A.

2.03 PIPE CURB ASSEMBLY

A. Prefabricated Galvanized Steel: Minimum 18-inch-high curb for pipe penetrations of roof, complete with cover**,** liner panel**,** factory installed insulation and accessories as required for conditions shown on Drawings.

B. Fabricate to fit roof slope and furnish covers to suit pipe penetrations indicated on Drawings.

C. Manufacturers and Products:

1. Pate Co.; PCA-2, with cover.
2. ThyCurb; Model TC-3, with cover.
3. RPS Corporation; Pipe Portal System.

2.04 PIPE SEALS

A. Prefabricated one-piece aluminum flanged base with stepped, graduated EPDM cap and adjustable stainless steel clamps.

B. Manufacturers and Products:

1. Pate Co.; Pipe Seal.
2. Portals Plus, Inc.; Alumi-Flash.

2.05 ANCILLARY MATERIALS

A. Sealing Tape: Polyisobutylene sealing tape specifically manufactured for setting flanges on bituminous roofing.

B. Isolation Paint: As specified in Section 09 90 00, Painting and Coating Paint System No. 27.

C. Coat aluminum surfaces in contact with concrete or dissimilar metals as specified in Section 09 90 00, Painting and Coating, Paint System No. 27.

D. Isolation Tape: Butyl or polyisobutylene, internally reinforced, or 20-mil-thick minimum polyester.

E. Plastic Roof Cement: ASTM D4586, Type II.

F. Fasteners: Stainless steel of type required.

PART 3 EXECUTION

3.01 PREPARATION

A. Examine surfaces and structures to receive the Work of this section.

B. Take measurements at Site and fabricate work to suit. No changes shall be made in supporting structure to accommodate this Work.

3.02 INSTALLATION

A. General:

1. Install roof specialties and accessories as detailed in approved shop drawings and in conformance with manufacturer's instructions, recommendations, and standards.
2. Use appropriate pipe curb assembly, pipe seal, flexible base pipe seal, or vent pipe flashing where pipe, conduit, or cable, etc., penetrate roofing membrane.
3. Factory Finished Units: Place color variations in pieces so no extremes are next to each other.
4. Make Work weathertight and free of expansion and contraction noise.
5. Maintain separation between aluminum surfaces and concrete or dissimilar metals with isolation paint or isolation tape.

END OF SECTION

SECTION 07 92 00
JOINT SEALANTS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C661, Standard Test Method for Indentation Hardness of Elastomeric-Type Sealants by Means of a Durometer.
   b. C920, Standard Specification for Elastomeric Joint Sealants.
   c. C1193, Standard Guide for Use of Joint Sealants.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Surface preparation instructions. Indicate where each product is proposed to be used.
2. Samples: Material proposed for use showing color range available.

B. Informational Submittals:

1. Installation instructions.
2. Documentation showing applicator qualifications.
3. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
4. Special guarantee.

1.03 QUALITY ASSURANCE

A. Applicator Qualifications: Minimum of 5 years' experience installing sealants in projects of similar scope.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Ambient Temperature: Between 40 degrees F and 80 degrees F (4 degrees C and 27 degrees C) when sealant is applied. Consult manufacturer when sealant cannot be applied within these temperature ranges.

1.05 SPECIAL GUARANTEE

A. Product: Furnish manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction or, at the option of the Owner, removal and replacement of Work specified in this section found defective during a period of 5 years

after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in the General Conditions.

B. Conditions: No adhesive or cohesive failure of sealant.

C. Sealed Joints: Watertight and weathertight with normal usage.

PART 2 PRODUCTS

2.01 SEALANT MATERIALS

A. Characteristics:

1. Uniform, homogeneous.
2. Free from lumps, skins, and coarse particles when mixed.
3. Nonstaining, nonbleeding.
4. Hardness of 15 minimum and 50 maximum, measured by ASTM C661 method.
5. Immersible may be substituted for nonimmersible.

B. Color: Unless specifically noted, match color of the principal material adjoining area of application. Color as selected by Owner or Engineer.

C. Type 1—Silicone, Nonsag, Nonimmersible:

1. Silicone base, single-component, moisture curing; ASTM C920, Type S, Grade NS, Class 25.
2. Capable of withstanding movement up to 50 percent of joint width.
3. Manufacturers and Products:
   a. Dow Corning Corp.; No. 790.
   b. General Electric; Silpruf.
   c. BASF; Sonneborn, Omniseal-50.

D. Type 2—Multipart Polyurethane, Self-leveling, Immersible:

1. Polyurethane base, multicomponent, chemical curing; ASTM C920, Type M, Grade P, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturers and Products:
   a. BASF; Sonneborn, SL-2.
   b. Pecora Corp.; Urexspan NR-200.
   c. Tremco; THC-900/901.
   d. Sika Chemical Corp.; Sikaflex 2c SL.

E. Type 3—Multipart Polyurethane, Nonsag, Immersible:

1. Polyurethane base, multicomponent, chemical curing; ASTM C920, Type M, Grade NS, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturers and Products:
   a. Pecora; DynaTrol II.
   b. Tremco; Dymeric 240.
   c. BASF; Sonneborn NP-2.
   d. Sika Chemical Corp.; Sikaflex 2c NS.

F. Type 5—One-part Polyurethane, Immersible:

1. Polyurethane base, single-component, moisture curing; ASTM C920, Type S, Grade NS or P, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturers and Products for Nonsag:
   a. Sika Chemical Corp.; Sikaflex-1a.
   b. Tremco; Vulkem 116.
4. Manufacturers and Products for Self-leveling:
   a. BASF; MasterSeal, SL-1.
   b. Tremco; Vulkem 45.
   c. Sika Chemical Corp.; Sikaflex 1c SL.

G. Type 7—Multipart Polysulfide, Immersible:

1. Polysulfide base, two-component, chemical curing; ASTM C920, Type M, Grade P or NS, Class 25.
2. Capable of being continuously immersed in water.
3. For use above grade and below grade.
4. Manufacturers and Products:
   a. W. R. Meadows; Deck-O-Seal Gun Grade, two-part.
   b. BASF; Sonolastic, two-part Polysulfde.

H. Type 11—Fire Penetration Seal:

1. Manufacturers and Products:
   a. 3M Corp.; Fire Barrier Caulk CP25 and Putty 303.
   b. General Electric; Pensil Sealant or Foam.
   c. Unifrax Corporation; Fyre Putty.
   d. Hilti USA; CP 604.

2.02 BACKUP MATERIAL

A. Nongassing, extruded, closed-cell round polyurethane foam or polyethylene foam rod, compatible with sealant used, and as recommended by sealant manufacturer.

B. Size: As shown or as recommended by sealant material manufacturer. Provide for joints greater than 3/16 inch wide.

C. Manufacturers and Products:

1. BASF; Sonneborn, Sonolastic Closed-cell Backing Rod.
2. Tremco; Closed-cell Backing Rod.
3. Pecora Corporation; Green Rod.

2.03 ANCILLARY MATERIALS

A. Bond Breaker: Pressure sensitive tape as recommended by sealant manufacturer to suit application.

B. Joint Cleaner: Noncorrosive and nonstaining type, recommended by sealant manufacturer; compatible with joint forming materials.

C. Primer: Nonstaining type recommended by sealant manufacturer to suit application.

PART 3 EXECUTION

3.01 GENERAL

A. Use of more than one material for the same joint is not allowed unless approved by sealant manufacturer.

B. Install joint sealants in accordance with ASTM C1193.

C. Horizontal and Sloping Joints up to 1 Percent Maximum Slope: Use self-leveling (Grade P) joint sealant.

D. Steeper Sloped Joints, Vertical Joints, and Overhead Joints: Use nonsag (Grade NS) joint sealant.

E. Use joint sealant as required for the applicable application and as follows:

Joint Size	Sealant Type
Less than 1"	1, 2, 3, 5, 7, or 11
Less than 2"	1, 2, 3, or 7
Over 2"	Follow manufacturer’s recommendation

3.02 PREPARATION

A. Verify that joint dimensions, and physical and environmental conditions, are acceptable to receive sealant.

B. Surfaces to be sealed shall be clean, dry, sound, and free of dust, loose mortar, oil, and other foreign materials.

1. Mask adjacent surfaces where necessary to maintain neat edge.
2. Starting of work will be construed as acceptance of subsurfaces.
3. Apply primer to dry surfaces as recommended by sealant manufacturer.

C. Verify joint shaping materials and release tapes are compatible with sealant.

D. Examine joint dimensions and size materials to achieve required width/depth ratios.

E. Follow manufacturer's instructions for mixing multi-component products.

3.03 INSTALLATION

A. Use joint filler to achieve required joint depths, to allow sealants to perform intended function.

1. Install backup material as recommended by sealant manufacturer.
2. Where possible, provide full length sections without splices; minimize number of splices.
3. Tape sealant may be used as joint filler if approved by sealant manufacturer.

B. Use bond breaker where recommended by sealant manufacturer.

C. Seal joints around window, door and louver frames, expansion joints, control joints, and elsewhere as indicated.

D. Joint Sealant Materials: Follow manufacturer's recommendation and instructions, filling joint completely from back to top, without voids.

E. Joints: Tool slightly concave after sealant is installed.

1. When tooling white or light color sealant, use a water wet tool.
2. Finish joints free of air pockets, foreign embedded matter, ridges, and sags.

3.04 CLEANING

A. Clean surfaces next to the sealed joints of smears or other soiling resultant of sealing application.

B. Replace damaged surfaces resulting from joint sealing or cleaning activities.

3.05 JOINT SEALANT SCHEDULE

A. This schedule lists the sealant types acceptable for each joint location. Use as few different sealant types as possible to meet the requirements of Project.

Joint Locations	Sealant Type(s)
Expansion/Contraction and Control Joints At:	
Concrete Walls (except water-holding and belowgrade portions of structures)	1, 3, 5
Concrete Floor Slabs (except for water-holding Structures)	2, 5
Concrete Walls and Slabs immersed in water and/or below grade	7
Masonry Walls	1, 3, 5, 7
Material Joints At:	
Metal Door, Window, and Louver Frames	1, 5
Wall Penetrations	1, 5
Floor Penetrations	5, 7
Ceiling Penetrations	1, 3, 5, 7
Roof Penetrations	5
Sheet Metal Flashings	5
Other Joints:	
Threshold Sealant Bed	5
Openings Around Pipes, Conduits, and Ducts Through Fire-Rated Construction	**11**

END OF SECTION

SECTION 08 16 13
FIBERGLASS DOORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. ASTM International (ASTM):
   a. D635, Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
   b. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.

1.02 DESIGN REQUIREMENTS

A. Installed Doors and Frames: See General Structural Notes on Drawings for load requirements.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Manufacturer's literature, and drawings prepared for this Project showing types, sizes, fire ratings, complete details of door and frame construction, including resin used, glass/resin ration, cutouts and anchorage for units.
2. Anchorage and bracing drawings and/or catalog information, as required by Section 01 88 15, Anchorage and Bracing, for loads provided in General Structural Notes on Drawings**.**

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing, for loads provided in General Structural Notes on Drawings. Submit with Action Submittal for the same item.
2. Manufacturer's installation instructions.
3. Manufacturer's instructions for handling and care of products.
4. Executed guarantee.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Delivery:

1. Deliver doors to Job Site after moisture-producing construction operations are complete and building has reached average prevailing relative humidity of locality.

2. Deliver doors and frames in unopened packages, clearly marked with manufacturer's name, brand name, size, thickness, and identifying symbol or mark related to door numbers used in Contract Documents.

B. Storage and Handling:

1. In strict compliance with manufacturer's instructions and recommendations.
2. Minimize onsite storage time.
3. Handle with clean gloves.
4. Do not drag doors across one another or across other surfaces.
5. Store in dry area and protect from damage.

1.05 SPECIAL GUARANTEE

A. As special guarantee, provide manufacturer's extended guarantee or warranty, with Owner named in writing as beneficiary. Special guarantee shall provide for correction, or at option of Owner, removal and replacement of Work specified in this Specification section found defective during a period of 10 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in General Conditions.

B. Defects include warp, separation or delamination from core, expansion of core, and failures due to corrosion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Chem-Pruf Door Company.

B. Fib-R-Dor, Division of Advance Fiberglass, Inc.

C. Tiger Door, Division of Composite Structures, Inc.

2.02 DOORS

A. General:

1. Flush construction, minimum 1-3/4 inches thick, with no seams, cracks, or joints.
2. Full length integral edge reinforcement.
3. Face shall not deviate more than 1/4 inch from a true plane at any point.
4. Reinforced to receive hardware specified.
5. Doors may be prehung at factory or hung in field.

6. Resins:
    a. Formulate for extremely corrosive and humid environments above 50 percent relative humidity.
    b. Fire retardant formulation plus antimony trioxide to achieve an ASTM E84 flame spread of 25 or less and be self-extinguishing in accordance with ASTM D635.
    c. Contain Ultraviolet light inhibitor additives.
7. Prepare doors and frames for hardware only after receipt of hardware templates.
8. Make cutouts for openings at factory and furnish with FRP frames and stops that prevent moisture from entering or passing through door.
9. Glazing: As specified in Section 08 80 00, Glazing.
10. Glazing may be done in factory or field.
11. FRP Door Frame Color: Medium Bronze – Opt 24.

B. Doors:

1. Molded in one continuous piece.
2. Core of end-grain balsa wood or closed cell, non-absorptive, 2 pounds per square foot density, isocyanurate or urethane rigid foam.
3. FRP Door Colors:
    a. Interior Doors: Smoky Blue – Opt 13.
    b. Exterior Doors: Sandstone – Opt 10.

2.03 FRAMES

A. Manufacturer's standard one-piece-pultruded, three-piece built-up, or one-piece molded FRP with double rabbeted profile, as detailed, reinforced for specified hardware, assembled with stainless steel fasteners, and furnished with wall anchors for installation after wall opening is complete.

B. Furnished by door manufacturer with finish to match doors and prepared for hardware specified.

PART 3 EXECUTION

3.01 INSPECTION

A. Verify doors and frames comply with approved Shop Drawings and meet indicated requirements for type, size, hardware, location, and swing.

B. Examine openings for conditions that would prevent proper installation.

C. Do not proceed with installation until defects are corrected.

D. Do not install doors in frames that would hinder operation of doors.

3.02 INSTALLATION

A. Install, following manufacturer's written instructions, using only noncorrosive materials and methods.

B. Tolerances:

1. From Door Bottom to Floor Covering: 1/2 inch.
2. From Bottom to Top of Threshold: 1/4 inch.
3. Maximum From Top: 1/8 inch.
4. Bevel Lock and Hinge Edges: 1/8 inch in 2 inches.
5. Clearance of Meeting Stiles of Pairs of Doors: 1/8 inch.

C. Install frames square, plumb, rigid, and in true alignment. Brace securely during construction to retain proper position and clearances. Anchor firmly in place.

D. Do not cut or otherwise alter integrity of door to allow door to fit frame.

E. Frames Set in Concrete or Masonry: Secure each jamb with four stainless steel expansion anchors following manufacturer's instructions.

3.03 ADJUST AND CLEAN

A. Replace or rehang doors that are hinge-bound and do not swing, latch or operate smoothly and freely.

B. Remove and install new prefinished doors in place of those damaged during installation.

C. Refinish, or replace with new, job-finished doors damaged during installation.

D. Modify doors and frames only at manufacturer's factory.

3.04 SCHEDULE

A. For tabulation of door and frame characteristics, such as size, type, detail, and finish hardware requirements see Door and Hardware Schedule on Drawings.

END OF SECTION

SECTION 08 30 00
SPECIALTY DOORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. The Aluminum Association, Incorporated (AA): Designation System for Aluminum Finishes.
2. ASTM International (ASTM):
   a. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   b. B308/B308M, Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Shop Drawings showing construction and installation details, and electrical characteristics and control diagrams for motor operators.
   b. Identify each door with same reference as used on Drawings.
   c. Anchorage and bracing drawings and/or catalog information, as required by Section 01 88 15, Anchorage and Bracing, for loads provided in General Structural Notes on Drawings.

B. Informational Submittals: Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing, for loads provided in General Structural Notes on Drawings. Submit with Action Submittal for the same item.

1.03 QUALITY ASSURANCE

A. Qualifications: Experienced, factory authorized installer.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver doors with separators and wrapping to protect units from damage during and after installation.

B. Store doors in protected dry area following manufacturer’s requirements.

C. Handle doors according to manufacturer’s instructions.

D. Protect exposed finish surfaces of prefinished items with wrapping.

PART 2 PRODUCTS

2.01 OVERHEAD COILING (ROLLUP) DOORS

A. Manufacturers:

1. Alpine Overhead Doors, Inc.
2. Cornell Iron Works, Inc.
3. Wayne-Dalton Corp.
4. Overhead Door Corp.
5. The Cookson Co.

B. Design Requirement: See General Structural Notes on Drawings for load requirements.

C. Insulated Curtain: Interlocking insulated flat slats of 16-gauge (B & S) minimum ASTM B209, 5052-H32 aluminum alloy with maximum U-value of 0.40 and backing to match face slat thermally separated from face slat.

D. Hood: Match curtain material and finish.

E. Slide Guides: ASTM B308/B308M, 6061-T6 aluminum alloy shapes as appropriate for conditions.

F. Brackets, Gears, and Barrel: Manufacturer's standard items.

G. Operation: Chain operated with stainless steel chain.

H. Locking: Manufacturer's standard slide bolt locking mechanism.

I. Finish:

1. Aluminum Curtain Slats**,** Hood, and Guides: Architectural Class 1 anodic coating (AA-M21C22A42) with integral color in dark bronze.
2. Steel Surfaces: One coat of corrosion-inhibiting prime paint compatible with finish paint specified in Section 09 90 00, Painting and Coating.

J. Special Features:

1. Bottom Bar:
   a. Provide extruded aluminum bottom bar with flexible weatherstripping astragal on exterior doors.
   b. Finish to match curtain slats.
2. End Locks and Wind Locks:
   a. Ends of each slat shall have end locks of material compatible with curtain.
   b. Provide wind locks at ends of every other slat minimum on exterior doors.

3. Weather Seals:
    a. Provide rubber, neoprene, or vinyl water seal at hood to prevent airflow around coil on exterior doors.
    b. Provide weather seal sealing strip on guide to close space between guide and curtain on exterior doors.
4. Vision Panels: Manufacturer's glazed vision panels.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install special doors in accordance with the manufacturer's recommendations and printed instructions.

B. Adjust doors for smooth, satisfactory operation.

3.02 PRIME COAT TOUCHUP

A. Damaged Prime Coat:

1. Remove rust.
2. Sand smooth.
3. Use same primer as shop.
4. Touch up so it is not obvious.

3.03 PROTECTION

A. Protect installed doors against damage from other construction work.

3.04 SCHEDULE

A. For tabulation of door and frame characteristics, such as size, type, detail, and finish hardware requirements, see Door and Hardware Schedule on Drawings.

END OF SECTION

SECTION 08 45 00
TRANSLUCENT WALL ASSEMBLIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Architectural Manufacturers Association (AAMA): 1503, Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors, and Glazed Wall Sections.
2. ASTM International (ASTM):
   a. C297/C297M, Standard Test Method for Flatwise Tensile Strength of Sandwich Constructions.
   b. D572, Standard Test Method for Rubber-Deterioration by Heat and Oxygen.
   c. D635, Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
   d. D1002, Standard Test Method for Apparent Shear Strength of Single-Lap-Joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-to-Metal).
   e. D1037, Standard Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials.
   f. D2244, Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates.
   g. D3163, Standard Test Method for Determining Strength of Adhesively Bonded Rigid Plastic Lap-Shear Joints in Shear by Tension Loading.
   h. D4060, Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser.
   i. E72, Standard Test Methods of Conducting Strength Tests of Panels for Building Construction.
   j. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
   k. E283, Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen.
   l. E699, Standard Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components.
3. International Code Council (ICC): AC 04, Acceptance Criteria for Sandwich Panels.

4. International Code Council – Evaluation Services (ICC-ES)
5. National Fenestration Rating Council (NFRC): 100, Procedure for Determining Fenestration Product U-Factors.

1.02 DESIGN REQUIREMENTS

A. Installed Panels: See General Structural Notes on Drawings for load requirements.

B. Design translucent panel system to accommodate expansion and contraction within system components caused by a cycling temperature range of plus 100 degrees F to 0 degree F without causing detrimental effects to system or components.

C. Design and size members to withstand dead loads and live loads caused by snow, hail, and pressure and suction of wind acting perpendicular to panel system as calculated in accordance with applicable building codes and specified design criteria.

D. System shall accommodate, without damage to system or components or deterioration of perimeter seal(s):

1. Movement within system; movement between system and perimeter framing components; dynamic loading and release of loads; and deflection of structural support framing.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Plans, elevations including gridlines in each panel, sections, details, and attachment to other work.
   b. Anchorage and bracing drawings and/or catalog information, as required by Section 01 88 15, Anchorage and Bracing, for loads provided in General Structural Notes on Drawings**.**

B. Informational Submittals:

1. Structural analysis data, including loads transmitted to building structural frame as required by design, prepared and sealed by a qualified professional engineer.
2. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing, for loads provided in General Structural Notes on Drawings**.** Submit with Action Submittal for the same item.
3. ICC-ES Evaluation Report for specific system proposed.
4. Manufacturer’s written approval of installer.

5. Product Test Reports: Certified test reports performed by independent testing organizations qualified per ASTM E699 for each type and class of panel system. Reports shall verify material will meet performance requirements of this Specification. Previously completed test reports shall be acceptable if current and indicative of products used on this Project.
    a. Test reports required are:
        1) Flame Spread and Smoke Development (ASTM E84).
        2) Burn Extent (ASTM D635).
        3) Color Difference (ASTM D2244).
        4) Impact Strength (Falling Ball Method).
        5) Adhesive Bond Strength (ASTM C297 and ASTM D1002).
        6) Accelerated Aging (ASTM D1037).
        7) Lap shear test (ASTM D3163).
        8) Tensile Strength (ASTM C297/C297M modified).
        9) Abrasion/Erosion Resistance (ASTM D4060).
        10) Beam Bending Strength (ASTM E72).
        11) Assembly U-Factor (NFRC 100).
        12) Condensation Resistance Factor (AAMA 1503).
        13) Air Leakage (ASTM E283).
6. Maintenance Data: Cleaning and refinishing instructions and recommended products.
7. Qualifications: Translucent panel manufacturer and panel erector shall show, upon request, proof of their ability to perform the Work.
8. Sample guarantee.

1.04 QUALITY ASSURANCE

A. Panel System Manufacturer: Listed by International Code Council as compliant with ICC AC04 Sandwich Panels. Current ICC-ES Evaluation Report for specific system shall affirm system can be installed in compliance with Connecticut State Building Code.

B. Installer: Provide panel manufacturer’s letter of approval stating that the installer is approved for the installation of named manufacturer’s product(s).

1.05 DELIVERY, STORAGE, AND HANDLING

A. Store translucent panels on long edge, several inches above ground, blocked and under cover to prevent warping.

B. Ship units assembled and ready for erection.

1.06 SPECIAL GUARANTEE

A. Provide manufacturer’s extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall

provide for correction, or at the option of the Owner, removal and replacement of Work specified in this Specification section found defective during a period of 20 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in the General Conditions.

B. Conditions:

1. Leakage of water to interior.
2. Structural failures including system deflection exceeding L/100 at midpoint of clear span.
3. Deterioration of metal finishes beyond normal weathering, including checking, crazing, peeling, chalking or fading.
4. Deterioration of exterior skins from windblown abrasives.
5. Delamination of coating from face sheet.
6. Delamination of panel sheets from panel structural cores.
7. Discoloration of exterior face of more than 3.0 Delta E Adams Units according to ASTM D2244.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials and products specified in this section shall be products of:

1. Kalwall Corp., Manchester, NH.
2. Major Industries, Wausau, WI.

2.02 MATERIALS

A. Translucent Fiberglass Face Sheets:

1. Strength: Exterior face sheet shall be uniform in strength and repel impact equal to 60 foot-pounds without fracture or tear.
2. Interior flamespread rating no greater than 50 and smoke developed no greater than 250, when tested in accordance with ASTM E84. Burn extent by ASTM D635 shall be no greater than 1 inch.
3. Exterior: Crystal, 0.070 inch thick.
4. Interior: White, 0.045 inch thick.
5. Free of ridges and wrinkles, which prevent proper surface contact in bonding to aluminum grid core. Clusters of air bubbles/pinholes that collect moisture and dirt will not be acceptable.
6. Exterior Face:
   a. Shall not change color more than 3.0 units (DELTA-E by ASTM D2244) after 5 years' outdoor weathering South Florida at 5 degrees facing south, determined by average of at least three white samples.

b. Shall have permanent glass veil erosion barrier and high performance thermoset acrylic protective surface (minimum thickness 1.2 mils) for maximum resistance to erosion and weather, applied in factory under controlled temperature conditions. Plastic overlay films are not acceptable. This coating shall be fully field refinishable if damaged.

7. Uniform in color.

B. Grid Core: Noncombustible aluminum I-beams**,** thermally broken at flat panels, 6063-T6, mechanical interlocking of muntin-mullion and perimeter, 7/16 inch width and thermally broken grid core shall have minimum Condensation Resistance Factor of 80 (AAMA 1503) measured on gridline.

C. Adhesive:

1. Heat and pressure resin type.
2. ICBO approved for use in sandwich panel construction.
3. Minimum Strength:
   a. Tensile:
      1) After two exposures to six cycles each of aging conditions in accordance with ASTM D1037:
         a) 750 psi by ASTM C297/C297M.
   b. Shear:
      1) After five separate aging conditions in accordance with ASTM D1002:
         a) 50 Percent Relative Humidity at 73 Degrees F: 540 psi.
         b) 182 Degrees F: 100 psi.
         c) Accelerated Aging by ASTM D1037 at Room Temperature: 800 psi.
         d) Accelerated Aging by ASTM D1037 at 182 Degrees F: 250 psi.
         e) 500-hour Oxygen Bomb by ASTM D572: 1,400 psi.

D. Battens and Perimeter Closure Systems:

1. Thermally Broken Battens and Closures: Extruded 6063-T6 and 6063-T5 aluminum screw clamp-tite closure system using 2-inch battens.
2. Fasteners: Stainless steel screws.

E. Flexible Sealing Tape: Manufacturer’s standard; preapplied to closure system at factory under controlled conditions.

F. Finish: Architectural Class I anodic coating in 0.70-mil thickness; dark bronze color.

2.03 FABRICATION

A. Insulated Translucent Panels (ITP):

1. True structural composite flat sandwich panels of flat face sheets bonded to thermally broken grid core of mechanically interlocking aluminum I-beams. Laminate together under controlled process of heat and pressure. Tape bond systems are not allowed.
2. Uniform Thickness: 2-3/4 inches.
3. "U" Value: 0.19 maximum.
4. Light Transmission: 14 percent minimum.
5. Shading Coefficient: 0.15 maximum.

B. Preassemble and seal panels at factory. Field assembly of major components will not be allowed.

C. Panel deflection for 10-foot clear span tested flat in accordance with ASTM E72 shall not exceed 1.9 inches at 30 pounds per square foot loading.

D. Grid Pattern: 24 inches by 12 inches nominal, and symmetrical about vertical centerline of each panel.

E. Adhesive Bonding Line: Straight, cover entire width of I-beam, and have a neat, sharp edge. In order to ensure bonding strength, white spots at intersections of muntins and mullions shall not exceed four for each 40 square feet of panel nor shall they be more than 3/64 inch wide.

PART 3 EXECUTION

3.01 PREPARATION

A. Prepare openings, including isolating aluminum system, from dissimilar materials that may cause damage by electrolysis.

3.02 ERECTION

A. Erect insulated translucent panel systems in strict accordance with manufacturer's instructions. Fasten and seal in strict accordance with manufacturer's shop drawings. Clean aluminum before applying sealants.

B. After other trades have completed work on adjacent material, carefully inspect translucent panel unit installation, ensure no shifting or rattling, and make adjustments necessary to ensure proper installation and weathertight conditions.

3.03 CLEANING

A. Leave translucent panels in undamaged condition and ready for final cleaning.

B. Clean both faces of panels in accordance with manufacturer's instructions.

3.04 PROTECTION OF COMPLETED WORK

A. Install marker tape across panels secured to frames or structure. No tape or marking allowed on panels after final cleaning.

END OF SECTION

SECTION 08 71 00
DOOR HARDWARE

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Builders Hardware Manufacturer's Association (BHMA):
   a. A156.1, Butts and Hinges.
   b. A156.3, Exit Devices.
   c. A156.4, Door Controls - Closers.
   d. A156.13, Mortise Locks & Latches.
   e. A156.16, Auxiliary Hardware.
   f. A156.18, Materials and Finishes.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product Data: Manufacturer's literature for each item of finish hardware required herein, clearly marked.
   b. Finish Hardware Schedule: Furnish complete and detailed schedule, show product items, numbers, and finishes for hardware for each separate opening.
   c. Special Tools: Provide listing and description of usage.

B. Informational Submittals:

1. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
2. Manufacturer's Field Service Report.
3. Certification of Hardware Consultant.
4. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.

1.03 QUALITY ASSURANCE

A. Qualifications of Supplier: Recognized supplier of architectural finish hardware, with warehousing facilities, who has been furnishing hardware in vicinity of Project for not less than 5 years, and who is, or who employs, architectural hardware consultant.

B. Qualifications of Architectural Hardware Consultant (AHC): Certified by Door and Hardware Institute.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Before delivery, clearly identify and tag each item of hardware with respect to specified description and location of installation.

B. Provide secure storage for finish hardware until installation is made.

1.05 EXTRA MATERIALS

A. Special Tools: Two sets for installation and maintenance of hardware.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide end products of one manufacturer for each product in order to achieve standardization for appearance, maintenance, and replacement.

B. Finishes: BHMA A156.18.

2.02 FASTENERS

A. Stainless steel.

2.03 HINGES

A. BHMA A156.1.

B. Width: Minimum for clearance of trim and 180-degree swing.

C. Exterior Hinges: Nonremoveable pin.

D. Joint Tolerance: 0.012 inch maximum, gauged in CLOSED position.

E. Finish: Satin stainless steel No. 630.

F. Types and Manufacturers:

No.	Type Description	Hager	Ives
H3	Heavy-duty stainless steel continuous hinge	790-900	700

2.04 LOCKS AND LATCH SETS

A. Mortise Locks: BHMA A156.13, Series 1000, Grade 1.

1. Materials: Brass or stainless steel.
2. Trim: Wrought or forged lever handles and roses.
3. Core Cylinders: Interchangeable, removable; minimum of six pins.

4. Bolt Throw: 5/8 inch minimum.
5. Lever Backset: 2-3/4 inches.
6. Manufacturers and Products:
    a. Best; 15.
    b. Sargent; L.
    c. Schlage; 06.

B. Finish: Satin stainless steel No. 630.

C. Types and Manufacturers:

No.	Type Description	Best	Sargent	Schlage	BHMA
L3	Mortise latch with lever handle	45H0N	8215	L9010	F01

2.05 KEYING

A. Lock Cylinders: Operate by master key system that allows for future expansion.

B. Keylocks: Key new locks into existing Sargent 10-line master key system as directed by Owner.

C. Keys: Two per lock; tag with schedule information.

D. Master Keys: Four; send by registered mail to Owner.

E. Furnish lock manufacturer's removable core maximum security keying system.

2.06 CONSTRUCTION KEY SYSTEM

A. Removable construction core system for locks.

B. See Article Manufacturer's Services under Part 3, Execution.

2.07 EXIT DEVICES

A. BHMA A156.3.

B. Furnish fire exit devices and mullions at fire-rated doors.

C. LeverTrim: Yale AU; Von Duprin 06.

D. Finish: Satin stainless steel No. 630.

E. Types and Manufacturers:

No.	Type Description	Yale	VonDuprin	BHMA
X1	Rim type with lock	7108	98L	Type 1 08
X10	Rim type with latch	7114	981-BE	Type 1

2.08 CLOSERS

A. BHMA A156.4.

B. Size closers in accordance with manufacturer's standards. Mount regular arm closers on pull side of doors. Mount parallel arm closers on push side of doors. On pair of doors provide closer on active leaf only, unless noted otherwise.

C. Finish: Manufacturer's standard painted or powder coated finish, with special rust inhibiting (SRI) pretreatment in aluminum color.

D. Types and Manufacturers:

No.	Type/Description	LCN	Sargent	BHMA
C2	Parallel arm	4110 Series	351-P Series	C02021
C6	Parallel arm with integral stop and hold-open	4110H Cush-N-Stop Series	351-PSH Series	C02061

2.09 STOPS AND HOLDERS

A. BHMA A156.16.

B. Machine Screws: In threaded anchors at concrete or masonry.

C. Finish: Satin chromium-plated No. 626.

D. Types and Manufacturers for Each Leaf:

No.	Type Description	BBW or GJ	Baldwin	BHMA
S2	Wall bumper	WC9X	4031	L02241

2.10 KICKPLATES

A. Solid metal, not plated. Bevel four edges.

B. Width of door leaf less than 1-1/2 inches at single leaf and less than 1 inch at pairs.

C. Finish: Satin stainless steel No. 630.

D. Types and Manufacturers: Builders Brass Works, Baldwin, Rockwood, or Cipco as follows:

1. K1 10 inches high by 0.05 inch thick.

2.11 THRESHOLDS

A. Thresholds: One-piece full width of opening; extend beyond jamb where indicated.

B. Provide with stainless steel machine screws in threaded expansion anchors at concrete.

C. Finish: Fiberglass Reinforced Plastic (FRP).

D. Types and Manufacturers:

No.	Type Description	Chem-Pruf	Reese
T2	Fiberglass saddle (serrated, 5" min. x 1/2")	FRP threshold	FRB555

2.12 WEATHERSTRIP

A. Finish: Dark bronze anodized aluminum, unless indicated otherwise.

B. Seal Types and Manufacturers:

No.	Type Description	Pemko	Reese
W1	Rubber or vinyl bulb at jambs and head	S88D	797B
	Door bottom sweep, stainless steel	321SSN	323SS
	Rain drip	346D	R201D
W2	Rubber or vinyl bulb at jambs and head, and at meeting stiles of pairs	S88D	797B
	Door bottom sweep, stainless steel	321SSN	323SS

2.13 TEMPLATES

A. Fabricate to template hardware applied to metal doors and frames.

B. Ensure that required templates are furnished to various manufacturers for fabrication purposes.

C. Templates: Make available not more than 10 days after receipt of approved Hardware Schedule.

2.14 EXIT AND FIRE DOORS

A. Exit Doors: Always openable from inside by simple turn of lever handle or push on panic bar without use of key or any special knowledge or effort, to include each leaf of door pairs.

B. Hardware for Fire Doors: Underwriters Laboratories Inc., Fire Protection Equipment List.

PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with manufacturer's written instructions.

B. Make Work neat and secure, develop full strength of components, and provide proper function.

C. Prevent marring, scratching, or otherwise damaging adjacent finishes during hardware installation.

D. Latchbolts:

1. Install to engage in strikes automatically, whether activated by closers or manually.
2. In no case shall additional manual pressure be required to engage latchbolt in strike.

E. Stops and Holders: Set to allow doors to open as far as possible.

F. Wall Mounted Hardware: Install over solid structural backing or solid blocking in hollow walls.

G. Thresholds:

1. Cope ends neatly to profile of jamb.
2. Set in sealant and seal ends to jambs.

H. Hardware: Adjust for easy, noise-free operation.

I. Replace damaged hardware items.

3.02 MOUNTING DIMENSIONS

A. Standard Door Hardware Locations: As recommended and published by Door and Hardware Institute, except as noted or detailed otherwise.

3.03 MANUFACTURER'S SERVICES

A. Deliver permanent lock cores to Site.

B. Remove temporary construction cores and insert permanent cores.

C. Inspect each lock set to ensure permanent cores are operating satisfactorily.

D. Deliver to Owner change and control keys for permanent system.

E. Return temporary construction cores to manufacturer.

F. Furnish manufacturer's representative for the following services at Site or classroom as designated by Owner, for minimum person-days listed below, travel time excluded:

1. 1/2 person-day for installation assistance, inspection, and Manufacturer's Certificate of Proper Installation.
2. 1/2 person-day for functional and performance testing.

3.04 PROTECTION

A. Cover and protect exposed surfaces of hardware during installation and until Substantial Completion.

B. Fit, dismantle, and reinstall finish hardware as required for finish painting work.

C. Protect and prevent staining of hardware during construction in accordance with manufacturer's recommendations.

D. Remove protective measures and permanent lock cylinders installed prior to final cleaning.

3.05 DOOR AND HARDWARE SCHEDULE

A. Door and Hardware Schedule on Drawings is guide to functional requirements of each opening.

B. Provide finish hardware as scheduled. Sizes omitted shall be as recommended by manufacturer.

3.06 HARDWARE SETS

HDW-1:	**Item**	**Type**
	1 Continuous stainless steel hinge	H3
	1 Rim type exit device with latch	X10
	1 Closer	C2
	1 Wall bumper	S2
	1 Metal kickplate	K1
	1 Threshold	T2
	1 Set weatherstrip	W2
HDW-2:	**Item**	**Type**
	1 Continuous stainless steel hinge	H3
	1 Rim type exit device with lock	X1
	1 Closer with stop and hold open	C6
	1 Metal kickplate	K1
	1 Threshold	T2
	1 Set weatherstrip	W1
HDW-3:	**Item**	**Type**
	1 Continuous stainless steel hinge	H3
	1 Latch	L3
	1 Closer	C2
	1 Wall bumper	S2
	1 Metal kickplates	K1
	1 Threshold	T2
	1 Set weatherstrip	W2

END OF SECTION

SECTION 08 80 00
GLAZING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C509, Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Material.
   b. C864, Standard Specification for Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers.
   c. C920, Standard Specification for Elastomeric Joint Sealants.
   d. C1048, Standard Specification for Heat-Treated Flat Glass—Kind HS, Kind FT Coated and Uncoated Glass.
   e. C1115, Standard Specification for Dense Elastomeric Silicone Rubber Gaskets and Accessories.
   f. C1193, Standard Guide for Use of Joint Sealants.
   g. C1376, Standard Specification for Pyrolytic and Vacuum Deposition Coatings on Flat Glass.
   h. E2190, Standard Specification for Insulating Glass Unit Performance and Evaluation.
2. Consumer Product Safety Commission (CPSC) Code of Federal Regulations (CFR): 16 CFR 1201, Safety Standard for Architectural Glazing Materials.
3. Glass Association of North America (GANA):
   a. Glazing Manual.
   b. Sealant Manual.
4. National Fenestration Rating Council Incorporated (NFRC):
   a. 100, Procedure for Determining Fenestration Product U-Factors.
   b. 200, Procedure for Determining Fenestration Product Solar Heat Gain Coefficient and Visible Transmittance at Normal Incidence.
   c. 300, Standard Test Method for Determining the Solar Optical Properties of Glazing Materials and Systems.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Complete schedule of glass and glazing material to be used for each purpose.
   b. Indicate sizes, layout, thicknesses, and loading conditions for glass.

2. Product Data:
    a. Catalog cuts of glazing materials with inclusion of glass edge cutting procedures.
    b. Glass: Provide structural, physical, and thermal and solar optical performance characteristics, size limitations, special handling or installation requirements.
    c. Glazing Sealants, Compounds, and Accessories: Provide chemical, functional, and environmental characteristics, limitations, special application requirements. Identify available colors where exposed.
    d. Anchorage and bracing drawings and data sheets, as required by Section 01 88 15, Anchorage and Bracing.
3. Samples: As required for color selection.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's Certificate of Compliance for each type of glazing, in accordance with Section 01 61 00, Common Product Requirements.
3. Details and methods of glazing for each type of glazing condition; include manufacturer's recommendations for setting, sealing materials, and installing each type of glazing.
4. Documentation declaring compatibility and adhesion test reports from sealant manufacturer indicating that glazing materials were tested for compatibility and adhesion with glazing sealants and other glazing materials.
5. Documentation of glazer's previous experience and manufacturer's approval.
6. Sample copy of guarantee.

1.03 QUALITY ASSURANCE

A. Installer Qualifications: Company specializing in performing Work of this section with minimum 3 years' documented experience approved by manufacturer.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage:

1. Support cases on both sides when stored vertically.
2. After unpacking, place interleaving protection between lites.
3. Keep glass and interleaving dry by storing inside where temperatures are above dewpoint, or if outside storage is necessary, cover glass interleaving with opaque tarpaulins or plastic and inspect periodically. Wet interleaving can stain glass.
4. Avoid exposing stored glass to direct sunlight.

B. Handling:

1. Stack individual lites on edge and lean them against sturdy uprights at a slope of 5 degrees to 7 degrees from vertical.
2. Cushion bottom edges with soft, firm pads free of dirt, grit, glass chips, or other foreign material.
3. Do not rotate or cartwheel insulating glass units over their corners. Use turning device such as a rolling block if units must be rotated.

1.05 SPECIAL GUARANTEE

A. Provide manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as Special Guarantee. Special Guarantee shall provide for correction, or at option of Owner, removal and replacement of Work specified in this specification section found defective during a period of **5 years** after date of Substantial Completion. Guarantee to cover deterioration because of normal conditions of use and not because of handling installing and cleaning practices performed contrary to glass manufacturer's published instructions. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in General Conditions.

PART 2 PRODUCTS

2.01 GENERAL

A. Single Source Fabrication Responsibility: Fabrication processes including Low-E and reflective coatings, insulating, laminating, silkscreen, and tempering, shall be fabricated by a single fabricator.

B. Structural Design: Design in accordance with Connecticut State Building Code for most critical combination of wind, snow, seismic, and dead loads.

C. Thermal and Solar Optical Performance: Measured or calculated in accordance with the following:

1. U-Values: NFRC 100.
2. Solar Heat Gain Coefficients: NFRC 200.
3. Solar Optical Properties: NFRC 300.

2.02 MATERIALS

A. Tempered Glass:

1. ASTM C1048, Type 1 transparent flat, Quality Q3, Kind FT fully tempered, Condition A uncoated, float glass with horizontal tempering.
2. Furnish tempered glass where heat strengthened glass cannot meet specified performance requirements.
3. Conforming to CPSC 16 CFR 1201 Category II.

2.03 PRODUCTS

A. Clear Tempered Glass (TG):

1. Tempered (FC-CT) float glass as specified; Class 1 clear.
2. Minimum Thickness**:** 1/4 inch.

B. Insulating Tempered Glass, Tinted (ITG):

1. ASTM E2190 certified by Insulating Glass Certification Council; with 10-year manufacturer warrantee on edge seal; purge interpane space with dry hermetic air.
2. Total Unit Thickness: 1 inch.
3. Insulating Glass Unit Edge Seal Construction: Aluminum, mitered and spigoted corners.
4. Outer Pane: Tinted tempered glass.
   a. Tempered float glass as specified; Class 2 tinted.
   b. Minimum Thickness: 1/4 inch.
   c. Tint: Gray.
5. Inner Pane: Low E Tempered Glass.
   a. Tempered float glass as specified; Class 1 clear or Class 2 tinted.
   b. Minimum Thickness: 1/4 inch.
   c. Coating: ASTM C1376.
6. U-Factor Winter: 0.29 maximum.
7. Shading Coefficient: 0.30 maximum.
8. Solar Heat Gain Coefficient: 0.41 maximum.
9. Visible Light Transmittance: 20 percent minimum.

2.04 GLAZING SEALANTS

A. Color: Black or as selected by Engineer.

B. Elastomeric Glazing Sealants: Materials compatible with adjacent materials including glass, insulating glass seals, and glazing channels.

1. Silicone Glazing Sealant:
   a. ASTM C920, Type S, Grade NS, Class and Use suitable for glazing application indicated; single component; capable of water immersion without loss of properties; cured Shore A Hardness Range 15 to 25.
   b. Structural Silicone: Furnish high-modulus structural silicone glazing materials where sealant bonds glass to substrate.
2. Polyurethane Glazing Sealant: ASTM C920, Type S, Grade NS, Class and Use suitable for glazing application indicated; single component, chemical curing, nonstaining, nonbleeding, Shore A Hardness Range 20 to 35.

C. Dense Gaskets:

1. Resilient extruded shape to suit glazing channel retaining slot.
2. Neoprene: ASTM C864.
3. EPDM: ASTM C864.
4. Silicone: ASTM C1115.

D. Soft Gaskets:

1. ASTM C509 Type II; resilient extruded shape to suit glazing channel retaining slot.
2. Neoprene.
3. EPDM.
4. Silicone.

E. Preformed Glazing Tape:

1. Size to suit application.
2. Preformed butyl compound; 10 to 15 Shore A durometer hardness; coiled on release paper.
3. Butyl Corner Sealant: ASTM C920 single component nonskinning butyl compatible with glazing tape.

2.05 GLAZING ACCESSORIES

A. Setting Blocks: Elastomeric material recommended by glass manufacturer, 80 to 90 Shore A durometer hardness, length of 0.1 inch for each square foot (25 mm for each square meter) of glazing or minimum 4 inch (100 mm) by width of glazing rabbet space minus 1/16 inch (1.5 mm) by height to suit glazing method and pane weight and area.

B. Spacer Shims: Elastomeric material recommended by glass manufacturer, 50 to 60 Shore A durometer hardness, minimum 3-inch (75-mm) long by one half the height of glazing stop by thickness to suit application.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify openings for glazing are correctly sized and within acceptable tolerance.

B. Verify surfaces of glazing channels or recesses are clean, free of obstructions impeding moisture movement, weeps are clear and ready to receive glazing.

3.02 PREPARATION

A. Do not perform glazing work in damp, foggy, or rainy weather, or when temperatures are not within range recommended by GANA “Glazing Manual.”

B. Surfaces:

1. Smooth, even, sound, dry, and clean.
2. Clean contact surfaces with solvent and wipe dry.

C. Priming:

1. Complete and cured.
2. Prime surfaces scheduled to receive sealant.

D. Measure size of frames to receive glass and compute actual glass size allowing for edge clearances.

E. Use tempered glass in non-fire-rated doors, transoms, and sidelights.

F. Verify functioning weep system is present.

G. Do not proceed with glazing until unsatisfactory conditions have been corrected.

3.03 GLAZING INSTALLATION

A. General: Follow recommendations of glass manufacturer GANA “Sealant Manual, GANA “Glazing Manual” and the following:

1. Glazing Sealants: Comply with ASTM C1193.

3.04 FIELD QUALITY CONTROL

A. Hose Test:

1. Use 3/4-inch minimum hose without nozzle. With full stream, flood glazing from bottom to top.
2. Correct leaks disclosed by hose test by reglazing and retesting until eliminated.

3.05 MANUFACTURER’S FIELD SERVICES

A. Provide manufacturer’s representative at Site in accordance with Section 01 43 33, Manufacturers’ Field Services, for installation assistance and inspection.

3.06 CLEANING

A. Leave glass and glazing in undamaged condition and ready for final cleaning.

B. Remove excess glazing compound from installed glass.

C. Remove labels from glass surface at time of final cleaning.

D. Wash and polish both faces of glass.

E. Clean adjacent surfaces of glass.

3.07 PROTECTION OF COMPLETED WORK

A. Protection:

1. Keep glass free from contamination by materials capable of staining glass.
2. Install tape across lights secured to frames or structure.
3. No tape or marking allowed on glass.

B. Replacements and Repairs:

1. Prior to Substantial Completion, replace broken, defective, or scratched glass and repair damaged compounds.
2. Include patch and repair of existing glass to remain that is damaged or otherwise disturbed as a result of this Work.

END OF SECTION

SECTION 08 90 00
LOUVERS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Movement and Control Association (AMCA): 500-L, Laboratory Methods of Testing Louvers for Rating.
2. The Aluminum Association, Incorporated (AA): Designation System for Aluminum Finishes.
3. ASTM International (ASTM): E84, Standard Test Method for Surface Burning Characteristics of Building Materials.

1.02 DESIGN REQUIREMENTS

A. Installed Louvers: See General Structural Notes on Drawings for load requirements.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Large scale details of louvers, anchorage, and relationship to adjoining construction.
   a. Manufacturer's Literature: Descriptive and performance data of louvers, including standard drawings and louver-free area.
   b. Anchorage and bracing drawings and data sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Factory test data.
3. Certificates of AMCA ratings.
4. Installation instructions.

PART 2 PRODUCTS

2.01 GENERAL

A. Nonacoustical louver sizes are based on 50 percent free area and 800 fpm maximum velocity through free area. If louvers furnished do not meet these parameters, Contractor is responsible for resizing louvers and wall openings, and for making other adjustments to allow for larger openings.

B. Water Penetration Rate: No greater than 0.02 ounce per square foot.

C. Louvers: Rated and tested in accordance with AMCA 500-L.

D. Furnish louvers with interior duct collars.

2.02 FIXED DRAINABLE LOUVER

A. Frame: Extruded aluminum channel, 0.081 inch thick, 6 inches deep, interior duct collar, concealed mullions.

B. Blades: Extruded aluminum, minimum 0.081 inch thick, 35-degree to 45-degree pitch angles, with integral front drain gutter, spaced 3 inches to 4 inches on center.

C. Pressure Loss: AMCA certified rating of no greater than 0.10-inch WC.

D. Sizes: As shown on Drawings.

E. Screen: Inside mounted, aluminum or stainless steel insect screen.

F. Finish: AA-M1022A44, dark bronze anodized.

G. Manufacturers and Products:

1. Construction Specialties; Model A6097.
2. Ruskin; Model ELF6375DX.

2.03 ACCESSORIES

A. Anchors and Fasteners: Stainless steel.

B. Flashings: Match louver frame.

C. Isolation Tape: Tremco 440, 3M EC1202, or Presstite 579.6.

D. Isolation Paint: In accordance with Section 09 90 00, Painting and Coating, System No 27.

E. Insulated Blank-Off Panels:

1. Panels: Urethane core faced on both sides with 0.032-inch stucco embossed 5005-H134 aluminum sheet in finish and color to match louvers.
2. Frames: 6063-T52 extruded aluminum sections 0.080 inch thick, with mitered corners.
3. Perimeter Gaskets: Closed-cell PVC, to ensure tight fit of panel to louver.

4. Thickness: 2 inches.
5. U-Value: 0.10.

2.04 SOURCE QUALITY CONTROL

A. Factory Performance Tests:

1. Airflow versus pressure loss.
2. Rain penetration data.

PART 3 EXECUTION

3.01 EXAMINATION

A. Check openings to ensure dimensions conform to Drawings.

B. Ensure openings are free of irregularities that would interfere with installation.

C. Do not install louvers until defects have been corrected.

3.02 INSTALLATION

A. Install louvers as shown on reviewed Shop Drawings. Coordinate with heating or ventilation ductwork to be connected.

B. Follow procedures in manufacturer's recommended installation instructions.

C. Install insulated blank-off panels where indicated, completely closing space between ducts and louver frames.

D. Separate aluminum from other metals with isolation tape or paint.

3.03 CLEANING

A. After erection, protect exposed portions from damage by machines, paint, lime, acid, cement, or other harmful compounds.

B. Remove protective materials and clean with plain water, water with soap, or household detergents.

END OF SECTION

SECTION 09 51 23
ACOUSTICAL TILE CEILINGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. ASTM International (ASTM):
   a. A641/A641M, Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire.
   b. C635/C635M, Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-In Panel Ceilings.
   c. C636/C636M, Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels.
   d. E1264, Standard Classification for Acoustical Ceiling Products.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Detailed layout of grid indicating hanger spacing, fastening and splicing details, change in level details, and access location.
   b. Anchorage and bracing drawings and/or catalog information, as required by Section 01 88 15, Anchorage and Bracing, for loads shown on General Structural Notes on Drawings.
2. Samples:
   a. One 12-inch square of each acoustical unit material to illustrate range of appearance.
   b. One full-size Sample of each suspension system member and molding.
   c. Mark with name of manufacturer and specific design and technical data.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing, for loads shown on General Structural Notes on Drawings.
2. Manufacturer’s recommendation for installation of system.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials with manufacturer's labels indicating brand name, pattern, size, thickness, and fire rating.

B. Store materials in original protective packaging to prevent soiling, physical damage, or wetting.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Where acoustical materials are to be installed, maintain humidity of 65 percent to 75 percent in area for 25 hours before, during, and 25 hours after installation.

B. Maintain a uniform temperature of 55 degrees F to 70 degrees F during installation of materials.

1.05 EXTRA MATERIAL

A. Provide acoustical units from same production run as installed equal to 1 percent of area.

PART 2 PRODUCTS

2.01 SUSPENSION SYSTEMS

A. Components, Materials, and Accessories: Product of a single manufacturer.

B. ASTM C635/C635M, Intermediate Duty:

1. Exposed Aluminum Tee Grid:
   a. Nonrated, light-duty, spaced to fit lay-in panels.
   b. Color: White.
   c. Exposed Flange Width: 15/16 inch.
   d. Edges: Single molding to match grid.
   e. Manufacturers and Products:
      1) Chicago Metallic Corp.; All Aluminum 830 System.
      2) Armstrong; AL Prelude Plus system.
2. Edge Molding:
   a. Channel-or angle-shaped.
   b. Flange Width: 15/16 inch, minimum.
   c. Finish to match main members.
3. Hanger Wire: ASTM A641/A641M, minimum 12-gauge, galvanized, soft-annealed, mild steel wire.
4. Wire Ties: ASTM A641/A641M, 18-gauge, galvanized, annealed steel wire.

2.02 ACOUSTICAL UNITS

A. Recessed Edge Lay-In Panels:

1. Material: Fire-resistive mineral fiber, Class A.
2. In accordance with ASTM E1264, Type III, Form 1.
3. Pattern: Fine.
4. Sag and Moisture Resistant.
5. Noise Reduction Coefficient (NRC): 0.65 to 0.75.
6. Ceiling Attenuation Class (CAC): 35 minimum.
7. Light Reflectance: LR 0.80 or over.
8. Nominal Size: 24 inches by 24 inches by 3/4 inch thick.
9. Edges: Angled Tegular.
10. Finish and Color: Painted white, unless scheduled otherwise.
11. Manufacturers and Products:
    a. Armstrong; Item 556, Cirrus Open Plan.
    b. U.S.G.; Item 76775 Eclipse Clima Plus.

PART 3 EXECUTION

3.01 SEQUENCING

A. Lay out grid.

B. Coordinate with mechanical and electrical equipment in framing and cutting material around ceiling penetrations.

C. Install suspension systems after mechanical work above is complete.

D. Install acoustical units.

3.02 INSTALLATION OF SUSPENDED GRID SYSTEM

A. Hang level and in straight alignment directly from structure following ASTM C636/C636M and manufacturer's current printed instructions.

B. Hanger Wires:

1. Space maximum 4 feet on center each direction and securely attach to structure above.
2. Install additional hangers at ends of each suspension member and at light fixtures, 6 inches from vertical surfaces.
3. Do not splay wires more than 5 inches in a 4-foot vertical drop.
4. Provide four-way wire splays at 45 degrees from main runner to support structure for every 144 square feet of ceiling area.
5. Wrap wire minimum three times horizontally, turning ends upward.
6. Where hanger wires cannot be hung vertically from structure above because of ducts, pipes, cable trays, or other interferences, provide steel

channel trapezes (minimum 2-inch deep, 16-gauge cold-rolled carrying channels) hung on steel rods or 8-gauge wire from structural members above. Hang ceiling wires from these trapezes or similar members supporting ducts or pipes. Do not hang directly from ducts or pipes.

7. Follow suspension system manufacturer's instructions for modified installation required for Seismic Design Category indicated in General Structural Notes on Drawings.

C. Edge Molding:

1. Install at intersection of suspended ceiling and vertical surfaces.
2. Miter corners where moldings intersect or install corner caps.
3. Attach to vertical surface with mechanical fasteners.

D. Provide additional channels, hangers, and trapezes as required to support edges of ceiling around and under mechanical and electrical work.

3.03 INSTALLATION OF ACOUSTICAL UNITS

A. Upon completion of suspended grid system and other concealed work, install with pattern running in one direction.

B. Place material to bear all around on suspension members.

3.04 CLEANING

A. Clean soiled or discolored unit surfaces after installation.

B. Touch up scratches, abrasions, voids, and other defects in painted surfaces.

3.05 SCHEDULE OF CEILING TYPES

A. Areas to Receive Acoustical Ceilings: As indicated with "ATC" on Interior Finish Schedule located on Drawings.

END OF SECTION

SECTION 09 90 00
PAINTING AND COATING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA):
   a. C203, Coal-Tar Protective Coatings and Linings for Steel Water Pipelines—Enamel and Tape—Hot-Applied.
   b. C209, Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
   c. C214, Tape Coating Systems for the Exterior of Steel Water Pipelines.
2. Environmental Protection Agency (EPA).
3. NACE International (NACE): SP0188, Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
4. Occupational Safety and Health Act (OSHA).
5. The Society for Protective Coatings (SSPC):
   a. PA 2, Procedure for Determining Conformance to Dry Coating Thickness Requirements.
   b. PA 10, Guide to Safety and Health Requirements for Industrial Painting Projects.
   c. SP 1, Solvent Cleaning.
   d. SP 5, White Metal Blast Cleaning.
   e. SP 7, Joint Surface Preparation Standard Brush-Off Blast Cleaning.
   f. SP 10, Near-White Blast Cleaning.
   g. SP 13, Surface Preparation of Concrete.
   h. SP 16, Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.

1.02 DEFINITIONS

A. Terms used in this section:

1. Coverage: Total minimum dry film thickness in mils or square feet per gallon.
2. FRP: Fiberglass Reinforced Plastic.
3. HCl: Hydrochloric Acid.
4. MDFT: Minimum Dry Film Thickness, mils.
5. Mil: Thousandth of an inch.
6. PDS: Product Data Sheet.
7. PSDS: Paint System Data Sheet.
8. PVC: Polyvinyl Chloride.

9. SFPG: Square Feet per Gallon.
10. SFPGPC: Square Feet per Gallon per Coat.
11. SP: Surface Preparation.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Data Sheets:
      1) For each product, furnish a Product Data Sheet (PDS), the manufacturer's technical data sheets, and paint colors available (where applicable). The PDS form is appended to the end of this section.
      2) For each paint system, furnish a Paint System Data Sheet (PSDS). The PSDS form is appended to the end of this section.
      3) Technical and performance information that demonstrates compliance with specification.
      4) Furnish copies of paint system submittals to the coating applicator.
      5) Indiscriminate submittal of only manufacturer's literature is not acceptable.
2. Samples:
   a. As required for color selection.
   b. For exposed pipes that require painting/coating listed in the Piping Schedule, Section 40 27 00, Process Piping—General, Supplement 1, furnish a proposed color selection for Owner approval. Provide recommended options (three minimum) for each color.

B. Informational Submittals:

1. Applicator's Qualification: List of references substantiating experience.
2. Coating manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services.
3. Factory Applied Coatings: Manufacturer's certification stating factory applied coating system meets or exceeds requirements specified.
4. Manufacturer's written verification that submitted material is suitable for the intended use.
5. If the manufacturer of finish coating differs from that of shop primer, provide finish coating manufacturer's written confirmation that materials are compatible.
6. Manufacturer's written instructions and special details for applying each type of paint.

1.04 QUALITY ASSURANCE

A. Applicator Qualifications: Minimum 5 years' experience in application of specified products.

B. Regulatory Requirements:

1. Meet federal, state, and local requirements limiting the emission of volatile organic compounds.
2. Perform surface preparation and painting in accordance with recommendations of the following:
   a. Paint manufacturer's instructions.
   b. SSPC PA 10.
   c. Federal, state, and local agencies having jurisdiction.

C. Mockup:

1. Before proceeding with Work under this section, finish one complete space or item of each color scheme required showing selected colors, finish texture, materials, quality of work, and special details.
2. After Engineer approval, sample spaces or items shall serve as a standard for similar work throughout the Project.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Shipping:

1. Where precoated items are to be shipped to the Site, protect coating from damage. Batten coated items to prevent abrasion.
2. Protect shop painted surfaces during shipment and handling by suitable provisions including padding, blocking, and use of canvas or nylon slings.

B. Storage:

1. Store products in a protected area that is heated or cooled to maintain temperatures within the range recommended by paint manufacturer.
2. Primed surfaces shall not be exposed to weather for more than 2 months before being top coated, or less time if recommended by coating manufacturer.

1.06 PROJECT CONDITIONS

A. Environmental Requirements:

1. Do not apply paint in temperatures or moisture conditions outside of manufacturer's recommended maximum or minimum allowable.

2. Do not perform final abrasive blast cleaning whenever relative humidity exceeds 85 percent, or whenever surface temperature is less than 5 degrees F above dew point of ambient air.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Nationally recognized manufacturers of paints and protective coatings who are regularly engaged in the production of such materials for essentially identical service conditions.

B. Minimum of 5 years' verifiable experience in manufacture of specified product.

C. Each of the following manufacturers is capable of supplying most of the products specified herein:

1. PPG.
2. Sherwin-Williams.
3. Tnemec.

2.02 PAINT MATERIALS

A. General:

1. Manufacturer's highest quality products suitable for intended service.
2. Compatibility: Only compatible materials from a single manufacturer shall be used in the Work. Particular attention shall be directed to compatibility of primers and finish coats.
3. Thinners, Cleaners, Driers, and Other Additives: As recommended by coating manufacturer.

B. Products:

Product	Definition
Acrylic Latex	100% acrylic, semigloss
Bituminous Paint	Single-component, coal-tar pitch based
Coal-Tar Epoxy	Amine, polyamide, or phenolic epoxy type 70% volume solids minimum, suitable for immersion service
Epoxy Filler/Surfacer	100% solids epoxy trowel grade filler and surfacer, nonshrinking, suitable for application to concrete and masonry. Approved for potable water contact and conforming to NSF 61, where required

Product	Definition
Epoxy Primer—Ferrous Metal	Anticorrosive, converted epoxy primer containing rust-inhibitive pigments
Epoxy Primer—Other	Epoxy primer, high-build, as recommended by coating manufacturer for specific galvanized metal, copper, or nonferrous metal alloy to be coated
High Build Epoxy	Polyamidoamine epoxy, minimum 69% volume solids, capability of 4 to 8 MDFT per coat
Polyurethane Enamel	Two-component, aliphatic or acrylic based polyurethane; high gloss finish

2.03 MIXING

A. Multiple-Component Coatings:

1. Prepare using each component as packaged by paint manufacturer.
2. No partial batches will be permitted.
3. Do not use multiple-component coatings that have been mixed beyond their pot life.
4. Furnish small quantity kits for touchup painting and for painting other small areas.
5. Mix only components specified and furnished by paint manufacturer.
6. Do not intermix additional components for reasons of color or otherwise, even within the same generic type of coating.

B. Colors: Formulate paints with colorants free of lead, lead compounds, or other materials that might be affected by presence of hydrogen sulfide or other gas likely to be present at Site.

2.04 SHOP FINISHES

A. Shop Blast Cleaning: Reference Paragraph, Shop Coating Requirements.

B. Surface Preparation: Provide Engineer minimum 7 days' advance notice to start of shop surface preparation work and coating application work.

C. Shop Coating Requirements:

1. When required by equipment specifications, such equipment shall be primed, and finish coated in shop by manufacturer and touched up in field with identical material after installation.
2. Where manufacturer's standard coating is not suitable for intended service condition, Engineer may approve use of a tie-coat to be used between manufacturer's standard coating and specified field finish. In such cases, tie-coat shall be surface tolerant epoxy as recommended by

manufacturer of specified field finish coat. Coordinate details of equipment manufacturer's standard coating with field coating manufacturer.

D. Pipe:

1. Ductile Iron Pipe:
   a. Use SSPC standards as a guide for desired prepared surface. Follow recommendations of pipe and coating manufacturers for means and methods to achieve SSPC-equivalent surface.
   b. The surface preparation and application of the primer shall be performed by pipe manufacturer.
   c. For high performance (epoxy) coatings, follow additional recommendations of pipe and coating manufacturers.
   d. Prior to blast cleaning, grind smooth surface imperfections, including, but not limited to delaminating metal or oxide layers.
2. Steel Pipe:
   a. Surface preparation and application of primer shall be performed by pipe manufacturer.
   b. For pipe with epoxy lining, do not place end cap seals until pipe lining material has sufficiently dried.

PART 3 EXECUTION

3.01 GENERAL

A. Provide Engineer minimum 7 days' advance notice to start of field surface preparation work and coating application work.

B. Perform the Work only in presence of Engineer, unless Engineer grants prior approval to perform the Work in Engineer's absence.

C. Schedule inspection of cleaned surfaces and all coats prior to succeeding coat in advance with Engineer.

3.02 EXAMINATION

A. Factory Finished Items:

1. Schedule inspection with Engineer before repairing damaged factory-finished items delivered to Site.
2. Repair abraded or otherwise damaged areas on factory-finished items as recommended by coating manufacturer. Carefully blend repaired areas into original finish. If required to match colors, provide full finish coat in field.

B. Surface Preparation Verification: Inspect and provide substrate surfaces prepared in accordance with these Specifications and printed directions and

recommendations of paint manufacturer whose product is to be applied. The more stringent requirements shall apply.

3.03 PROTECTION OF ITEMS NOT TO BE PAINTED

A. Remove, mask, or otherwise protect hardware, lighting fixtures, switchplates, aluminum surfaces, machined surfaces, couplings, shafts, bearings, nameplates on machinery, and other surfaces not specified elsewhere to be painted.

B. Provide drop cloths to prevent paint materials from falling on or marring adjacent surfaces.

C. Protect working parts of mechanical and electrical equipment from damage during surface preparation and painting process.

D. Mask openings in motors to prevent paint and other materials from entering.

E. Protect surfaces adjacent to or downwind of Work area from overspray.

3.04 SURFACE PREPARATION

A. Field Abrasive Blasting:

1. Perform blasting for items and equipment where specified and as required to restore damaged surfaces previously shop or field blasted and primed or coated.
2. Refer to coating systems for degree of abrasive blasting required.
3. Where the specified degree of surface preparation differs from manufacturer's recommendations, the more stringent shall apply.

B. Metal Surface Preparation:

1. Where indicated, meet requirements of SSPC Specifications summarized below:
   a. SP 1, Solvent Cleaning: Removal of visible oil, grease, soil, drawing and cutting compounds, and other soluble contaminants by cleaning with solvent.
   b. SP 5, White Metal Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter by blast cleaning.
   c. SP 7, Brush-Off Blast Cleaning: Removal of visible rust, oil, grease, soil, dust, loose mill scale, loose rust, and loose coatings. Tightly adherent mill scale, rust, and coating may remain on surface.
   d. SP 10, Near-White Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter, except for random staining limited to no

more than 5 percent of each unit area of surface which may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied coatings.

e. SP-16, Brush Blasting of Non-Ferrous Metals: A brush-off blast cleaned non-ferrous metal surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, metal oxides (corrosion products), and other foreign matter. Intact, tightly adherent coating is permitted to remain. A coating is considered tightly adherent if it cannot be removed by lifting with a dull putty knife. Bare metal substrates shall have a minimum profile of 19 micrometers (0.75 mil).

2. The words “solvent cleaning”, “hand tool cleaning”, “wire brushing”, and “blast cleaning”, or similar words of equal intent in these Specifications or in paint manufacturer’s specification refer to the applicable SSPC Specification.
3. Where OSHA or EPA regulations preclude standard abrasive blast cleaning, wet or vacu-blast methods may be required. Coating manufacturers’ recommendations for wet blast additives and first coat application shall apply.
4. Ductile Iron Pipe Supplied with Asphaltic Varnish Finish: Remove asphaltic varnish finish prior to performing specified surface preparation.
5. Hand tool clean areas that cannot be cleaned by power tool cleaning.
6. Round or chamfer sharp edges and grind smooth burrs, jagged edges, and surface defects.
7. Welds and Adjacent Areas:
   a. Prepare such that there is:
      1) No undercutting or reverse ridges on weld bead.
      2) No weld spatter on or adjacent to weld or any area to be painted.
      3) No sharp peaks or ridges along weld bead.
   b. Grind embedded pieces of electrode or wire flush with adjacent surface of weld bead.
8. Preblast Cleaning Requirements:
   a. Remove oil, grease, welding fluxes, and other surface contaminants prior to blast cleaning.
   b. Cleaning Methods: Steam, open flame, hot water, or cold water with appropriate detergent additives followed with clean water rinsing.
   c. Clean small, isolated areas as above or solvent clean with suitable solvent and clean cloth.
9. Blast Cleaning Requirements:
   a. Type of Equipment and Speed of Travel: Design to obtain specified degree of cleanliness. Minimum surface preparation is as specified herein and takes precedence over coating manufacturer’s recommendations.

b. Select type and size of abrasive to produce surface profile that meets coating manufacturer's recommendations for particular primer to be used.
c. Use only dry blast cleaning methods.
d. Do not reuse abrasive, except for designed recyclable systems.
e. Meet applicable federal, state, and local air pollution and environmental control regulations for blast cleaning, confined space entry (if required), and disposition of spent aggregate and debris.

10. Post-Blast Cleaning and Other Cleaning Requirements:
a. Clean surfaces of dust and residual particles from cleaning operations by dry (no oil or water vapor) air blast cleaning or other method prior to painting. Vacuum clean enclosed areas and other areas where dust settling is a problem and wipe with a tack cloth.
b. Paint surfaces the same day they are blasted. Reblast surfaces that have started to rust before they are painted.

C. Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation:

1. Remove soil, cement spatter, and other surface dirt with appropriate hand or power tools.
2. Brush blast in accordance with SSPC SP 16.
3. Obtain and follow coating manufacturer's recommendations for additional preparation that may be required.

D. Concrete Surface Preparation:

1. Do not begin until 30 days after concrete has been placed.
2. Meet requirements of SSPC SP 13.
3. Remove grease, oil, dirt, salts or other chemicals, loose materials, or other foreign matter by solvent, detergent, or other suitable cleaning methods.
4. Brush-off blast clean to remove loose concrete and laitance and provide a tooth for binding. Upon approval by Engineer, surface may be cleaned by acid etching method. Approval is subject to producing desired profile equivalent to No. 80 grit flint sandpaper. Acid etching of vertical or overhead surfaces shall not be allowed.
5. Secure coating manufacturer's recommendations for additional preparation, if required, for excessive bug holes exposed after blasting.
6. Unless otherwise required for proper adhesion, ensure surfaces are dry prior to painting.

E. Plastic and FRP Surface Preparation:

1. Hand sand plastic surfaces to be coated with medium grit sandpaper to provide tooth for coating system.

2. Large areas may be power sanded, or brush-off blasted, provided sufficient controls are employed so surface is roughened without removing excess material.

F. Masonry Surface Preparation:

1. Complete and cure masonry construction for 14 days or more before starting surface preparation work.
2. Remove oil, grease, dirt, salts or other chemicals, loose materials, or other foreign matter by solvent, detergent washing, or other suitable cleaning methods.
3. Clean masonry surfaces of mortar and grout spillage and other surface deposits using one of the following:
   a. Nonmetallic fiber brushes and commercial muriatic acid followed by rinsing with clean water.
   b. Brush-off blasting.
   c. Water blasting.
4. Do not damage masonry mortar joints or adjacent surfaces.
5. Leave surfaces clean and, unless otherwise required for proper adhesion, dry prior to painting.
6. Masonry Surfaces to be Painted: Uniform texture and free of surface imperfections that would impair intended finished appearance.
7. Masonry Surfaces to be Clear Coated: Free of discolorations and uniform in texture after cleaning.

3.05 SURFACE CLEANING

A. Brush-off Blast Cleaning:

1. Equipment, procedure, and degree of cleaning shall meet requirements of SSPC SP 7.
2. Abrasive: Either wet or dry blasting sand, grit, or nutshell.
3. Select various surface preparation parameters, such as size and hardness of abrasive, nozzle size, air pressure, and nozzle distance from surface such that surface is cleaned without pitting, chipping, or other damage.
4. Verify parameter selection by blast cleaning a trial area that will not be exposed to view.
5. Engineer will review acceptable trial blast cleaned area and use area as a representative sample of surface preparation.
6. Repair or replace surface damaged by blast cleaning.

B. Acid Etching:

1. After precleaning, spread the following solution by brush or plastic sprinkling can: One part commercial muriatic acid reduced by two parts water by volume. Adding acid to water in these proportions gives an approximate 10 percent solution of HCl.

2. Application:
    a. Rate: Approximately 2 gallons per 100 square feet.
    b. Work acid solution into surface by hard-bristled brushes or brooms until complete wetting and coverage is obtained.
    c. Acid will react vigorously for a few minutes, during which time brushing shall be continued.
    d. After bubbling subsides (10 minutes), hose down remaining slurry with high pressure clean water.
    e. Rinse immediately to avoid formation on the surface of salts that are difficult to remove.
    f. Thoroughly rinse to remove any residual acid surface condition that may impair adhesion.
3. Ensure surface is completely dry before application of coating.
4. Apply acid etching to obtain a “grit sandpaper” surface profile. If not, repeat treatment.

C. Solvent Cleaning:

1. Consists of removal of foreign matter such as oil, grease, soil, drawing and cutting compounds, and any other surface contaminants by using solvents, emulsions, cleaning compounds, steam cleaning, or similar materials and methods that involve a solvent or cleaning action.
2. Meet requirements of SSPC SP 1.

3.06 APPLICATION

A. General:

1. The intention of these Specifications is for new metal and new interior masonry and concrete surfaces to be painted, whether specifically mentioned or not, except as specified otherwise.
2. Extent of Coating (Immersion): Coatings shall be applied to internal vessel and pipe surfaces, nozzle bores, flange gasket sealing surfaces, carbon steel internals, and stainless steel internals, unless otherwise specified.
3. For coatings subject to immersion, obtain full cure for completed system. Consult coatings manufacturer’s written instructions for these requirements. Do not immerse coating until completion of curing cycle.
4. Apply coatings in accordance with these Specifications and paint manufacturers’ printed recommendations and special details. The more stringent requirements shall apply. Allow sufficient time between coats to assure thorough drying of previously applied paint.
5. Sand wood lightly between coats to achieve required finish.
6. Vacuum clean surfaces free of loose particles. Use tack cloth just prior to applying next coat.
7. Coat units or surfaces to be bolted together or joined closely to structures or to one another prior to assembly or installation.

8. On pipelines, terminate coatings along pipe runs to 1 inch inside pipe penetrations.
9. Keep paint materials sealed when not in use.
10. Where more than one coat is applied within a given system, alternate colors to provide a visual reference showing required number of coats have been applied.

B. Galvanized Metal, Copper, and Nonferrous Metal Alloys:

1. Concealed galvanized, copper, and nonferrous metal alloy surfaces (behind building panels or walls) do not require painting, unless specifically indicated herein.
2. Prepare surface and apply primer in accordance with System No. 10 specification.
3. Apply intermediate and finish coats of the coating system appropriate for the exposure.

C. Porous Surfaces, Such as Concrete and Masonry:

1. Filler/Surfacer: Use coating manufacturer's recommended product to fill air holes, bug holes, and other surface voids or defects.
2. Prime Coat: May be thinned to provide maximum penetration and adhesion.
   a. Type and Amount of Thinning: Determined by paint manufacturer and dependent on surface density and type of coating.
3. Surface Specified to Receive Water Base Coating: Damp, but free of running water, just prior to application of coating.

D. Film Thickness and Coverage:

1. Number of Coats:
   a. Minimum required without regard to coating thickness.
   b. Additional coats may be required to obtain minimum required paint thickness, depending on method of application, differences in manufacturers' products, and atmospheric conditions.
2. Application Thickness:
   a. Do not exceed coating manufacturer's recommendations.
   b. Measure using a wet film thickness gauge to ensure proper coating thickness during application.
3. Film Thickness Measurements and Electrical Inspection of Coated Surfaces:
   a. Perform with properly calibrated instruments.
   b. Recoat and repair as necessary for compliance with specification.
   c. Coats are subject to inspection by Engineer and coating manufacturer's representative.
4. Visually inspect concrete, masonry, nonferrous metal, plastic, and wood surfaces to ensure proper and complete coverage has been attained.

5. Give particular attention to edges, angles, flanges, and other similar areas, where insufficient film thicknesses are likely to be present, and ensure proper millage in these areas.
6. Apply additional coats as required to achieve complete hiding of underlying coats. Hiding shall be so complete that additional coats would not increase the hiding.

3.07 PROTECTIVE COATINGS SYSTEMS AND APPLICATION SCHEDULE

A. Unless otherwise shown or specified, paint surfaces in accordance with the following application schedule. In the event of discrepancies or omissions in the following, request clarification from Engineer before starting work in question.

B. As shown in Finish Schedule on Drawings. Additional requirements are included in the Piping Schedule.

C. System No. 2 Submerged Metal—Domestic Sewage:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 5, White Metal Blast Cleaning	Prime in accordance with manufacturer's recommendations	
	Coal-Tar Epoxy -OR- High Build Epoxy	2 coats, 16 MDFT 2 coats, 16 MDFT

1. Use on new metal surfaces below a plane 1 foot above maximum liquid surface, metal surfaces above maximum liquid surface that are a part of immersed equipment, concrete embedded surfaces of metallic items, such as wall pipes, pipes, pipe sleeves, access manholes, gate guides and thimbles, and structural steel, and the following specific surfaces:
   a. Interior surfaces of steel piping noted in the Piping Schedule.

D. System No. 4 Exposed Metal:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Epoxy Primer—Ferrous Metal	1 coat, 2.5 MDFT
	High Build Epoxy	1 coat, 4 MDFT
	Polyurethane Enamel	1 coat, 3 MDFT

1. Use on new exposed metal surfaces, located inside or outside of structures, and the following specific surfaces:
   a. Exposed metal piping noted in Piping Schedule. Do not paint stainless steel surfaces.

b. Structural steel framing and supports.
c. Galvanized steel supports, lintels and roof decking after Paint System No. 10.
d. Guard posts.
e. Equipment and supports (e.g., pumps, grinders, valves).

2. Do not use on pipe supports. All pipe supports are hot-dipped galvanized per Section 40 05 15, Piping Support Systems.

E. System No. 8 Buried Metal—General:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Standard Hot Coal-Tar Enamel -OR- Coal-Tar Epoxy	AWWA C203 2 coats, 16 MDFT
	For Highly Abrasive Soil, Brackish Water: Tape Coat System	AWWA C214 with Double Outer Wrap

1. For steel pipe and fittings, follow AWWA C209 and AWWA C214 with double outer wrap.
2. Use on buried, belowgrade portions of steel items, except buried stainless steel or ductile iron**.**

F. System No. 10 Galvanized Metal, Copper, and Nonferrous Metal Alloy Conditioning:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation	Epoxy Primer—Other	As recommended by coating manufacturer Remaining coats as required for exposure

1. Use on galvanized steel, copper, and aluminum surfaces requiring painting.
2. After application of System No. 10, apply finish coats of System No. 4 or System No. 2 for submerged metal and System No. 8 for buried metal.

G. System No. 22 Chemical-Resistant Wall and Ceiling, Heavy-Duty—Concrete and Masonry:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Concrete and Masonry Surface Preparation	Epoxy Filler/Surfacer	1 coat as required to fill voids and smooth surface; apply to 100 percent of surface.
	High Build Epoxy	1 coat, 160 SFPG
	High Build Epoxy, Gloss	1 coat, 160 SFPG

1. Use on masonry walls and concrete walls and ceilings as scheduled in the Interior Finish Schedule on Drawings.

H. System No. 25 Exposed FRP, PVC:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Plastic and FRP Surface Preparation	Acrylic Latex, Semigloss	2 coats, 320 SFPGPC

1. Use on exposed-to-view PVC and CPVC surfaces, and FRP surfaces without integral UV-resistant gel coat including PVC and CPVC piping.

I. System No. 27 Aluminum and Dissimilar Metal Insulation:

Surface Prep.	Paint Material	Min. Coats, Cover
Solvent Clean (SP 1)	Prime in accordance with manufacturer's recommendations	
	Bituminous Paint	1 coat, 10 MDFT

1. Use on aluminum surfaces embedded or in contact with concrete, grout, or masonry, or in contact with dissimilar metals other than stainless steel, including aluminum handrails, and aluminum stairs.
2. Use for dissimilar metal insulation.

3.08 COLORS

A. Provide as designated herein, shown in Piping Schedule, or as selected by Owner or Engineer.

B. Proprietary identification of colors is for identification only. Selected manufacturer may supply matches.

C. Equipment Colors:

1. Equipment includes the machinery or vessel itself plus the structural supports and fasteners and attached electrical conduits.
2. Paint nonsubmerged portions of equipment the same color as the piping it serves, except as itemized below:
   a. Dangerous Parts of Equipment and Machinery: OSHA Orange.
   b. Fire Protection Equipment and Apparatus: OSHA Red.
   c. Radiation Hazards: OSHA Purple.
   d. Physical hazards in normal operating area and energy lockout devices, including, but not limited to, electrical disconnects for equipment and equipment isolation valves in air and liquid lines under pressure: OSHA Yellow.

D. Pipe Identification Painting:

1. Color code nonsubmerged metal piping, except electrical conduit. Paint fittings and valves the same color as pipe, except equipment isolation valves.
2. Pipe Color Coding: In accordance with Piping Schedule.
3. On exposed stainless steel piping, apply color 24 inches in length along pipe axis at connections to equipment, valves, or branch fittings, at wall boundaries, and at intervals along piping not greater than 9 feet on center.

3.09 FIELD QUALITY CONTROL

A. Testing:

1. Thickness and Continuity Testing:
   a. Measure coating thickness specified in mils with a magnetic type, dry film thickness gauge, in accordance with SSPC PA 2. Check each coat for correct millage. Do not make measurement before a minimum of 8 hours after application of coating.
   b. Holiday detect coatings 20 mils thick or less, except zinc primer and galvanizing, with low voltage wet sponge electrical holiday detector in accordance with NACE SP0188.
   c. Holiday detect coatings in excess of 20 mils dry with high voltage spark tester as recommended by coating manufacturer and in accordance with NACE SP0188.
   d. After repaired and recoated areas have dried sufficiently, retest each repaired area. Final tests may also be conducted by Engineer.

B. Inspection: Leave staging and lighting in place until Engineer has inspected surface or coating. Replace staging removed prior to approval by Engineer. Provide additional staging and lighting as requested by Engineer.

C. Unsatisfactory Application:

1. If item has an improper finish color or insufficient film thickness, clean surface and topcoat with specified paint material to obtain specified color and coverage. Obtain specific surface preparation information from coating manufacturer.
2. Evidence of runs, bridges, shiners, laps, or other imperfections is cause for rejection.
3. Repair defects in accordance with written recommendations of coating manufacturer.

D. Damaged Coatings, Pinholes, and Holidays:

1. Hand or power sand visible areas of chipped, peeled, or abraded paint, and feather edges. Follow with primer and finish coat. Depending on extent of repair and appearance, a finish sanding and topcoat may be required.
2. Remove rust and contaminants from metal surface. Provide surface cleanliness and profile in accordance with surface preparation requirements for specified paint system.
3. Feather edges and repair in accordance with recommendations of paint manufacturer.
4. Apply finish coats, including touchup and damage-repair coats in a manner that will present a uniform texture and color-matched appearance.

3.10 MANUFACTURER'S SERVICES

A. In accordance with Section 01 43 33, Manufacturers' Field Services, coating manufacturer's representative shall be present at Site as follows:

1. On first day of application of any coating system.
2. A minimum of two additional Site inspection visits, each for a minimum of 4 hours, in order to provide Manufacturer's Certificate of Proper Installation.
3. As required to resolve field problems attributable to or associated with manufacturer's product.
4. To verify full cure of coating prior to coated surfaces being placed into immersion service.

3.11 CLEANUP

A. Place cloths and waste that might constitute a fire hazard in closed metal containers or destroy at end of each day.

B. Upon completion of the Work, remove staging, scaffolding, and containers from Site or destroy in a legal manner.

C. Remove paint spots, oil, or stains upon adjacent surfaces and floors and leave entire job clean.

3.12 SUPPLEMENTS

A. The supplements listed below, following “End of Section,” are a part of this specification:

1. Paint System Data Sheet (PSDS)
2. Product Data Sheet (PDS).

END OF SECTION

PAINT SYSTEM DATA SHEET

Complete this PSDS for each coating system, include all components of the system (surface preparation, primer, intermediate coats, and finish coats). Include all components of a given coating system on a single PSDS.

Paint System Number (from Spec.):		
Paint System Title (from Spec.):		
Coating Supplier:		
Representative:		
Surface Preparation:		
Paint Material (Generic)	**Product Name/Number (Proprietary)**	**Min. Coats, Coverage**

PAINT PRODUCT DATA SHEET

Complete and attach manufacturer's Technical Data Sheet to this PDS for each product submitted. Provide manufacturer's recommendations for the following parameters at temperature (F)/relative humidity:

Temperature/RH	50/50	70/30	90/25
Induction Time			
Pot Life			
Shelf Life			
Drying Time			
Curing Time			
Min. Recoat Time			
Max. Recoat Time			

Provide manufacturer's recommendations for the following:

Mixing Ratio:

Maximum Permissible Thinning:____

Ambient Temperature Limitations: min.: max.:____

Surface Temperature Limitations: min.: max.:____

Surface Profile Requirements: min.: max.:____

SECTION 10 14 00
SIGNAGE

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Society of Mechanical Engineers (ASME): A13.1, Scheme for the Identification of Piping Systems.
2. Occupational Safety and Health Act (OSHA).

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Drawings showing layouts, actual letter sizes and styles, and Project-specific mounting details.
   b. Manufacturer's literature showing letter sizes and styles, sign materials, and standard mounting details.
2. Anchorage and bracing data sheets and drawings as required by Section 01 88 15, Anchorage and Bracing.
3. Samples: As required for color selections.

B. Informational Submittals:

1. Manufacturer's installation instructions.
2. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.

PART 2 PRODUCTS

2.01 BUILDING IDENTIFICATION

A. Cast aluminum letters projected mounting.

B. Size: 8-inch high regular depth.

C. Lettering Style: Futura matching existing.

D. Finish: Architectural Class I anodic coating in 0.70-mil thickness; color to match existing.

E. Fasteners: Concealed.

F. Text: PROCESS AIR FACILITY

G. Location: See Drawings for locations.

H. Manufacturers:

1. Eder Metal Letter Co., Milwaukee, WI.
2. Spanjer Brothers, Inc., Chicago, IL.
3. Andco Industries Corp., Greensboro, NC.

2.02 SIGN TYPES

A. Fiberglass Sign (Type C):

1. Material: Three-ply laminated fiberglass, minimum 1/8 inch thick, with contrasting color core message layer between two clear weather-resistant surface layers.
2. Manufacturers:
   a. Brady Signmark.
   b. Emedco.

2.03 IDENTIFICATION LABELS

A. Pipe Labels:

1. Labels: Self-adhesive tape, with separate directional flow arrows.
2. Material: Pressure sensitive vinyl.
3. Letters and Arrows: Black or white on contrasting background.
4. Color Field and Letter Height: ASME A13.1.
5. Message: Piping system name as indicated on Piping Schedule.
6. Manufacturers and Products:
   a. Brady Signmark; B-946 Self-Sticking Vinyl Pipe Markers and Vinyl Arrows.
   b. Seton Identification Products; Opti-Code Markers and Directional Arrows.

B. Equipment Labels:

1. Applies to equipment with assigned tag numbers, where specified.
2. Letters: White, 3/4 inch minimum high.
3. Background: Black.
4. Materials: Fiberglass with encased lettering.
5. Furnish 1-inch margin with holes at each end of label, for mounting. On fiberglass labels, furnish grommets at each hole.
6. Size:
   a. 2 inches minimum and 3 inches maximum high, by 14 inches minimum and 18 inches maximum long.
   b. Furnish same size base dimensions for all labels.
7. Message: Equipment names and tag numbers as used in sections where equipment is specified.

8. Manufacturers:
    a. Brady Signmark.
    b. Seton Identification Products.

2.04 ANCILLARY MATERIALS

A. Fasteners: Stainless steel screws or bolts of appropriate sizes.

PART 3 EXECUTION

3.01 INSTALLATION—GENERAL

A. In accordance with manufacturer's recommendations.

B. Mount securely, plumb, and level.

3.02 SIGNS

A. General:

1. Fasten to walls or posts or hang as scheduled.
2. Anchor in place for easy removal and reinstallation with ordinary hand tools.

B. Information and Safety Signs:

1. Install facing traffic. Locate for high visibility with minimum restriction of working area around walkways and equipment.
2. Install as scheduled.

3.03 IDENTIFICATION LABELS

A. Pipe Labels:

1. Locate at connections to equipment, valves, or branching fittings at wall boundaries.
2. At intervals along piping not greater than 18 feet on center with at least one label applied to each exposed horizontal and vertical run of pipe.
3. At exposed piping not normally in view, such as above suspended ceilings and in closets and cabinets.
4. Supplementary Labels: Provide to Owner those listed on Piping Schedule that do not receive arrows.
5. Apply to pipe after painting in vicinity is complete, or as approved by Engineer.
6. Install in accordance with manufacturer's instructions.

B. Equipment Labels:

1. Locate and install on equipment or concrete equipment base.

2. Anchor to equipment or base for easy removal and replacement with ordinary hand tools.

3.04 SUPPLEMENTS

A. The supplement listed below, following “End of Section,” is a part of this specification.

1. Sign Schedule: Tabulation of characteristics and mounting information for information and safety signs numbered on Drawings. Provide items as scheduled. Meet requirements of Occupational Safety and Health Act (OSHA).

END OF SECTION

Sign Schedule

Sign									Lettering					
			Size			Mounting								
Number[1]	Sign Type[2]	Detail Reference[3]	Width	Height	Color	Location	Method	Height to Top	Height	Style	Color	Message	Faces	Other Requirements
C-1	C	1014-002	20"	14"	Yellow	Wall	Screws or Bolts	5'-6"	1" min.	Helvetica	Black	CAUTION Equipment Starts Automatically	1	
C-2	C	1014-002	20"	14"	Yellow	Wall	Screws or Bolts	5'-6"	1" min.	Helvetica	Black	CAUTION Ear Protection Required	1	
D-1	C	1014-001	20"	14"	White	Door	Screws or Bolts	5'-6"	1" min.	Helvetica	Black	DANGER High Voltage	1	

[1]Numbers refer to a particular sign type with a particular message.
[2]Letters refer to Sign Types specified in this section.
[3]Numbers refer to Design Details that show sign layout.

SECTION 10 44 00
FIRE PROTECTION SPECIALTIES AND SAFETY EQUIPMENT

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. National Fire Protection Association (NFPA): 10, Standard for Portable Fire Extinguishers.
2. Occupational Safety and Health Administration (OSHA).
3. Underwriters Laboratories Inc. (UL): Fire Protection Equipment Directory.

1.02 PERFORMANCE REQUIREMENTS

A. Conform to NFPA 10 Regulatory Requirements and meet requirements of the Connecticut State Building Code and as supplemented by these Specifications.

B. Provide extinguishers classified and labeled by for purpose specified and indicated.

C. Provide fire rated fire extinguisher cabinets classified and labeled by Underwriters Laboratories Inc. for purpose specified and indicated.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Fire Extinguishers: Manufacturer's product data for each item, including sizes, ratings, UL listings, or other certifications, and mounting information.
   b. Product Data: Extinguisher operational features, color and finish, and anchorage details.

B. Informational Submittals:

1. Manufacturer's Installation Instructions.
2. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.
3. Operation and Maintenance Data: Submit test, refill or recharge schedules and recertification requirements.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Section 01 61 00, Common Product Requirements: Environmental conditions affecting products onsite.

B. Do not install extinguishers when ambient temperatures are capable of freezing extinguisher ingredients.

PART 2 PRODUCTS

2.01 PORTABLE FIRE EXTINGUISHERS

A. Manufacturers:

1. JL Industries.
2. Larsen's Manufacturing Co.
3. Nystrom Products Co
4. Potter Roemer.

B. General:

1. Conform to NFPA 10 for fire extinguishers.
2. Furnish fire extinguishers and cabinets from one manufacturer.
3. UL listed, charged and ready for service.

C. Multipurpose Hand Extinguisher (F.EXT-1):

1. Tri-class dry chemical extinguishing agent.
2. Pressurized, red enameled steel shell cylinder.
3. Activated by top squeeze handle.
4. Agent propelled through hose or opening at top of unit.
5. For use on A, B, and C class fires.
6. Minimum UL Rating: 4A-60B:C, 10-pound capacity.

D. Clean Agent Hand Extinguisher (F.EXT-2):

1. Clean agent with nonozone depleting potential extinguishant.
2. Pressurized, red enameled steel shell cylinder.
3. Activated by top squeeze handle.
4. Colorless, odorless, electrically non-conductive clean agent which discharges as a liquid and flashes to a gas.
5. Environmentally friendly, with zero ozone depletion potential, containing no chlorofluorocarbons, hydrochlorofluorocarbons, or halon.
6. For use on Class A, B, or C fires.
7. Minimum UL Rating: 2A-10B:C, 13-pound capacity.

2.02 FIRST-AID CABINETS AND SUPPLIES

A. Manufacturers:

1. Afassco, Inc.
2. Johnson & Johnson.
3. Zee Medical Products Co., Inc.

B. Cases:

1. Enameled metal or break-resistant plastic.
2. Carrying handles.
3. Made to hang on wall.

C. Supplies: ANSI Z308.1 Class A first-aid kit includes the following minimum items:

1. 16 - Adhesive bandages, 1-inch by 3-inch.
2. 1 - Adhesive tape 2.5 yards.
3. 10 - Antibiotic treatment applications, 1/57 ounce.
4. 10 - Antiseptic applications 1/57 ounce.
5. 1 - Breathing barrier.
6. 1 - Burn dressing, gel-soaked, 4-inch by 4-inch.
7. 10 - Burn treatments, 1/32 ounce.
8. 1 - Cold pack.
9. 2 - Eye coverings.
10. 1 - Eye wash, 1 ounce.
11. 1 – First-aid guide.
12. 6 - Hand sanitizers, 0.9 g.
13. 2 - Pair exam gloves.
14. 1 - Roller bandage, 2-inch by 4 yards.
15. 1 – Scissors.
16. 2 - Sterile pads, 3-inch by 3-inch.
17. 2 - Trauma pads, 5-inch by 9-inch.
18. 1 - Triangular bandage, 40-inch by 40-inch by 56-inch.

2.03 ACCESSORIES

A. Extinguisher Brackets: For hand extinguishers not located in cabinets, furnish heavy-duty brackets with clip-together strap for wall mounting.

B. Fire Extinguisher Signage: Provide wall mounted 2-sided aluminum fire extinguisher sign with pictogram and label above each fire extinguisher, minimum 9 inches by 7 inches.

C. Graphic Identification: Provide graphic identification marking for each fire extinguisher type. OSHA approved pictorial markings to indicate the extinguisher uses and nonuses on a single label.

D. Fasteners: Furnish necessary screws, bolts, brackets, and other fastenings of suitable type and size to secure items of fire and safety equipment in position.

1. Metal expansion shields for machine screws at concrete and masonry.
2. Stainless steel.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify cabinets are correctly sized for fire extinguisher type.

B. Verify rough openings for cabinet are correctly sized and located.

3.02 INSTALLATION

A. Install where indicated or directed and in accordance with manufacturer's recommendations.

B. Secure cabinets and brackets rigidly to structure.

C. Provide adequate backing for mounting surfaces.

D. Place extinguishers on wall brackets.

E. Position signage as required by authorities having jurisdiction.

3.03 PORTABLE FIRE EXTINGUISHERS

A. Provide at locations shown or as directed by Engineer.

B. Mount hangers securely in position, following manufacturer's recommendations.

C. Top of Extinguisher: No more than 54 inches above floor.

D. Install wall brackets, maximum 48 inches from finished floor to top of extinguisher handle.

END OF SECTION

SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Moving and Conditioning Association, Inc. (AMCA): 203, Field Performance Measurement of Fan Systems.
2. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE): HVAC Applications Handbook.
3. Associated Air Balance Council (AABC): National Standards for Field Management and Instrumentation Total System Balance.
4. National Environmental Balancing Bureau (NEBB):
   a. Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.
   b. Procedural Standards for Measuring Sound and Vibration.
5. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): HVAC Testing, Adjusting, and Balancing Manual.

1.02 SUBMITTALS

A. Informational Submittals:

1. Documentation of experience record of testing authority.
2. Documentation of current AABC or NEBB certifications for those technicians in responsible charge of the work under this Contract.
3. Submit detailed test and balance procedures, including test conditions for systems to be tested, prior to beginning the Work.
4. Written verification of calibration of testing and balancing equipment.
5. Balancing Log Report following completion of system adjustments including test results, adjustments, and rebalancing procedures.

1.03 QUALITY ASSURANCE

A. Air Balancing and Test Agency Qualifications:

1. Certification by AABC of NEBB for testing, adjusting and balancing of HVAC systems.
2. Corporately and financially independent organization functioning as an unbiased testing authority.
3. Professionally independent of manufacturers, suppliers, and installers of HVAC equipment being tested.
4. Have a proven record of at least five similar projects.

5. Employer of engineers and technicians regularly engaged in testing, adjusting and balancing of HVAC equipment and systems.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide materials, tools, test equipment, computers and instrumentation required to complete the work included.

B. Test Hole Plugs: Plug test holes in ducts with plugs made for that purpose and replace any insulation removed to specified conditions.

C. Drives for Belt-Driven Fans:

1. Furnish cast iron or flanged steel sheaves.
2. Sheaves and belt combination shall be capable of providing 150 percent of motor horsepower.

PART 3 EXECUTION

3.01 GENERAL

A. Adjust and balance air and water systems in accordance with standard procedures and recognized practices of the AABC or SMACNA.

B. Adjust and balance the following systems:

1. Supply, return and exhaust air systems.
2. Heating, and cooling systems.
3. Domestic hot water system (recirculation pump).

3.02 ADJUSTING AND BALANCING AIR SIDE

A. Preparation:

1. Prior to beginning the Work, perform the following activities:
   a. Review shop drawings and installed system for adequate and accessible balancing devices and test points.
   b. Recommend to Engineer dampers that need to be added or replaced in order to obtain proper air control.
   c. Verify proper startup procedures have been completed on the system.
   d. Verify controls installation is complete and system is in stable operation under automatic control.
   e. Verify test instruments have been calibrated to a recognized standard and are within manufacturer’s recommended calibration interval before beginning the Work.

B. General:

1. When adjustments are made to a portion of a fan system, reread other portions of that same system to determine effects imposed by adjustments. Readjust as necessary.
2. Lock and mark final positions of balancing dampers with permanent felt pen.
3. Correct fan and airflow measurements for Site elevation.

C. Equipment Data:

1. Collect the following data and included in final report:
   a. Type of unit.
   b. Equipment identification number.
   c. Equipment nameplate data (including manufacturer, model, size, type, and serial number).
   d. Motor data (frame, hp, volts, FLA rpm, and service factor).
   e. Sheave manufacturer, size, and bore.
   f. Belt size and number.
   g. Sheave centerline distance and adjustment limits.
   h. Starter and motor overload protection data.
   i. Include changes made during course of system balancing.

D. Fan Systems:

1. Measure fan system performance in accordance with AMCA 203.
2. In each system at least one airpath from fan to final branch duct termination shall have dampers fully open. Achieve final air quantities by adjusting fan speed.
3. Adjust Fan Air Volumes:
   a. Adjust fan speeds and motor drives for required equipment air volumes, with allowable variation of plus 10 percent minus 0 percent.
   b. After final adjustments, do not operate motor above nameplate amperage on any phase.
   c. After final adjustments, do not operate fan above maximum rated speed.
   d. Perform airflow test readings under simulated or actual conditions of full cooling, full heating, minimum outside air, full outside air and exhaust, and full return air.
   e. Provide and make drive and belt changes on motors or fans as required to adjust equipment to specified conditions. Drives shall be able to deliver 150 percent of motor horsepower. Provide

written notice to air handling unit manufacturer and Engineer if drive or belt changes were made.

4. Adjust outside air dampers, return air dampers, relief air dampers, exhaust air dampers, and motorized louvers for maximum and minimum air requirements.
5. Read and record static pressures at unit inlet and discharge, each filter set, coils, dampers, plenums, and mixing dual-duct or adjustable-volume boxes, on every supply, return, and exhaust fan for each test condition.
6. Read and record motor amperage on all phases for each test condition.

E. Building Static Pressure:

1. Measure building static pressure relative to outside in perimeter entrances during normal system conditions that would yield widest range in internal building pressure.
2. Adjust building static pressure control parameters to ensure perimeter entrances are positive to outdoors by 0.05-inch WC with entrance doors closed.
3. For multi-story buildings, test pressure conditions at ground, intermediate, and upper levels.

3.03 FIELD QUALITY CONTROL

A. General: Perform functional tests as required by Section 01 91 00, Equipment Systems Commissioning.

B. Performance Testing:

1. Electric Heating Coil Testing:
   a. Adjust system as required to achieve full output from coil.
   b. Read and record amperages and voltages for all phases.
2. Heating or Sensible Cooling Coil Testing:
   a. Adjust system as required to achieve design flow conditions for both air and water sides of coil.
   b. Measure and record airflow rate, water flow rate, entering air temperature, entering water temperature, leaving air temperature and leaving water temperature.
3. Cooling or Dehumidification Coil Testing:
   a. Adjust system as required to achieve design flow conditions for both air and water sides of coil.
   b. Measure and record airflow rate, water flow rate, entering air dry bulb and wet bulb temperatures, entering water temperature, leaving air dry bulb and wet bulb temperatures and leaving water temperature.

4. Vibration Testing:
    a. Upon completion of air and water system balance, perform vibration testing as specified below for the following rotating or reciprocating equipment:
        1) Chillers.
        2) AHU.
    b. Test Procedures:
        1) Identify maximum vibration velocity limits as specified for each piece of equipment to be tested.
        2) Take measurements at each bearing housing using calibrated electronic analyzer.
        3) Measure velocity in direction parallel to rotating shaft, and in two directions perpendicular to shaft and to each other. Align measurement directions where possible to the horizontal and vertical planes.
        4) Record log shall include equipment symbol or tag, location, identification, specified vibration velocity limits, and maximum measured velocity in each direction.
        5) Notify Engineer if amplitude exceeds upper limit specified.

C. Balancing Log Report Requirements:

1. Include narrative description for each system explaining TAB methodology and assumptions used. Clearly identify test conditions for tests performed. Include control setpoint.
2. Log and record operational information from every test for each system, as necessary to accomplish services described.
3. Include equipment data for units tested.
4. Include reduced set of HVAC Drawings or system schematic diagrams with each element uniquely identified and indexed to balance log.
5. Indicate recorded site values, and velocity and mass correction factors used to provide equivalent standard air quantities.
6. Include separate section in log, if necessary, describing operating difficulties in air or water systems that could not be eliminated by specified procedures. Identify these problems by system and location within building; include outline or summary of condition and its effect on building, and describe corrective actions attempted and recommended.

D. Quality Control Verification:

1. After adjustments have been completed and balance logs submitted, balancing and testing agency shall be available to demonstrate the following:
    a. Air and water balancing procedures, vibration tests, and verification of test results.

b. Perform spot tests on a maximum of 20 percent of total diffusers and grilles, on two air handling fan devices per building, and on 10 percent of total water balance fittings, with measuring equipment used in original tests, at random points selected by Engineer.
c. Results of these spot tests shall agree with balance logs within plus or minus 10 percent. Where this accuracy cannot be verified, rebalance portions of system as requested by Engineer.
d. At completion of rebalance procedures, perform another spot test if required to verify results.

END OF SECTION

SECTION 23 07 00
HVAC INSULATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Heating, Refrigerating & Air-Conditioning Engineers Inc. (ASHRAE): 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
2. Association of the Nonwoven Fabric Industry (INDA). IST 80.6, Water Resistance (Hydrostatic Pressure).
3. ASTM International (ASTM):
   a. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   b. C547, Standard Specification for Mineral Fiber Pipe Insulation.
   c. C553, Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
   d. C1071, Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
   e. C1139, Standard Specification for Fibrous Glass Thermal Insulation for Sound Absorbing Blanket and Board for Military Applications.
   f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
   g. G21, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
   h. G22, Standard Practice for Determining Resistance of Plastics to Bacteria.
4. National Fire Protection Association (NFPA):
   a. 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
   b. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
   c. 259, Standard Test Method for Potential Heat of Building Materials.
5. UL.

1.02 DEFINITIONS

A. Cold Air Ductwork: Designed to convey mechanically cooled air or return ducts in such systems.

B. Warm Air Ductwork: Designed to convey mechanically heated air or return ducts in such systems.

1.03 SUBMITTALS

A. Action Submittals: Product description, list of materials and thickness for each service or equipment scheduled, locations, and manufacturer's installation instructions.

B. Informational Submittals:

1. Proof of compliance for test of products for fire rating, corrosiveness, and compressive strength.
2. Operation and maintenance data as specified in Section 01 78 23, Operation and Maintenance Data.

1.04 QUALITY ASSURANCE

A. Materials furnished under this specification shall be standard, cataloged products, new and commercially available, suitable for service requiring high performance and reliability with low maintenance, and free from all defects.

B. Provide materials by firms engaged in the manufacture of insulation products of the types and characteristics specified herein, whose products have been in use for not less than 5 years.

C. UL listing or satisfactory certified test report from an approved testing laboratory is required to indicate fire hazard ratings for materials proposed for use do not exceed those specified.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Stamp or Label:

1. Every package or standard container of insulation, jackets, cements, adhesives and coatings delivered to Project Site for use must have manufacturer's stamp or label attached, giving name of manufacturer, brand, and description of material.
2. Insulation Packages and Containers: Marked "asbestos-free."

PART 2 PRODUCTS

2.01 GENERAL

A. Insulation Exterior: Cleanable, grease-resistant, nonflaking, and nonpeeling.

B. Insulation: Conform to referenced publications and specified temperature ranges and densities in pounds per cubic foot.

C. Insulation for Fittings, Flanges, and Valves: Premolded, precut, or job-fabricated insulation of same thickness and conductivity as used on adjacent piping.

D. Fire Resistance:

1. Insulation, Adhesives, Vapor Barrier Materials and Other Accessories, Except as Specified Herein: Noncombustible.
2. Do not use fugitive or corrosive treatments to impart flame resistance.
3. Flame proofing treatments subject to deterioration resulting from the effects of moisture or high humidity are not acceptable.
4. Provide materials including facings, mastics, and adhesives, with fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke, developed as per tests conducted in accordance with ASTM E84 (NFPA 255) methods.

E. Materials exempt from fire-resistant rating:

1. Nylon anchors.
2. Treated wood inserts.

F. Materials exempt from fire-resistant rating when installed in outside locations, buried, or encased in concrete:

1. Polyurethane insulation.
2. PVC casing.
3. Fiberglass-reinforced plastic casing.

2.02 PIPE INSULATION

A. Type P2—Calcium Silicate (ASTM C533, 1,200 Degrees F, Maximum):

1. Calcium silicate, minimum 12 pcf density, K factor 0.46 maximum at 300 degrees F mean, without factory-applied jacket.
2. Manufacturers and Products:
    a. Owens/Corning Fiberglass; Kaylo 10.
    b. Johns Manville; Thermo-12 Gold.
    c. Calsilite; 1,200-degree thermal insulation.

B. Type P3—Elastomeric (ASTM C534, Minus 40 to 220 Degrees F):

1. Flexible, closed cell elastomeric.
2. Nominal 6 pcf density, K factor 0.27 maximum at 75 degrees F mean.
3. Water vapor transmission 0.1 perm-inch, or less.
4. Manufacturers and Products:
    a. Armacell; AP Armaflex.
    b. Nomaco; K-Flex LS.

2.03 INSULATION FINISH SYSTEMS

A. Type F2—Paint:

1. Acrylic latex paint, white, and suitable for outdoor use.
2. Manufacturer and Product: Armstrong; WB Armaflex finish.

B. Type F5—Stainless Steel:

1. Stainless Steel Roll Jacketing: Manufactured from Type 316 prime grade annealed Austenitic stainless steel with a regular 2B mill finish for flatness and reduced glare. The yield strength is 30,000 psi, the tensile is 75,000 psi. Meet ASTM A240 and ASTM A666 standards, minimum 0.016-inch thickness, with smooth mill finish.
2. Vapor Barrier: Provide factory applied vapor barrier, 40-pound Kraft (1-1/2-mil polyethylene) or a 3-mil polysurlyn moisture retarder which is heat and pressure bonded to the interior surface. Provide moisture retarder to prevent galvanic corrosion caused by contact of dissimilar metals in the presence of moisture or chemical corrosion which may result from installing sheets over damp insulation materials.
3. Fitting Covers: Match jacketing material, premolded and manufactured to meet ASTM C450, one-piece or two-piece covers, including elbows, tee/valves, end caps, mechanical line couplings, and specialty fittings.
4. Manufacturers and Products:
   a. RPR Products; Insul-Mate.
   b. ITW, Pabco-Childers.

PART 3 EXECUTION

3.01 APPLICATION OF PIPING INSULATION

A. Install insulation products in accordance with manufacturer’s written instructions, and in accordance with recognized industry practices.

B. Apply insulation over clean, finish painted, and dry surfaces.

C. Install insulation after piping system has been pressure tested and leaks corrected.

D. Use insulating cements, lagging adhesives, and weatherproof mastics recommended by insulation manufacturer.

E. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete the run. Do not use cut pieces of scraps abutting each other.

F. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.

G. Maintain integrity of vapor-barrier jackets on pipe insulation and protect to prevent puncture or other damage. Seal open ends of insulation with mastic. Sectionally seal all butt ends of chilled water and condensate drain piping insulation at fittings with white vapor barrier coating.

H. Cover valves, flanges, fittings, and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job-fabricated units. Finish cold pipe fittings with white vapor barrier coating and hot piping with white vinyl acrylic mastic, both reinforced with glass cloth.

I. Extend piping insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise indicated.

J. Install protective metal shields and foamglass inserts where pipe hangers bear on outside of insulation.

K. Insulation on piping that is to be heat traced shall be installed after installation of heat tape.

L. Insulate valve bodies, flanges, and pipe couplings.

M. Insulate and vapor seal hangers, supports, anchors, and other piping appurtenances that are secured directly to cold surfaces.

N. Do not insulate flexible pipe couplings and expansion joints.

O. Do not allow insulation to cover nameplates or code inspection stamps.

P. Install removable insulation sections on devices that require access for maintenance of equipment or removal, such as unions and strainer end plates.

Q. Connection to Existing Piping: Cut back existing insulation to remove portion damaged by piping revisions. Install new insulation.

R. Cold Surfaces: Provide continuous vapor seal on insulation on cold surfaces where vapor barrier jackets are used.

S. Placement:

1. Slip insulation on pipe or tubing before assembly, when practical, to avoid longitudinal seams.
2. Insulate valves and fittings with sleeved or cut pieces of same material.
3. Seal and tape joints.

T. Insulation at Hangers and Supports: Install under piping, centered at each hanger or support.

U. Vapor Barrier:

1. Provide continuous vapor barrier at joints between rigid insulation and pipe insulation.
2. Install vapor barrier jackets with pipe hangers and supports outside jacket.
3. Do not use staples and screws to secure vapor sealed system components.

3.02 INSTALLATION OF INSULATION FINISH SYSTEMS

A. Use a continuous friction type joint to hold jacket in-place, providing positive weatherproof seal over entire length of jacket.

B. Secure circumferential joints with preformed snap straps containing weatherproof sealant.

C. On exterior piping, apply coating over insulation and vapor barrier to prevent damage when aluminum fitting covers are installed.

D. Do not use screws or rivets to fasten the fitting covers.

E. Install removable prefabricated aluminum covers on exterior flanges and unions.

F. Caulk and seal all exterior joints to make watertight.

3.03 PIPING INSULATION REQUIREMENTS

A. Refrigeration Suction:

1. Type P3, elastomeric.
2. 1/2-inch thickness for pipe sizes up to 1 inch.
3. 3/4-inch thickness for pipe sizes over 1 inch.

B. Refrigeration Hot Gas Reheat:

1. Type P3, elastomeric.
2. 3/4-inch thickness.

C. Condensate Drain:

1. Type P3, elastomeric.
2. 1/2-inch thickness for pipe sizes up to 2-5/8 inches ID.
3. 3/4-inch thickness for pipe sizes over 2-5/8 inches ID.

D. Pipe Hangers:

1. Type P1, Fiberglass: UL-rated, preformed rigid pipe insulation inserts of thickness equal to adjoining insulation, 10 inches in length, with

factory-applied, vinyl-coated and embossed vapor barrier jacket with self-sealing lap.

2. Type P3, Elastomeric: Rigid insulation section with 9-inch-long, 16-gauge galvanized steel saddle.

3.04 INSULATION FINISH REQUIREMENTS

A. Piping Insulation (Exposed to View, Indoors): Type F2, Paint.

B. Ductwork Insulation (Exposed to View, Indoors): Factory finish.

C. Apply coating of insulating cement where needed to obtain smooth and continuous appearance.

3.05 FIELD QUALITY CONTROL

A. Test factory-applied materials assembled. Field-applied materials may be tested individually.

END OF SECTION

SECTION 23 09 13
HVAC CONTROLS, FIELD COMPONENTS, AND INSTRUMENTS

PART 1 GENERAL

1.01 SYSTEM DESCRIPTION

A. General Requirements:

1. Provide control wiring, power wiring, conduit, hardware, and electrical work associated with the HVAC control system.
2. Provide control wiring between HVAC control panel contacts and field control devices, such as duct smoke detectors and motor starter control coil contacts.
3. Provide controls necessary for entire system to have fail-safe operation.
4. Control sequences and functions including alarms, monitoring and resetting functions, and operational sequences shall not be limited to point schedules and sequences of operation.
5. Provide sequences and functions as required to deliver a fully functioning HVAC system.
6. Modify and extend, as required, the existing system of automatic controls to include control signals from the new HVAC equipment specified furnished under Division 23, Mechanical.
7. Coordinate with work specified under Division 26, Electrical, and other Divisions of these Specifications to provide complete operating systems.
8. Control systems for the new equipment shall be solid-state electronic direct-digital control (DDC) type for integration with the existing Energy management system (EMS).
9. Refer to Division 26, Electrical for material types for conduits, etc.

1.02 ELECTRICAL COMPONENTS AND ACCESSORIES

A. Wiring: Furnish and install conduit and wiring necessary for the systems and equipment of this Section, except that shown on the Electrical Drawings. All wiring shall meet the requirements of Section 26 05 05, Conductors, and NFPA 70. All insulation shall be rated 600 volts, minimum. All low-voltage (24V) signals shall be run in twisted, shielded pair cable.

B. Electrical Raceways: All conduits and its installation shall meet the requirements of Section 26 05 33, Electrical Raceways, and NFPA 70.

1.03 SUBMITTALS

A. Action Submittals:

1. Complete specifications, descriptive drawings, catalog cuts, and descriptive literature that include make, model, dimensions, weight of equipment, and electrical schematics, for all control system components.
2. Complete system power, interlock, control, and data transmission wiring diagrams no smaller than 11 inches by 17 inches.
3. Complete drawings and schematics of proposed control system, including panel power requirements.
4. System operating sequences to be programmed, in exact English language.
5. Complete points list.
6. Interfaces with HVAC equipment.
   a. Schematic diagram of each equipment item including interface with existing DDC system.
   b. Indicate location of each control item in equipment.
   c. Show equipment manufacturer controls where installed.
7. Panel face layout drawings.
8. Damper actuator sizing calculations, in schedule form.
9. Automatic control valve sizing calculations, in schedule form.

1.04 EXTRA MATERIALS

A. HVAC Control Panel (HCP) Spare Lamps: Furnish spare lamps for each type and color of pilot light used, a minimum of one per HCP, stored inside HCP in dummy light sockets secured to back panel surface.

PART 2 PRODUCTS

2.01 HVAC CONTROL PANELS (HCPS)

A. HCPs shall be capable of working in a network configuration with existing server/client and in stand-alone mode.

B. Each HCP shall be served by a single 120-volt, 20-amp feeder.

C. HCP Contents:

1. Set point adjustment, microprocessor control modules, electronic indication relays, control switches, transformers, pilot lights, alarm lights, display screens, keypads, and other devices necessary for the particular system.
2. Components shall be UL listed.

D. HCP Construction:

1. NEMA 250, Type 3R rated except where indicated otherwise.
2. Metal enclosure to accommodate secure conduit fittings and protect against electrical transients.
3. Hinged front door with locking handle.
4. Mount all lights, switches, gauges, and dials in full view with the panel door closed.
5. Provide a flashing common alarm light, visible from the room entrance, to call attention to any alarm event.
6. Identify panel mounted operator interface devices and HCP by engraved laminated plastic nameplates with white letters on black background.
7. Panels which consist of multiple components shall be listed and labeled as a unit.

E. Logic card, containing active electrical components, shall be easily removable from the wiring base without the use of tools. Include quick-disconnect interconnection with electrical wiring.

F. Input/Output:

1. Universal inputs accepting industry standard analog signals (4 to 20 mA, 1 to 5V dc, etc.) and binary contact closures.
2. Digital Outputs: Latched or momentary contact type.
3. Analog Outputs: 1 percent resolution over total output space of 100 percent.

G. Network Communication: Communicate on the existing Building Level Network is configured as peer-to-peer network. System shall be multitasking and capable of simultaneous multi-user operation. Include jack for connection of portable operator interface device for commissioning, adjustment, and diagnosis.

H. Field Communication Ports: Individually electrically isolated to protect against transients, spikes, and power surges. Optically isolated from each other, the controller circuit board, and from power wiring. Optical isolation either as an integral component to the controller or as a separate interface device between the controller and field wiring.

I. Connections: Terminal blocks shall be plug-in type.

J. Self-Diagnostics: Self-test procedure for checking communications and verifying the functionality of the memory and database. Upon detection of communication loss, retransmission shall be attempted. Continuing failure shall cause a trouble signal to be annunciated at the HVAC Control Panel (HCP).

K. Backup and Restore: Current database of all controller modules shall be archived at the HCP. Updates shall occur automatically online. Data shall be automatically downloaded to the controller modules as needed.

L. Power Loss/Restart: Tolerant of power failures. Memory shall be nonvolatile or unit shall hold memory for a minimum of 30 days on backup batteries. When a power failure has occurred and power is restored, the controller shall restart automatically and without operator intervention. The restart procedures shall include:

1. Come online.
2. Update monitored functions.
3. Implement special facility startup strategies as required.
4. Resume operation based on current time and status.

M. Software:

1. Menu-driven in English language.
2. The user shall be able to add, delete, or modify all control blocks online. Adding, deleting, or changing a system point or control strategy shall not require EPROM re-burning or programming to be performed control contractor.
3. Passwords: Multiple access levels; each level user definable.
4. Help Menu: Online help for each menu item describing the consequences of selecting the highlighted menu item.
5. PI and PID control loops.
6. Programming Functions: Subroutine blocks shall be available to be used in any combination for program modifications in the field. As a minimum, these routines shall include:
   a. Time- or event-based scheduling.
   b. Adaptive optimum start/stop.
   c. Demand limiting load shedding.
   d. Enthalpy control.
   e. Hydronic heating supply temperature outdoor air reset.
   f. Run time totalization.
   g. Alarm detection and dial out.
   h. Night setback.
   i. Historical Trending: Trend data shall be fully compatible with Microsoft Access and Excel.

N. Refer to Section 01 61 00, Common Product Requirements, for additional environmental performance requirements.

O. Manufacturers and Products:

1. Siemens Building Technologies.
2. Johnson Controls.
3. Honeywell.
4. Andover.
5. Or-equal.

2.02 CONTROL DAMPERS

A. General:

1. Specification applies to control dampers, except those specified to be furnished with equipment.
2. Furnish opposed-blade type for proportional action and parallel-blade type for two-position action, except where indicated otherwise.

B. High Performance Control Dampers (M):

1. Frame: 5 inches by 1 inch by minimum 0.125 inch 6063-T5 extruded aluminum hat-shaped channel, mounting flanges on both sides of frame, reinforced at corners.
2. Blades:
   a. Style: Airfoil-shaped, single-piece.
   b. Orientation: Horizontal or vertical with thrust washers, as indicated on Drawings.
   c. Material: Heavy-duty 6063-T5 extruded aluminum.
   d. Width: Nominal 6 inches.
3. Bearings: Molded synthetic sleeve, turning in extruded hole in frame.
4. Seals:
   a. Blade Seals: Extruded neoprene type for ultra-low leakage from minus 72 to 275 degrees F. Mechanically attached to blade edge.
   b. Jamb Seals: Flexible metal compression type.
5. Linkage: Concealed in frame.
6. Axles:
   a. Minimum 1/2-inch diameter, hex-shaped, mechanically attached to blade.
   b. Material: Plated steel.
7. Performance Data: As follows:
   a. Temperature Rating: Withstand minus 72 to 275 degrees F.
   b. Capacity: Demonstrate capacity of damper to withstand HVAC system operating conditions.
   c. Closed Position: Maximum pressure of 13 inches w.g. at 12-inch blade length (305).
   d. Open Position: Maximum air velocity of 6,000 feet per minute.

e. Leakage: Maximum 5.2 cubic feet per minute per square foot at 4 inches w.g. for size 48 inches by 48 inches.
f. Pressure Drop: Maximum 0.03-inch w.g. at 1,500 feet per minute across 24-inch by 24-inch damper.

8. Accessories: As follows:
   a. Actuator: Refer to Article Control Damper Operators, for requirements.
   b. Switch Package: Two-position indicator switches linked directly to damper blade to remotely indicate damper blade position.
   c. Flange Frame: 1-1/2 inches, roll formed as part of frame, double configuration.
   d. T-Flange Frame:
      1) Minimum 6 inches by 1-3/8 inches by 0.125-inch aluminum, bolt holes in corners.
      2) Mates to TDC, TDF, Ductmate, Nexus, Ward, and other T-flange duct connections.
   e. Factory Sleeve: Minimum 20-gauge thickness, minimum 12-inch length.
9. Manufacturers and Products:
   a. Ruskin; Model CD-50.
   b. American Warming and Ventilating.
   c. TAMCO.
   d. Or-equal.

2.03 CONTROL DAMPER OPERATORS

A. General:

1. Drawings and control diagrams indicate only one damper motor for each motorized damper (M).
2. Select actual quantity of motors required to operate each damper in accordance with size of damper provided.
3. Coordinate exact quantity of damper motors with electrical work to ensure that necessary wiring and conduit is provided for installation.
4. Provide operators for motorized dampers and motorized louvers.

B. Electric Damper Operators:

1. Performance: As follows:
   a. 120V, 60-Hz, two-position unless otherwise indicated.
   b. Fail Position: Closed, unless indicated otherwise.
2. Mounting: External side plate. Ample power to overcome friction of damper linkage and air pressure acting on damper blades.
3. Furnished with external adjustable stops to limit stroke.
4. Operators on modulating dampers that are to be sequenced with other control devices shall have full relay type pilot positioner and

interconnecting linkage to provide mechanical feedback that will accurately position and control damper.

5. Intake, relief, and exhaust dampers shall close and return dampers shall open on control failure, unless indicated otherwise.
6. Operating Torque:
    a. Provide multiple independent damper sections, each with separate actuator, as needed to provide minimum of 120 percent of operating torque required by damper(s).
    b. Required damper operating torque for actuator sizing calculations shall include friction of damper linkage and 1-inch WC air pressure on damper blades:
        1) Opposed-blade Dampers: Minimum 5 inch-pounds per square foot of damper area, unless higher values are recommended by damper manufacturer.
        2) Parallel-blade Dampers: Minimum 7 inch-pounds per square foot of damper area, unless higher values are recommended by damper manufacturer.
7. Manufacturers:
    a. Belimo.
    b. Siemens Building Technologies.
    c. Johnson Controls.
    d. Honeywell.

2.04 ELECTRIC THERMOSTATS (ET)

A. Office Area Room Thermostat:

1. Modulating electric type, except where two-position action is required.
2. Temperature Scale: Furnish 50 to 100 degrees F dial.
3. Concealed adjustments.
4. Adjustable sensitivity.
5. Locking cover.
6. Insulating back, where exterior wall mounting is indicated.

B. Process Area Room Thermostat:

1. Modulating electric type, except where two-position action is required.
2. Temperature Scale: Furnish 20 to 120 degrees F dial.
3. Concealed adjustments.
4. Adjustable sensitivity.
5. Insulating back where exterior wall mounting is indicated.
6. Locking wire protective guard.

2.05 ELECTRONIC SENSORS

A. Temperature (TS):

1. General Requirements:
   a. Sensors and transmitters shall be provided, as outlined in input/ output summary and sequence of operations.
   b. Temperature sensor shall resistance type and shall be either 2-wire 1,000-ohm nickel RTD or 2-wire 1,000-ohm platinum RTD.
   c. The following point types (and accuracy of each) are required, and their associated accuracy values include errors associated with sensor, lead wire, and A to D conversion:

Point Type	Accuracy
Room temperature	± 0.5 degrees F
Duct temperature	± 0.5 degrees F
All others	± 0.75 degrees F

2. Room Temperature:
   a. Constructed for either surface or wall box mounting.
   b. Nonlocking wire protective guards for room temperature sensors installed in process areas.
   c. Shall have the following options when specified:
      1) Setpoint reset slide switch providing plus or minus 3 degrees F (adjustable) range.
      2) Individual heating/cooling setpoint slide switches.
      3) Momentary override request pushbutton for activation of after-hours operation.
      4) Analog thermometer.
3. Room Temperature Sensors with Integral Display:
   a. Constructed for either surface or wall box mounting.
   b. Nonlocking wire protective guards for room temperature sensors installed in process areas.
   c. Integral LCD display and 4-button keypad with the following capabilities:
      1) Display room and outside air temperatures.
      2) Display and adjust room comfort setpoint.
      3) Display and adjust fan operation status.
      4) Timed override request pushbutton with LED status for activation of after-hours operation.
      5) Display controller mode.
      6) Password selectable adjustment of setpoint and override modes.

4. Outdoor Temperature:
    a. Accuracy: Plus or minus 1 degree F.
    b. Range: Minus 40 to 140 degrees F.
    c. Cover: Weathertight, with sealed conduit connection and sun shield.

B. Pressure (PS):

1. Air Pressure:
    a. Accuracy: 5 percent of range.
    b. Range: 150 percent of measured variable.
    c. Mount nonvibrating.
    d. Cover: NEMA 250 Type, suitable for area classification; in accordance with NFPA 70.

C. Current Sensors (CS):

1. Fixed Setpoint, Digital Output Current Switch:
    a. Application: Monitoring status of direct drive equipment.
    b. Current-operated solid-state relay.
    c. Split core design.
    d. Trip Setpoint: Fixed.
    e. Output: Digital switch.
    f. Sensor Power: Induced from line.
    g. Manufacturer and Product: Veris; Hawkeye 600/800.
2. Adjustable Setpoint, Digital Output Current Switch:
    a. Application: Monitoring status of belt drive equipment.
    b. Current-operated solid-state relay.
    c. Split core design.
    d. Trip Setpoint: Adjustable.
    e. Output: Digital switch, with status LED.
    f. Sensor Power: Induced from line.
    g. Manufacturer and Product: Veris; Hawkeye 708/908.
3. Adjustable Setpoint, Digital Output, AFD Current Switch:
    a. Application: Monitoring status of belt-drive or direct-drive equipment controlled by an AFD.
    b. Microprocessor-based current-operated solid state relay.
    c. Automatic compensation for AFD frequency and current changes.
    d. Split core design.
    e. Trip Setpoint: Self-calibrating.
    f. Output: Digital switch, with normal and alarm status LED.
    g. Sensor Power: Induced from line.
    h. Manufacturer and Product: Veris; Hawkeye 904.

2.06 MISCELLANEOUS DEVICES

A. General:

1. RTD to voltage (0- to 5-volt) converters with zero span adjustments for use with analog inputs.
2. Limited range thermistors are acceptable provided they sense expected range for point at specified accuracy with 0- to 5-volt output.
3. Auxiliary contacts in each motor starter, Work of Division 26, Electrical.
4. START/STOP relay module for either momentary or maintained switch action as indicated.

B. Pilot Relays:

1. Plug-in type.
2. Interchangeable.
3. Mounted on a circuit board.
4. Wired to numbered terminal strips.

PART 3 EXECUTION

3.01 SEQUENCES OF OPERATION

A. Reference Contract Drawings.

3.02 INSTALLATION

A. General:

1. Install systems and materials in accordance with manufacturer's instructions, rough-in drawings, and equipment details.
2. Changes in location or installation of control devices or equipment shall be approved by Engineer before proceeding with the Work.
3. Mount devices requiring manual reset and all other user serviceable control devices in readily accessible locations.

B. Hazardous and Corrosive Areas:

1. Protect control equipment located in areas identified as being corrosive as follows:
   a. Use corrosion-inhibiting vapor capsules inside control equipment enclosures and HVAC control panel (HCP).
   b. Replace capsules prior to Owner's acceptance of equipment.

C. Wiring:

1. General:
   a. Install electric wire, cable, fittings, and conduit associated with systems specified in this section, in accordance with requirements of NFPA 70.
   b. Install control and interlock wiring separate from power wiring.
   c. Number code or color code conductors, excluding those used for individual zone controls, appropriately for future identification and servicing of control system.
   d. Provide wire markers on each conductor in panel and at load connections. Identify circuit with control wire number.
   e. Restrain wiring in control panels by plastic ties or ducts.
   f. Hinge wiring shall be secured at each end so that any bending or twisting will be around longitudinal axis of wire and bend area shall be protected with sleeve.
   g. Arrange wiring neatly, cut to length, and remove surplus wiring. Provide abrasion protection for any wire bundles that pass through holes or across edges of sheet metal.
   h. Use manufacturer's recommended tool with proper sized anvil for crimp terminations. No more than two wires may be terminated in single crimp lug and no more than two lugs may be installed on single screw terminal.
   i. Wiring shall not be spliced or tapped except at device terminals or terminal blocks.
   j. Properly support and run wiring in a neat manner.
   k. Run wiring parallel or at right angles to building structure.
2. Concealment:
   a. Generally conceal wiring from view, except in mechanical rooms and areas where other conduit and piping are exposed; install exposed wiring and conduit to be as unobtrusive as possible.
   b. Install line voltage control wiring, wiring exposed to view, surface-mounted wiring, and wiring concealed within walls in conduit, in accordance with Division 26, Electrical.
   c. Wiring within enclosures shall be neatly bundled and anchored to prevent obstruction to devices and terminals.
   d. Conduit shall be sized to suit the number, type, and size of conductors as specified in Section 26 05 05, Conductors.

D. End-User Accessible Control Components:

1. Do not mark room thermostats.
2. Mount user adjustable control components (room thermostats, humidistats, temperature sensors, humidity sensors, etc.) level and in accordance with applicable accessibility requirements of local Building Code.

E. Control Dampers:

1. Verify correctness of installation.
2. For pneumatic systems, calibrate and adjust positioners and IP transducers.
3. Verify proper control action.
4. Adjust limit switch settings.
5. Adjust opening and closing speeds, and travel stops.
6. Stroke control dampers by means of associated control output.

F. DDC Controllers:

1. Verify control wiring for correctness.
2. Verify power wiring.
3. Calibrate and adjust manual and auto control actions of controllers.
4. Tune control loop.
5. Stroke associated final element through controller output.
6. Verify set points and alarm functions.

G. HCP Equipment:

1. Mount HCPs level, plumb, and securely to wall or column. Verify that adequate clearance is provided to allow for full front panel swing.
2. Provide field terminations and conduit knockouts for control/instrumentation wiring.
3. Field termination wiring shall have designated instrument tag.
4. Panel cutouts shall be cut, punched, or drilled and smoothly finished with round edges.
5. Provide separate conduit entry for each power feeder circuit.
6. Signals requiring grounding shall be grounded within panel.
7. Field end of conductor shield/drain wires shall be folded back and placed under heat-shrink tubing without being grounded.
8. Panel end of conductor shield/drain wires shall be covered with clear tubing at panel and grounded.
9. Calibrate instrumentation provided on control panels.
10. Provide labels for internal panel material (e.g., terminal blocks, power supplies, relays, PLC racks).

3.03 FIELD QUALITY CONTROL

A. Performance and Functional Testing:

1. Tests and certification shall be as specified in Section 01 91 14, Equipment Testing and Facility Startup, and Section 01 43 33, Manufacturers' Field Services.

2. HVAC controls interface with process control system shall be coordinated with the Work of Section 40 90 01, Instrumentation and Control for Process Systems.

3.04 MANUFACTURER'S SERVICES

1. Provide manufacturer's services in conformance with requirements of Section 01 43 33, Manufacturers' Field Services.
2. Manufacturer's Representative: Present at Site or classroom as designated by Owner, for minimum person-days listed below, travel time excluded:
   a. 1 person-day for installation, assistance, and inspection.
   b. 1 person-day for functional and performance testing and Manufacturer's Certificate of Proper Installation.
   c. 1 person-day for prestartup classroom or Site training.

3.05 TRAINING

A. Provide training of Owner's personnel to enable them to operate HVAC equipment in available modes, to adjust set points, and to interpret alarm signals.

B. Training sessions shall be prepared in advance, and arranged for clear, effective transfer of information in minimum time.

3.06 ADJUSTING AND CALIBRATING

A. Control system shall be adjusted and calibrated by qualified manufacturer's representative.

B. Calibrate control devices at time of installation to ensure measuring and reading accuracy.

C. Adjustment Record:

1. Prepare complete record of system adjustments for each control system.
2. Indicate deviations from specified temperatures.
3. Include copy of completed record in each copy of operation and maintenance manual.

END OF SECTION

SECTION 23 23 00
REFRIGERANT PIPING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 760, Performance Rating of Solenoid Valves for Use with Volatile Refrigerants.
2. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE): 15, Safety Standard for Refrigeration Systems.
3. American Society of Mechanical Engineers (ASME):
   a. B16.22, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
   b. B31.5, Refrigeration Piping and Heat Transfer Components.
4. American Welding Society (AWS):
   a. A5.8M/A5.8, Specification for Filler Metals for Brazing and Braze Welding.
   b. BRH, Brazing Handbook.
5. ASTM International (ASTM): B280, Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
6. National Electrical Manufacturers Association (NEMA).
7. UL.

1.02 DEFINITIONS

A. ACR: Air conditioning and refrigeration.

B. NRTL: National recognized testing laboratory.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings in 1/4-inch scale for refrigerant piping showing pipe and tube sizes, flow capacities location, elevations, fittings, accessories, and piping connections.
2. Manufacturer’s data on refrigerant piping, piping products, thermostatic expansion valves, solenoid valves, hot-gas bypass valves, filter dryers, strainers, pressure regulating valves and accessories.

B. Informational Submittals:

1. Welding certificates.
2. Field quality control; test report.
3. Operation and maintenance data as specified in Section 01 78 23, Operation and Maintenance Data.

1.04 QUALITY ASSURANCE

A. Safety Code Compliance: Comply with applicable portions of ASHRAE 15.

B. Brazing: Comply with applicable requirements of ASME B31.5 pertaining to brazing of refrigerant piping for shop and Project Site locations.

C. Installer: A firm with at least 5 years of successful installation experience on projects with refrigerant piping similar to that required for this Project.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Refrigerant piping shall be cleaned, dehydrated, and sealed when delivered.

B. Store piping in clean and protected area with end caps in place.

PART 2 PRODUCTS

2.01 MATERIALS

A. Material and dimensional requirements for field assembled refrigerant piping, valves, fittings and accessories shall conform to ASHRAE 15 and ASME B31.5, except as hereinafter specified.

B. Piping, 4 Inches and Smaller: Copper, Type ACR tube, ASTM B280, copper No. 122, hard-drawn temper. Brazed joints required.

C. Fittings for Copper Tube: Wrought-copper/bronze solder-joint fittings in accordance with ASME B16.22.

D. Pipe Insulation: Refer to Section 23 07 00, HVAC Insulation.

2.02 MISCELLANEOUS PIPING PRODUCTS

A. Brazing Materials:

1. Except as otherwise indicated, provide 15 percent silver alloy brazing material for copper to copper and copper to brass fittings.
2. Comply with AWS A5.8M/A5.8 for brazing filler materials.

B. Refrigerant Specialties:

1. Refrigerant Suction Line Filter-Dryer:
   a. Provide steel shell, corrosion-resistant finish filter-dryer, with molded felt core with 10-micron particle retention, in size and working pressure indicated, with copper connectors, and access valve (not applicable for heat pump system).
   b. Operating Temperature Rating: 240 degrees F.
   c. Working Pressure: 500 psi.
   d. Provide size recommended by refrigeration equipment manufacturer.
2. Refrigerant Liquid Line Dryer:
   a. Provide refrigerant liquid line filter-dryer for all units.
   b. Operating Temperature Rating: 240 degrees F.
   c. Working Pressure: 500 psi.
   d. For heat pumps, provide biflow directional types (not required if included with air-conditioning equipment).
   e. Provide size recommended by refrigeration equipment manufacturer.

C. Refrigerant Valves:

1. Globe and Check Valves: Listed and labeled by an NRTL.
   a. Shutoff Valves:
      1) Forged brass, packed, back seating winged seal cap, 300 degrees F (140 degrees C) temperature rating 500 psi working pressure.
      2) Maximum Opening Pressure: 0.5 psig.
      3) Valve required only if shutoff service valves are not included with package air-conditioning equipment.
   b. Manufacturers:
      1) Henry Technologies.
      2) Parker Hannifin Corp.
2. Solenoid Valve: Listed and labeled by an NRTL.
   a. Two-Way Solenoid Valves: Forged brass, designed to conform to AHRI 760, normally closed, Teflon valve seat, NEMA 1 solenoid enclosure, 24 volts, 60-Hz, UL Listed, 1/2-inch conduit adapter, 250 degrees F (121 degrees C) temperature rating 500 psi working pressure.
   b. Provide valve only if recommended by air-conditioning equipment manufacturer.
   c. Manual Operator: Provide optional manual operator to open valve.
   d. Manufacturers:
      1) Alco Controls Div.; Emerson Electric Co.
      2) Automatic Switch Co.
      3) Parker Hannifin Corp.

3. Thermostatic Expansion Valve:
    a. Body Bonnet and Seal Cap: Forged brass or steel.
    b. Diaphragm, Piston, Closing Spring and Seat Insert: Stainless steel.
    c. Capillary and Bulb: Copper tubing filled with refrigerant.
    d. Suction Temperature: 40 degrees F.
    e. End Connections: Socket or flare.
    f. Working Pressure: 700 psig.
    g. Manufacturers:
        1) Henry Technologies.
        2) Parker Hannifin Corp.
        3) Danfoss Group Global.
4. Safety Relief Valve:
    a. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
    b. Seat Disk: Polytetrafluoroethylene.
    c. Working Pressure: 500 psig.
    d. Operating Temperature: 240 degrees F, maximum.
    e. Manufacturers:
        1) Henry Technologies.
        2) Parker Hannifin Corp.
        3) Danfoss Group Global.

D. Refer to Section 40 05 15, Piping Support Systems, for piping shields and piping support requirements.

PART 3 EXECUTION

3.01 INSTALLATION OF PIPING SYSTEM

A. Install piping products in accordance with manufacturer's written instructions, applicable requirements of ASME B31.5, ASHRAE 15, and in accordance with recognized industry practices to ensure products serve intended function.

B. Install dryers on liquid and suction lines.

C. Refrigerant Piping:

1. Cut pipe accurately to measurements established at Site and work into place without springing or forcing.
2. Install piping with sufficient flexibility to adequately provide for expansion and contraction as a result of temperature fluctuation inherent in its operation.
3. Where pipe passes through building structure, pipe joints shall not be concealed, but located where they may be readily inspected.
4. Run pipe to be insulated as shown and as required with sufficient clearance to permit application of insulation.
5. Run piping as shown on Drawings, taking care to avoid interference with other piping, conduit or equipment. Except where specifically

indicated otherwise, run piping plumb, and straight and parallel to walls and ceilings.

6. Trapping of lines shall not be permitted, except where indicated.
7. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
8. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
9. Install piping free of sags and bends.
10. Install fittings for changes in direction and branch connections.
11. Install refrigerant piping in protective conduit where installed belowground.
12. Install accumulator in suction line near condensing unit.
13. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
14. Slope refrigerant piping as follows:
    a. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
    b. Install horizontal suction lines with a uniform slope downward to compressor.
    c. Install traps and double risers to entrain oil in vertical runs.
    d. Liquid lines may be installed level.

D. Pipe Sleeves:

1. Provide pipe sleeves of suitable size for pipe and tubing that penetrate building structure.
2. Secure sleeves in position and location before and during construction. Space between pipe and sleeves, or between insulation and pipe sleeves, shall be not less than 1/4 inch between outside of pipe or insulation, and inside wall of sleeves.
3. Sleeves for uninsulated pipes shall have ends flush with finished wall surfaces; provide pipe or tubing as above with outside perimeter of pipe caulked to sleeve.
4. Extend sleeves for insulated pipes 1/2 inch from wall faces and caulk to sleeve on both sides.
5. Seal terminal ends of pipe insulation with mastic.
6. Extend sleeves for lines passing through floors 3 inches above finished floor slab and caulk to slab.
7. Seal penetrations through fire and smoke barriers according to Section 07 84 00, Firestopping.

E. Braze cap (seal) ends of piping when not connected to mechanical equipment.

3.02 SOLDER JOINTS

A. Solder joints shall not be used for joining refrigerant piping systems.

3.03 BRAZED JOINTS

A. Braze copper piping with silver solder complying with AWS A5.8M/A5.8.

B. Brazed Joints:

1. Construct joints according to AWS *Brazing Handbook* Chapter “Pipe and Tube”.
2. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
3. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

C. Inside of tubing and fittings shall be free of flux.

D. Clean parts to be joined with emery cloth and keep hot until solder has penetrated full depth of fitting and extra flux has been expelled.

E. Cool joints in air and remove flame marks and traces of flux.

F. During brazing operation, prevent an oxide film from forming on inside of tubing by slowly flowing dry nitrogen to expel air.

G. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion valve bulb.

3.04 PIPE HANGERS

A. Refer to Section 40 05 15, Piping Support Systems, for piping shields and piping support requirements.

3.05 EQUIPMENT CONNECTIONS

A. Connect refrigerant piping to mechanical equipment in the manner shown, and comply with equipment manufacturer’s instructions where not otherwise indicated.

3.06 FIELD QUALITY CONTROL

A. General:

1. Notify Engineer at least 48 hours before testing is performed.
2. Furnish equipment required for tests.
3. Group as many systems together as possible when testing in order to consolidate number of test inspections.

B. Leak Test:

1. Prior to initial operation, clean and test refrigerant piping in accordance with ASME B31.5.
2. Perform initial test with dry nitrogen to 300 psig minimum using soap solution to test joints.
3. Evacuate system after initial test and charge system with refrigerant or dry nitrogen, 20 percent refrigeration mixture to 600 psig minimum.
4. Upon completion of initial system test, test factory, as well as field, refrigerant piping joints with electronic-type leak detector to acquire a leak-tight refrigerant system.
    a. If leaks are detected, remove entire refrigerant charge for the system, replace defective pipe or fitting, and retest entire system as specified above.

C. Evacuation, Dehydration, and Charging:

1. After system is found to be without leaks, evacuate system using reliable gauge and vacuum pump capable of pulling a vacuum of at least 1-mm Hg absolute (29.88-inch Hg gage).
2. Evacuate system with vacuum pump until temperature of 35 degrees F (2 degrees C) is indicated on vacuum dehydration indicator.
3. During evacuation, apply heat to pockets, elbows, and low spots in piping.
4. Maintain vacuum on system for minimum of 12 hours after closing valve between vacuum pump and system. If system holds vacuum for 12 hours it is ready for charging.
5. Break vacuum with refrigerant gas or dry nitrogen gas, allowing pressure to build up to 2 psi (15 kPa).
6. Install new filter-dryer core in charging line.
7. Repeat evacuation procedure and complete charging of system; provide full operating charge.

3.07 ADJUSTING

A. General:

1. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
2. Adjust high-pressure and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
3. Adjust setpoint temperature of air-conditioning or chilled-water controllers to system design temperature.
4. Perform following adjustments according to manufacturer’s written instructions before operating refrigeration system:
    a. Open shutoff valves in condenser water circuit.
    b. Verify compressor oil level is correct.
    c. Open compressor suction and discharge valves.

d. Open refrigerant valves, except bypass valves that are used for other purposes.
e. Check open compressor-motor alignment and verify lubrication for motors and bearings.

B. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION

SECTION 23 31 13
METAL DUCTS AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Movement and Control Association (AMCA): 500, Test Methods for Louvers, Dampers and Shutters.
2. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Handbook.
3. American Society of Mechanical Engineers (ASME): A13.1, Scheme for the Identification of Piping Systems.
4. Association of the Nonwoven Fabrics Industry (INDA): IST 80.6, Water Resistance (Hydrostatic Pressure).
5. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A90/A90M, Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
   c. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   d. A176, Standard Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip.
   e. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   f. A480/A480M, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip.
   g. A568/A568M, Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for.
   h. A653/A653M, Standard Specifications for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   i. A700, Standard Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment.
   j. A924/A924M, Specification for General Requirements for Sheet Steel, Metallic-Coated by the Hot-Dip Process.
   k. A1008/A1008M, Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.

l. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High- Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
m. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
n. C423, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
o. C916, Standard Specification for Adhesives for Duct Thermal Insulation.
p. C1071, Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
q. C1139, Standard Specification for Fibrous Glass Thermal Insulation for Sound Absorbing Blanket and Board for Military Applications.
r. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
s. E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials.

6. National Air Duct Cleaners Association (NADCA): General Specifications for the Cleaning of Commercial Heating, Ventilation and Air Conditioning Systems.
7. National Fire Protection Association (NFPA):
   a. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
   b. 90B Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
   c. 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
   d. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
   e. 259, Standard Test Method for Potential Heat of Building Materials.
   f. 701, Standard Methods of Fire Tests for Flame Propagation of Textiles and Films.
8. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
   a. Duct Construction Standards.
   b. Guidelines for Seismic Restraints of Mechanical Systems.
   c. Fibrous Glass Duct Construction Standards.
   d. Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems.
   e. HVAC Air Duct Leakage Test Manual.
9. UL:
   a. 181, Standard for Safety Factory-Made Air Ducts and Connectors.
   b. 214, Standard for Tests for Flame-Propagation of Fabrics and Films.

c. 555, Standard for Safety Fire Dampers.
d. 555S, Standard for Safety Smoke Dampers.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. CFM: Cubic feet per minute.
2. FPM: Feet per minute.
3. PCF: Pounds per cubic foot.
4. WC: Water column.

B. Sealing Requirements: For the purpose of duct systems sealing requirements specified in this section, the following definitions apply:

1. Seams: Joining of two longitudinally (in direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on perimeter are deemed to be joints.
2. Joints, duct surface connections including:
   a. Girth joints.
   b. Branch and subbranch intersections.
   c. Duct collar tap-ins.
   d. Fitting subsections.
   e. Louver and air terminal connections to ducts.
   f. Access door, and access panel frames and jambs.
   g. Duct, plenum, and casing abutments to building structures.

1.03 SUBMITTALS

A. Action Submittals:

1. Product Data:
   a. Rectangular, Rigid Round, and Oval Ductwork:
      1) Schedules of duct systems, materials, joints, sealing, gage and reinforcement.
      2) SMACNA Figure Numbers for each shop fabricated item.
      3) Reinforcing details and spacing.
      4) Seam and joint construction details.
      5) Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.
   b. Ductwork Accessories:
      1) Manufacturer’s product data including catalog sheets, diagrams, standard schematic drawings, installation instructions and details, details of materials, construction, dimensions of individual components, and finishes, including the following items:
         a) Fittings and volume control damper installation (both manual and automatic) details.

b) Duct liner.
c) Sealing materials.
d) Dampers; include leakage, pressure drop, and maximum back-pressure data.
e) Duct-mounted access panels and doors.
f) Flexible ducts.
g) Sheet metal fasteners.

2. Duct Fabrication Drawings:
   a. Drawn after actual job measurements are obtained.
   b. Drawn to a scale not smaller than 1/4 inch equals 1 foot, on drawing sheets same size as Contract Drawings.
   c. Include the following features:
      1) Fabrication, assembly, and installation details including plans, elevations, sections, details of components, and attachments to other work.
      2) Duct layout, indicating pressure classifications, and sizes in plan view.
      3) For materials handling exhaust duct systems, indicate classification of materials handled.
      4) Duct material and thickness.
      5) Fittings and volume control damper installation (both manual and automatic) details.
      6) Reinforcing details and spacing.
      7) Seam and joint construction details.
      8) Penetrations through fire-rated and other partitions.
      9) Duct accessories and control devices such as automatic dampers, airflow monitors, terminal units, smoke detectors, regulators, air distribution devices, etc.
      10) Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.
      11) Fire and smoke damper installations, including sleeves and duct-mounted access door and panel installation.
      12) Coordination with ceiling suspension members.
      13) Spatial coordination with other systems installed in same space with duct systems.
      14) Coordination of ceiling- and wall-mounted access doors and panels required for access to dampers and other operating devices.
      15) Coordination with ceiling-mounted lighting fixtures, air outlets, and inlets.
      16) Coordination of ductwork with sprinkler piping and other mechanical and electrical services, and equipment.

B. Informational Submittals:

1. Record Drawings: Include duct systems routing, fittings details, and installed accessories and devices.

1.04 QUALITY ASSURANCE

A. Industry Standards:

1. Unless otherwise indicated or specified, sheet metal ductwork shall be constructed and installed in accordance with SMACNA Duct Construction Standards relevant to ductwork system being provided. These standards are herein referenced as the SMACNA Manual, unless otherwise indicated.
2. Comply with ASHRAE Fundamentals Handbook recommendations, except as otherwise indicated.
3. NFPA Compliance: NFPA 90A and NFPA 90B.

B. Manufacturers: Firms regularly engaged in manufacture of ductwork products of types, materials, and sizes required, whose products have been satisfactorily used in similar service for not less than 5 years.

C. Suppliers of duct and fitting components shall provide on request the following information:

1. Laboratory performance data for duct, including leakage rate, bursting strength, collapse strength, seam strength, and pressure loss.
2. Laboratory performance data for fittings, including zero-length dynamic losses.

D. Installer shall be a firm with at least 3 years' experience of successful installation on ductwork systems similar to that required for this Project.

E. Changes or alterations to layout or configuration of duct system shall be:

1. Specifically approved in writing by Engineer.
2. Proposed layout shall provide original design results, without increasing system total pressure.

1.05 EXTRA MATERIALS

A. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect ductwork from dirt, water, and debris. During storage on Job Site, keep ends of ductwork covered to prevent foreign objects and water from entering ductwork.

B. If fabricated sound-lined ductwork or ductboard gets wet during installation, remove and dispose of ductwork from the Site.

C. Deliver sealant materials to Site in original unopened containers labeled with manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.

D. Store and handle sealant materials in compliance with manufacturers' recommendations to prevent deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

E. Deliver and store stainless steel sheets with mill-applied adhesive protective paper, maintained through fabrication and installation.

PART 2 PRODUCTS

2.01 SCHEDULES

A. Ductwork Schedule: Refer to Drawings.

2.02 GENERAL

A. Specified components of this ductwork system, including facings, mastics, and adhesives, shall have fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke developed, as per test conducted in accordance with ASTM E84 and NFPA 255 methods.

B. Internally Lined Ductwork: Duct sizes indicated for internally lined ducts are the clear inside dimensions, and shall be increased in both dimensions by twice the thickness of the liner.

C. Ductwork thinner than 26-gauge will not be allowed.

D. Ductwork Interior Surfaces:

1. Smooth.
2. No sheet metal parts, tabs, angles, or other items may project into air ducts, unless otherwise specified.
3. Seams and joints shall be external.
4. For ductwork that is required to be reinforced, use only external reinforcing.

2.03 SHEET METAL MATERIALS

A. Construct metal duct systems from galvanized steel, aluminum and Type 316 stainless steel per design drawing.

B. Where no specific ductwork materials are indicated in Specifications or on Drawings, galvanized steel sheet metal shall be basis of Contract.

C. Galvanized Steel Ductwork:

1. Comply with ASTM A653/A653M and ASTM A924/924M.
2. Product Name: Steel sheet, zinc-coated (galvanized steel).
3. Sheet Designation: CS Type B.
4. Applicable Specification: ASTM A653/A653M.
5. (Zinc) Coating Designation: G90.
6. Coating designation in accordance with Test Method A, ASTM A90/A90M. and ASTM A924/A924M.
7. Provide mill-phosphatized finish for ducts exposed to view and for ducts scheduled to be painted.
8. Provide sheet metal packaged and marked as specified in ASTM A700.

D. Aluminum Ductwork:

1. Comply with ASTM B209.
2. Aluminum Sheet: Alloy 3003-H14, unless indicated otherwise.
3. Aluminum Connectors and Bar Stock: Alloy 6061-T6 or equivalent.

E. Stainless Steel Ductwork:

1. Comply with ASTM A167, ASTM A176, ASTM A240/A240M, and ASTM A480/A480M.
2. Stainless Steel Sheet: Type 316, unless indicated otherwise.
3. Gauge shall comply with SMACNA manual, unless specified otherwise.
4. Finish: No. 2 B (cold-rolled, bright) finish, except as otherwise noted.

F. Exposed Ductwork: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, oil canning, stains, discoloration, and other imperfections, including those which would impair painting.

G. Reinforcement Shapes and Plates: Unless otherwise indicated, provide reinforcements of same material as ductwork.

2.04 DUCT SEALING MATERIALS

A. General: The term sealant used here is not limited to materials of adhesive or mastic nature, but also includes tapes and combinations of open weave fabric strips and mastics.

B. Adhesives, Cements, Sealant, and Installation Accessories: As recommended by duct manufacturer for application.

C. Solvent-based Sealants:

1. Ultraviolet light resistant.
2. Mildew resistant.
3. Flashpoint: Greater than 70 degrees F, SETA CC.
4. Manufacturers and Products:

a. Hardcast, Inc.; Versagrip 102.
b. Rectorseal; AT-33.
c. Childers CP-140.

D. Water-based Sealants:

1. Listed by manufacturer as nonflammable in wet and dry state.
2. Manufacturers and Products:
   a. Foster; Series 32.
   b. Childers; CP-145A, 146.
   c. Rectorseal; Airlok 181.

2.05 FIRESTOPPING

A. Refer to Section 07 84 00, Firestopping.

2.06 DUCTWORK FASTENERS

A. General:

1. Rivets, bolts, or sheet metal screws.
2. Ductwork fasteners shall be same metal as duct being supported, unless otherwise noted.

B. Self-Drilling Screws:

1. Galvanized Steel Ductwork System: Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated carbon steel with zinc electroplated finish.
2. Aluminum Ductwork System:
   a. Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated Type 410 stainless steel, complete with bonded metal and fiber washer for dielectric separation.
   b. Manufacturers:
      1) DB Building Fasteners Inc., Santa Fe Springs, CA.
      2) Clark Craft Fasteners, Tonawanda, NY.

2.07 DUCTWORK PRESSURE CLASS

A. Construct duct systems to pressure classifications indicated in Ductwork Schedule.

B. Where no specific duct pressure designations are indicated in Specifications or on Drawings, 4-inch WC pressure class shall be basis of Contract.

2.08 RECTANGULAR DUCTWORK

A. Fabricate rectangular ducts in accordance with SMACNA unless specified otherwise.

B. Crossbreaking or Cross Beading: Crossbreak or bead duct sides that are 19 inches and larger and are 20-gauge or less, with more than 10 square feet of unbraced panel area, as indicated in SMACNA Manual, unless they are lined or are externally insulated.

C. Air Handling Unit Discharge Ductwork: Ductwork extending from air handling units up to and including first elbow shall be constructed of 16-gauge, minimum sheet metal, same material as remainder of system.

2.09 RECTANGULAR DUCTWORK FITTINGS

A. Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA Rectangular Industrial Duct Construction Standards.

B. Elbows:

1. Fit square-turn elbows with vane side rails.
2. Shop fabricate double-blade turning vanes of same material as ductwork.
3. Fabricate with equal inlet and outlet.
4. Rectangular radius elbows with inside radius of 3/4 of duct width in direction of turn.
5. Manufacturers and Products:
   a. Elgen; A: All-Tight.
   b. Duro-Dyne; C: Type TR.

2.10 RECTANGULAR DUCTWORK BRANCH CONNECTIONS

A. Branch duct connections to rectangular duct mains shall be made using factory fabricated fittings with spot welded tap to main duct connections.

2.11 RECTANGULAR DUCTWORK INSULATION LINER

A. Location: Provide ductwork with internal insulation liner where indicated on Drawings or in Ductwork Schedule.

B. Material:

1. Fiberglass, nominal 1.5 pcf density liner, K factor 0.25 maximum at 75 degrees F mean.
2. Black composite coating on surface exposed to airstream to prevent erosion of glass fibers, for temperatures to 250 degrees F.

3. Liquid water repellency rating not less than 4.0 when tested in accordance with INDA IST 80.6.
4. Potential heat value not exceeding 3,500 Btu per hour per pound when tested in accordance with NFPA 259 and meeting classification of "Limited Combustible" as defined by NFPA 90A.
5. Maximum rated velocity not less than 6,000 fpm when tested in accordance with ASTM C1071.
6. Resistant to microbial growth using a "no-growth criteria" when tested in accordance with ASTM C1139.
7. Manufacturers and Products:
   a. CertainTeed; Toughgard.
   b. Johns Manville; Linacoustic RC.
   c. Knauf; Duct Liner M.

C. Thickness: Minimum 1 inch or greater thickness where indicated on Drawings or Ductwork Schedule.

D. R-value: Minimum 4.2 hours foot squared degrees F per Btu or greater, where indicated on Drawings or Ductwork Schedule.

E. Liner Adhesive: In accordance with NFPA 90A and ASTM C916.

F. Mechanical Fasteners:

1. Same material as ductwork, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct.
2. Provide fasteners that do not damage liner when applied as recommended by manufacturer, that do not cause leakage in duct, and will indefinitely sustain 50-pound tensile dead load test perpendicular to duct wall.
3. Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.
4. Adhesive for Attachment of Mechanical Fasteners: In accordance with Fire Hazard Classification of duct liner system.

G. Liner Application:

1. Ductwork liner shall be applied at time of ductwork manufacture in an approved sheet metal workshop.
2. Adhere single layer of indicated thickness of duct liner with 90 percent coverage of adhesive at liner contact surface area. Multiple layers of insulation to achieve indicated thickness is prohibited.
3. Apply coat of adhesive to liner facing in direction of airflow not receiving metal nosing.
4. Butt transverse joints without gaps and coat joint with adhesive.
5. Fold and compress liner in corners of rectangular ducts or cut and fit to assure butted edge overlapping.
6. Longitudinal Joints:

a. Shall not occur except at corners of ducts, unless size of duct and standard liner product dimensions make longitudinal joints necessary.
b. Apply adhesive coating on longitudinal seams in ducts exceeding 2,500 fpm air velocity.

7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely around perimeter, at 3 inches from transverse joints, and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing airstream with metal nosing that are either channel or "Z" profile or are integrally formed from duct wall at the following locations:
   a. Fan discharge.
   b. Intervals of lined duct preceding unlined duct.
   c. Upstream edges of transverse joints in ducts.
9. Seal insulation edges.
10. Repair abrasions or tears with mastic.

2.12 RIGID ROUND DUCTWORK

A. Construct rigid round ducts in accordance with SMACNA Round Industrial Duct Construction Standards, unless specified otherwise.

B. Basic Round Diameter: As used in this Article, is inside diameter of size of round duct.

C. Where space limitations prevent use of round duct or where shown on Drawings, provide ductwork of flat oval construction hydraulically equivalent to round ductwork.

D. Fabricate round ducts with spiral seam construction, except where diameters exceed 72 inches. Fabricate ducts having diameters greater than 72 inches with longitudinal butt-welded seams.

E. Ductwork seams of Snaplock type shall not be used.

2.13 RIGID ROUND DUCTWORK FITTINGS

A. Construct rigid round ductwork fittings in accordance with SMACNA Round Industrial Duct Construction Standards, unless otherwise specified.

B. 90-degree Tees, Laterals, and Conical Tees: Fabricate to conform to SMACNA manual with metal thicknesses specified for longitudinal seam straight duct.

C. Diverging Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from body onto branch tap entrance.

D. Elbows:

1. Fabricate in stamped (die-formed), pleated, or segmented (gored) construction 1.5 times elbow diameter. Two piece segment elbows are not allowed, except with turning vanes.
2. Segmented Elbows: Fabricate with welded construction.
3. Round Elbows 8 Inches and Smaller:
   a. Stamped elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees configuration.
   b. Fabricate nonstandard bend angle configurations or nonstandard sized (for example, 3-1/2 and 4-1/2 inches) elbows with segmented construction.
4. Round Elbows 9 through 14 Inches:
   a. Segmented or pleated elbows for 30, 45, 60, and 90 degrees.
   b. Fabricate nonstandard bend angle configurations or nonstandard sized (for example, 9-1/2 and 10-1/2 inches) elbows with segmented construction.

2.14 ROUND DUCTWORK BRANCH CONNECTIONS

A. Branch duct connections (taps) to round duct mains shall be made using factory fabricated fittings.

B. Field installed taps are not acceptable.

2.15 DUCTWORK HANGERS AND SUPPORTS

A. General:

1. Attachments, hangers, and supports for ductwork shall be in accordance with SMACNA Manual referenced for type of duct system being installed.
2. Duct hanging system shall be composed of three elements; upper attachment to building, hanger itself, and lower attachment to duct.
3. Wire hangers are not acceptable.
4. Hanger Spacing:
   a. Ducts Up to 60 inches in Largest Dimension: 10 feet, maximum.
   b. Ducts Over 61 inches in Largest Dimension: 8 feet, maximum.

B. Construction Materials: Supporting devices including, but not limited to, angles used for support and bracing, baseplates, rods, hangers, straps, screws, bolts shall be as follows:

1. Aluminum Ductwork Indoors and Outdoors:
   a. Carbon steel, hot-dipped galvanized after fabrication.
   b. Non-metallic pad between lower attachment and ductwork, to achieve dielectric separation.

C. Building Attachments:

1. Concrete inserts, powder-actuated fasteners, or structural steel fasteners appropriate for building materials.
2. Do not use powder-actuated concrete fasteners for lightweight aggregate concrete or for slabs less than 4 inches thick.
3. Upper Attachment (Concrete):
   a. Drive pin fastener and expansion nail anchor may be used for ducts up to 18-inch maximum dimension.
   b. Threaded stud fastener may be used for ducts up to 36-inch maximum dimension.
   c. Concrete attachments shall be made of steel.

D. Duct Fasteners: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials and conforming to requirements of Article Ductwork Fasteners.

E. Trapeze and Riser Supports: Steel shapes conforming to ASTM A36/A36M, hot-dipped galvanized after fabrication.

2.16 DUCTWORK FLEXIBLE CONNECTIONS

A. General:

1. Factory fabricated metal-edged fabric flexible connectors for commercial or industrial applications.
2. Sheet metal permanently secured to fabric with double fabric fold, double metal crimp.
3. Comply with NFPA 90A and NFPA 90B requirements.
4. Airtight and waterproof.

B. Materials:

1. Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
2. Metal Edges: Construct from same material as ductwork, unless otherwise noted.
3. Fabric:
   a. Comply with NFPA 701 or UL 214 (except Teflon-coated).
   b. Woven polyester or nylon for most applications.
   c. Woven fiberglass for high temperature applications.
   d. Coating: Neoprene.

C. Construction:

1. Fold and crimp metal edge strips onto fabric as illustrated in SMACNA Manual.

2. Standard Metal Edged Connectors: Strip of fabric 3 inches wide attached to two strips of 3-inch-wide sheet metal.
3. Wide Metal Edged Connectors: Strip of fabric 4 inches wide attached to two strips of 4-inch-wide sheet metal.
4. Extra Wide Metal Edged Connectors: Strip of fabric 6 inches wide attached to two strips of 6-inch-wide sheet metal.

D. Manufacturers:

1. Ductmate; PROflex, Commercial.
2. Ventfabrics.
3. Duro-Dyne.

2.17 DUCT INSPECTION DOORS

A. General:

1. Insulated, gasketed, and at least 15 inches by 15 inches when duct dimensions are large enough.
2. On ductwork where largest side dimension is less than 16 inches, furnish inspection doors at least 8 inches by 8 inches.
3. Complete with necessary hardware and either Amerlock 10 or Ventlock No. 100 latches, and Ventlock Series No. 100 hinges.
4. Fabricated of same material as ductwork.

B. Round Spin-in Type Access Doors:

1. Size: 18-inch and 24-inch diameter will be acceptable in lieu of comparable size square or rectangular access doors specified herein.
2. Complete with insulation, spin-in frame, inner door, attachment cable, gaskets, three latches, and pull ring.
3. Manufacturer and Product: Flexmaster; Inspector Series.

C. Casing and Plenum Access Doors:

1. Size: 57 inches high by 24 inches wide minimum where possible.
2. Complete with hardware, hinges, seals, and latch handles.
3. Latch Handles: Ventlock, Series No. 260.
4. Hinges: Ventlock, Series No. 200 and No. 300.

D. Manufacturers:

1. Ventlok.
2. Duro-Dyne.
3. Flexmaster.

2.18 MANUAL DAMPERS

A. Butterfly Manual Dampers:

1. Fabricate from two gauges heavier than duct in which installed, of same material as ductwork.
2. Align operating handle with damper blade.
3. Provide 2-inch standoff bracket for insulated duct systems.
4. Damper Manufacturers:
   a. Ruskin.
   b. American Warming and Ventilating.
5. Operator Manufacturers:
   a. Accessible Ductwork: Ventlok; Type 620 or 635.
   b. Accessible Insulated Ductwork: Ventlok; Type 639.
   c. Concealed Ductwork: Ventlok; Type 677 with extended operating rod and concealed regulator with plain cover.

B. Manual Opposed-blade Balancing Dampers:

1. Externally operated gang airfoil, damper blades.
2. Fabricate from same material as ductwork.
3. Stainless steel or nylon sleeve bearings.
4. Construction shall have interlocking edges and maximum 10-inch blade width.
5. Manufacturers and Products:
   a. Ruskin; CD102.
   b. American Warming and Ventilating; Model VC-31.

2.19 BACK DRAFT DAMPERS (BD)

A. General: Damper pressure drop ratings shall be based on tests and procedures performed in accordance with AMCA 500.

B. Aluminum, Counterbalanced, Heavy-duty:

1. Fabrication:
   a. Frame: 2-1/4 inches by minimum 0.125 inch 6063-T5 extruded aluminum channel with front flange and galvanized steel braces at mitered corners.
   b. Blades:
      1) Style: Single piece, overlap frame.
      2) Action: Parallel.
      3) Orientation: Horizontal.
      4) Material: Minimum 0.070-inch 6063-T5 extruded aluminum.
      5) Width: Maximum 6 inches.
   c. Bearings: Corrosion-resistant, long-life, synthetic, formed as single piece with axles.

d. Blade Seals: Extruded vinyl, mechanically attached to blade edge.
e. Linkage: Minimum 1/2-inch aluminum tie bar with stainless steel pivot pins mounted on blades.
f. Axles: Corrosion-resistant, long-life, synthetic, locked to blade and formed as single piece with bearings.
g. Counterbalances: Adjustable zinc plated steel weights mechanically attached to blade enabling damper to operate over wide range of pressures.
h. Mounting:
1) Suitable for mounting in vertical, horizontal airflow up, and horizontal airflow down positions.
2) Configured for positions as shown on Drawings.
i. Finish: Factory applied air-dried epoxy paint on all damper parts.

2. Performance Data:
a. Temperature Rating: Withstand minus 40 to 200 degrees F.
b. Maximum Back Pressure: 16-inch WC.
c. Maximum Air Velocity: 2,500 fpm.
d. Operation of Blades:
1) Start to Open: 0.01-inch WC.
2) Fully Open: 0.05-inch WC.
e. Pressure Drop: Maximum 0.15-inch WC at 1,500 fpm through 24-inch by 24-inch damper.

3. Accessories:
a. Duct Transition Connection: Rectangular.
b. Factory Sleeve: Minimum 20-gauge thickness, minimum 12-inch length.
c. Screen:
1) Type: Insect.
2) Location: Front with sleeve.
3) Material: Aluminum.

4. Manufacturer and Product: Ruskin; Model CBD6.

2.20 CONTROL DAMPERS

A. Refer Section 23 09 13, HVAC Controls, Field Components, and Instruments, for requirements.

2.21 DUCT INSULATION

A. Refer to Section 23 07 00; HVAC Insulation.

2.22 MISCELLANEOUS ACCESSORIES

A. Louver and Grille Blank-off Sections:

1. Fabricate from 20-gauge sheets of same material as louver/grille.
2. Line with sound attenuation/insulating material.

3. Shop-prime and paint outside face of blank-off section with two coats of flat black exterior paint.

B. Auxiliary Drain Pans:

1. Dimensions: Minimum 6 inches larger in both dimensions than equipment it is serving and 2 inches high, minimum.
2. Construction: 16-gauge stainless steel with welded joints. Pans shall be watertight and have hemmed edges.
3. Drain Connection:
   a. Minimum 1-inch IPS or as shown on Drawings.
   b. Locate at lowest point of drain pan.
   c. In lieu of drain connection, float switch may be installed. Float switch shall shut down air handling equipment upon sensing water.

C. Prefabricated Roof Curb: Refer to Section 07 70 01, Roof Specialties and Accessories.

D. Accessories Hardware:

1. Instrument Test Holes:
   a. Cast metal, material to suit duct material, including screw cap and gasket and flat mounting gasket.
   b. Size to allow insertion of pitot tube and other testing instruments.
   c. Provide in length to suit duct insulation thickness.
2. Flexible Duct Clamps:
   a. Stainless steel band with cadmium-plated hex screw to tighten band with worm-gear action.
   b. Provide in sizes from 3 inches to 18 inches to suit duct size.
3. Adhesives: High strength, quick setting, neoprene based, waterproof and resistant to gasoline, and grease.

PART 3 EXECUTION

3.01 GENERAL INSTALLATION

A. Miscellaneous:

1. Install sheet metal ductwork and flexible ductwork in accordance with SMACNA Manual, NFPA 90A, and NFPA 90B.
2. Install ductwork using manufacturer’s recommended adhesives, cement, sealant, and insulation accessories.
3. Align ductwork accurately at connections, within 1/8-inch misalignment tolerance and with internal surfaces smooth.
4. Interface Between Ductwork and Louvers: At locations where ductwork is connected to louver for either intake or exhaust purposes, ductwork

shall be installed, sloped, and connected to louver so water entering ductwork system positively drains back to and out of louver.

B. Ductwork Location:

1. Locate ductwork runs vertically and horizontally, unless otherwise indicated.
2. Avoid diagonal runs wherever possible.
3. As indicated by diagrams, details, and notations or, if not otherwise indicated, run ductwork in shortest route that does not obstruct usable space or block access for servicing building and equipment.
4. In general, install as close to bottom of structure as possible.
5. For ductwork concealed above ceiling, maximize clearance between bottom of ductwork and top of ceiling construction.
6. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
7. Ductwork that must transition and drop below piping or other ductwork shall be transitioned back to bottom of structure immediately adjacent to obstruction.

C. Penetrations:

1. Provide duct sleeves or prepared openings for duct mains, duct branches, and ducts passing through roofs, walls and ceilings.
2. Clearances:
   a. For uninsulated ducts, allow 1-inch clearance between duct and sleeve, except at grilles, registers, and diffusers.
   b. For insulated ducts, allow 1-inch clearance between insulation and sleeve, except at grilles, registers, and diffusers.
3. Closure Collars:
   a. Minimum 4 inches wide on each side of walls or floors where sleeves or prepared openings are installed.
   b. Fit collars snugly around ducts and insulation.
   c. Same gauge and material as duct.
   d. Grind edges of collar smooth to preclude tearing or puncturing insulation covering or vapor barrier.
   e. Use fasteners with maximum 6-inch centers on collars.
4. Packing: Mineral fiber in spaces between sleeve or opening and duct or duct insulation.

D. Concealment:

1. Wherever possible in finished and occupied spaces, conceal ductwork from view by locating in mechanical shafts, hollow wall construction, or above suspended ceiling.
2. Do not encase horizontal runs in solid partitions, except as specifically shown.

3. Limit clearance to 1 inch where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any.

E. Coordination with Other Trades:

1. Coordinate duct installation with installation of accessories, dampers, coil frames, equipment, controls, and other associated work of ductwork system.
2. Ductwork shall be configured, positioned, and installed to permit installation of light fixtures as indicated on Drawings.
3. Coordinate ductwork layout with suspended ceiling, lighting and sprinkler head layouts and similar finished work.
4. Electrical Equipment Spaces: Do not run ductwork through transformer vaults and other electrical equipment spaces and enclosures.

3.02 RECTANGULAR DUCTWORK

A. General:

1. Where possible, install ductwork so seams and joints will not be cut for installation of grilles, registers, or ceiling outlets.
2. If cutting of seams or joints is unavoidable, reinforce cut portion to original strength.

B. Low-pressure Taps:

1. Use bell mouth or conical fittings with integral locking quadrant damper. Spin-in fitting shall be sealed at duct tap with a gasket or sealed with sealant as specified for medium pressure ductwork.
2. Determine location of spin-in after outlet location is determined.
3. Fitting shall be securely attached to shaft to prevent damper from rotating around shaft.

C. Fittings:

1. Use bell-mouth or conical tee fittings for round duct takeoffs from rectangular mains.
2. Use 45-degree entry fittings conforming to SMACNA requirements for rectangular takeoffs from rectangular or round mains.
3. Make offsets with maximum angle of 45 degrees.
4. Use fabricated fittings for changes in directions, changes in size and shape, and connections.

D. Rectangular Ductwork Transverse Joints:

1. Install each run with a minimum of joints.
2. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.

3. Mechanical Joint Option:
    a. Construct transverse joints with Ductmate 25/35 duct connector systems, Ductmate W.D.C.I. Heavy/Lite duct connector systems, or Ductlok J/E duct connector system. Slip-on duct flange connectors shall have integral sealant pocket with permanently flexible sealant.
    b. When using Ductmate W.D.C.I. Heavy/Lite system, construct ductwork in accordance to the Ductmate W.D.C.I. Heavy J and Light H Assembly Manual and Duct Construction Standards.
    c. When using Ductlok J/E duct connector system, construct ductwork in accordance with Ductlok's Rectangular Duct Construction Manual for Low, Medium, and High Pressure.
    d. For longitudinal seams, use Pittsburgh lock seam sealed internally with permanently elastic sealer such as Ductmate 5511M mastic.
    e. Conform to SMACNA Class A sealing requirements.

3.03 RIGID ROUND OR OVAL DUCTWORK

A. General: Except where interrupted by fittings, install round ducts in lengths as long as possible to minimize joints.

B. Rigid Round or Oval Ductwork Joints:

1. Rigid round ductwork joints shall be in accordance with SMACNA Round Industrial Duct Construction Standards, unless otherwise specified.
2. Single- and Double-wall Supply and Return System Joints:
    a. Less than 36 Inches: Slip coupling.
    b. 36 Inches and Larger: Flanged connector, Van Stone, or welded companion flange type.
3. Single- and Double-wall Exhaust and Return System Joints:
    a. Spiral Seam Duct: Welded flanged connector.
    b. Longitudinal Seam Duct: Van Stone flange connector.

3.04 DUCTWORK HANGERS AND SUPPORTS

A. Install ductwork with support systems in accordance with SMACNA Manual, unless otherwise noted.

B. Support ducts rigidly with suitable ties, braces, hangers, and anchors of type, which will hold ducts true-to-shape and to prevent buckling.

C. Install additional bracing on ductwork as required, to prevent ballooning or breathing.

D. Support horizontal ducts within 2 feet of each elbow and within 4 feet of each branch intersection.

E. Support vertical ducts at maximum interval of 16 feet and at each floor.

F. Upper attachments to structures shall have allowable load not exceeding 1/4 of failure (proof test) load but are not limited to specific methods indicated.

G. In new construction, install concrete insert prior to placing concrete.

3.05 FLEXIBLE CONNECTIONS

A. Flexible Collars and Connections:

1. Use between fans and ducts.
2. For round ducts, securely fasten flexible connections by zinc-coated steel clinch-type draw bands.
3. For rectangular ducts, lock flexible connections to metal collars.

3.06 DAMPERS

A. General:

1. Inspection:
   a. Inspect areas to receive dampers.
   b. Notify Engineer of conditions that would adversely affect installation or subsequent utilization of dampers.
   c. Do not proceed with installation until unsatisfactory conditions are corrected.
2. Install dampers at locations indicated on Drawings and in accordance with manufacturer's installation instructions.
3. Install square and level.
4. Handle damper using sleeve or frame. Do not lift damper using blades or jack-shaft.
5. Damper blades and hardware shall operate freely without obstruction.
6. Damper blades and hardware that bind within frame or obstructed by adjacent construction will not be acceptable.
7. When installed, damper frames shall be gasketed or caulked to eliminate leakage between duct and damper frames.
8. Head and sill shall have stops.
9. Suitable for installation in mounting arrangement shown.
10. Do not compress or stretch damper frame into duct or opening.

B. Manual Dampers:

1. Provide balancing dampers for grilles and diffusers in branch duct as near main as possible.
2. Add or remove balancing dampers as requested by air balancing firm for necessary control of air.

C. Back Draft Dampers:

1. Install dampers square and free from racking with blades running horizontally.
2. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Install bracing as needed.

3.07 ACCESS DOORS

A. Ductwork: Install access doors in ductwork, in accordance with manufacturer's instructions, at each:

1. Duct-mounted fire damper.
2. Duct-mounted smoke or ionization detector.
3. Motorized damper.
4. Sail switch.
5. Turning vane.
6. Volume damper.
7. Automatic damper.
8. Temperature controller.

3.08 DUCT INSULATION

A. Refer to Section 23 07 00; HVAC Insulation.

3.09 MISCELLANEOUS ACCESSORIES

A. Auxiliary Drain Pans:

1. Under equipment for which pan is shown on Drawings and under all horizontal air handling units located above ceilings and piping located in ceiling space directly above computer facility areas; furnish and install auxiliary drain pans.
2. Route drain lines to nearest floor or hub drain independent of any other drain.
3. Slope drain pans toward drain connection to promote drainage.

B. Louver and Grille Blank-off Sections: Attach airtight to louver or grille and install to allow for easy removal.

C. Prefabricated Roof Curb: Refer to Section 07 70 01, Roof Specialties and Accessories.

D. Inspection Plates and Test Holes:

1. Where required in ductwork for balance measurements.
2. Test holes shall be airtight and noncorrosive with screw cap and gasket.
3. Extend cap through insulation.

3.10 DUCT SEALING

A. Seal duct seams and joints as indicated on Ductwork Schedule.

B. If no specific duct sealing requirements are specified, requirements of SMACNA manual shall govern.

C. Seal externally insulated ducts prior to insulation installation.

D. Provide additional duct sealing as required to comply with Article Ductwork Leakage Testing.

E. Seal all audible leaks.

3.11 DUCTWORK LEAKAGE TESTING

A. General:

1. Tests shall be conducted on completed ductwork systems.
2. Testing of partial installations or limited sections of ductwork will not be acceptable.
3. All ductwork leakage test procedures and results shall be submitted to Engineer for review.
4. Engineer shall retain the right to witness some or all ductwork leakage testing procedures.
5. Contractor shall notify Engineer in writing at least 5 working days prior to ductwork testing.

B. Leakage Criteria: Assemble and install ductwork with maximum leakage limited as indicated in Ductwork Schedule.

C. Leakage Testing Method:

1. Contractor shall be responsible for providing all necessary test fans and calibrated measuring devices to accomplish ductwork leakage test and to demonstrate that ductwork systems leakage rate is less than maximum rate specified.
2. Pressure testing shall be accomplished using a pressure blower with a calibrated orifice and manometer.
3. Blower shall maintain system design static pressure during test.
4. Perform testing in accordance with procedures given in SMACNA HVAC Air Duct Leakage Test Manual.

3.12 BALANCING OF AIR SYSTEMS

A. Perform air balancing in accordance with requirements of Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

3.13 PROTECTION OF INSTALLED WORK

A. Open ends of installed ductwork systems shall be covered to prevent dust, foreign objects and water from entering ductwork.

B. Ductwork systems shall not be used for air conveyance until adequate air filtration devices are installed in air handling equipment, to prevent ingress of construction dust.

3.14 CLEANING

A. Ductwork shall be cleaned of rust, dust, and debris, both internally and externally, before placing in operation.

B. Before installing air outlets, use air handler to blow dry air through entire system at maximum attainable velocity. Provide temporary air filters for this operation.

C. If duct systems are found to contain construction debris at time of construction completion Contractor shall provide complete ductwork system cleaning in accordance with NADCA Standards.

END OF SECTION

SECTION 23 34 00
HVAC FANS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Acoustical Society of America (ASA): S2.19, Mechanical Vibration—Balance Quality Requirements of Rigid Rotors—Part 1, Determination of Permissible Residual Unbalance.
2. Air Movement and Control Association International (AMCA):
   a. 99, Standards Handbook.
   b. 201, Fans and Systems.
   c. 203, Field Performance Measurement of Fan Systems.
   d. 210, Laboratory Methods of Testing Fans for Rating.
   e. 300, Reverberant Room Method for Sound Testing of Fans.
   f. 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
3. American Bearing Manufacturers Association (ABMA): 9, Load Ratings and Fatigue Life for Ball Bearings.
4. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
   a. 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
   b. HVAC Applications Handbook.
5. ASTM International (ASTM):
   a. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
   b. D2247, Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity.
   c. D2794, Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
   d. D3363, Standard Test Method for Film Hardness by Pencil Test.
   e. D4167, Standard Specification for Fiber-Reinforced Plastic Fans and Blowers.
   f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
6. National Electrical Manufacturers Association (NEMA).
7. National Fire Protection Association (NFPA): 45, Fire Protection for Laboratories Using Chemicals.
8. Occupational Safety and Health Administration (OSHA).

9. Society for Protective Coatings (SSPC):
    a. SP 3, Power Tool Cleaning.
    b. SP 5, White Metal Blast Cleaning.
    c. SP 6, Commercial Blast Cleaning.
    d. SP 10, Near-White Blast Cleaning.
10. UL: 507, Electric Fans.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. AC: Alternating current.
2. CISD: Chemical industry, severe-duty.
3. dB: Decibel.
4. DWDI: Double width, double inlet.
5. FRP: Fiberglass-reinforced plastic.
6. hp: Horsepower.
7. ODP: Open drip proof.
8. SWSI: Single width, single inlet.
9. TEFC: Totally enclosed, fan cooled.
10. UV: Ultraviolet.
11. XP: Explosion proof.

1.03 SUBMITTALS

A. Action Submittals:

1. Provide for all products specified, as follows:
    a. Identification as referenced in Contract Documents.
    b. Manufacturer's name and model number.
    c. Descriptive specifications, literature and drawings.
    d. Dimensions and weights.
    e. Fan sound power level data (reference 10 to power minus 12 watts) at design operating point.
    f. Fan Curves:
        1) Performance Curves Indicating:
            a) Relationship of flow rate to static pressure for various fan speeds.
            b) Brake horsepower curves.
            c) Acceptable selection range (surge curves, maximum revolutions per minute, etc).
            d) Static pressure, capacity, horsepower demand and overall efficiency required at the duty point, including drive losses.
        2) For variable air volume applications, indicate operating points at 100, 80, 60 and 40 percent of design capacity on fan curves including data to indicate effect of capacity

control devices such as inlet vanes on flow, pressure and brake horsepower.

g. Capacities and ratings.
h. Construction materials.
i. Fan type, size, class, drive arrangement, discharge, rotation, and bearings.
j. Wheel type, diameter, revolutions per minute, and tip speed.
k. Motor data.
l. Power and control wiring diagrams, including terminals and numbers.
m. Vibration isolation.
n. Factory finish system.
o. Color selection charts where applicable.
p. Corrosion protection coating product data.
q. Fiberglass Material: Statement of resins and reinforcing proposed for use.

2. "Or-equal" Equipment:
   a. Where submitted equipment results in change to fan inlet or outlet ductwork configuration shown on Drawings, submit system effect factor calculations indicating increased static pressure requirements as described in AMCA 201.
   b. Where submitted equipment results in change to ductwork and equipment configuration shown on Drawings, submit detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement to equipment furnished.

B. Informational Submittals:

1. Recommended procedures for protection and handling of products prior to installation.
2. Manufacturer's installation instructions.
3. Manufacturer's Certificate of Compliance in accordance with Section 01 43 33, Manufacturers' Field Services, for the following:
   a. Motors specified to be premium efficient type.
   b. FRP fans.
4. Manufacturers' Certificate of Proper Installation in accordance with Section 01 43 33, Manufacturers' Field Services.
5. Test reports.
6. Operation and maintenance data in conformance with Section 01 78 23, Operation and Maintenance Data. Include as-built version of equipment schedules.

1.04 QUALITY ASSURANCE

A. Performance Ratings: Tested in accordance with AMCA 210.

B. Sound Ratings: Tested in accordance with AMCA 300.

C. Fabrication: In accordance with AMCA 99.

1.05 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts, and materials:

Item	Quantity
V-belts	One complete set per unit

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Some specific equipment requirements are listed in Equipment Schedules. Refer to Drawings.

2.02 SPARK RESISTANT CONSTRUCTION

A. Fans required to be spark resistant shall comply with requirements of AMCA 99-0401.

2.03 NAMEPLATES

A. All units shall include factory installed permanently attached nameplate displaying unit model and serial number.

2.04 OPERATING LIMITS

A. Fans designated to meet a specified fan class shall comply with requirements of AMCA 99-2408-69.

2.05 ACOUSTICAL LEVELS

A. Equipment selections shall produce sound power levels in each octave band no greater than shown in Equipment Schedule.

2.06 FAN DRIVES

A. Furnish multiple drive belts where motor horsepower is 2 hp or larger.

B. Drive assembly shall be sized for a minimum 140 percent of fan motor horsepower rating.

C. Sheaves shall be capable of providing 150 percent of motor horsepower.

D. Fan Shafts: First critical speed of at least 125 percent of fan maximum operating speed.

E. Belts: Oil and heat resistant, nonstatic type.

F. Furnish motors for V-belt drives with adjustable rails or bases.

G. Unless otherwise noted, furnish belt-driven fans with cast iron or flanged steel sheaves.

H. Motors 20 hp or Smaller:

1. Variable pitch V-belt sheaves allowing at least 20 percent speed variation.
2. Final operating point shall be at approximate sheave midpoint.

I. Motors Larger than 20 hp: Fixed-pitch sheaves.

J. Drive Adjustment:

1. When fixed-pitch sheaves are furnished, accomplish system air balancing by either trial of different fixed-pitch sheaves or use of temporary adjustable-pitch sheaves.
2. Provide trial and final sheaves, as well as drive belts, as required.

K. Weather Cover: For outdoor applications, factory fabricated drive assembly of same material as fan housing, unless specified otherwise.

L. Belt and Shaft Guards:

1. Easily removable and to enclose entire drive assembly, meeting federal, OSHA and Commonwealth of Virginia requirements.
2. Guard faces of expanded metal having minimum 60 percent free area for ventilation.
3. Bright yellow finish.

M. Provide speed test openings at shaft locations.

2.07 FINISHES

A. Carbon Steel Parts: Factory finish as follows, unless indicated otherwise.

1. Parts cleaned and chemically pretreated with a phosphatizing process.
2. Alkyd enamel primer.
3. Air-dry enamel topcoat.

B. Aluminum Parts: Finished smooth and left unpainted, unless stated otherwise.

C. Stainless Steel Parts: Finished smooth and left unpainted.

D. Fiberglass Parts: Finished in accordance with Paragraph, Fiberglass Material.

2.08 ROOF FAN, CENTRIFUGAL UPBLAST

A. General:

1. Factory-assembled centrifugal upblast roof fan; including housing, fan wheel, drive assembly, motor and accessories.
2. Bearing AMCA certified ratings seal for sound and air performance.

B. Housing:

1. Construction: Spun-formed aluminum, minimum 16-gauge marine alloy.
2. Windband: Finish with rolled bead.
3. Top Cap: Motor access via quick release latches.
4. Motor completely sealed from exhaust air stream.
5. Motor cooling via air breather tubes.
6. Integral conduit chase for wiring.
7. Drain trough at lowest point of housing.
8. Fan Inlet:
   a. Full inlet cone of aluminum construction.
   b. Match inlet shroud.

C. Wheel:

1. Aluminum construction, backward inclined centrifugal, nonoverloading type.
2. Machined, cast aluminum hub.
3. Matched to deep spun inlet venturi.

D. Shaft, Bearings, Drive:

1. Shaft:
   a. Turned, ground and polished carbon steel.
   b. Keyed for sheave installation.
   c. Zinc-phosphate coated and oil emulsion-dipped.

2. Bearings:
    a. Grease lubricated, precision antifriction ball, self-aligning, pillow block style.
    b. Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
    c. Terminate with zerk fittings.
3. Drives:
    a. In accordance with Article Fan Drives.
    b. Factory set to specified fan revolutions per minute.
    c. Type: Belt or direct, as indicated in Equipment Schedule.

E. Accessories:

1. Gravity Backdraft Damper: Gravity operation, adjustable counterweight, and aluminum construction.
2. Bird Screens: Aluminum construction.
3. Roof Curb:
    a. Factory fabricated, aluminum construction.
    b. With damper tray.
    c. Sloped to match roof pitch, and to provide level top.
    d. Height Above Finished Roof: 12 inches.
    e. Mitered continuous welded corner seams.
    f. Pressure-treated wood nailer.
    g. Insulation: Minimum 1-1/2-inch thick, 3-pound per cubic foot density, rigid mineral fiberboard insulation with metal liner.
4. Disconnect: Factory installed, nonfused, NEMA Type 4X.
5. Bearing Lubrication Lines:
    a. Extended to outside of fan housing.
    b. Type 316 stainless steel construction.
    c. Terminate with zerk fittings.
6. Spark Resistant Construction Classification: AMCA 99-0401 Type B.
7. Corrosion Protection Coating:
    a. Provide factory-applied corrosion protection coating on these fan components:
        1) Wheel.
        2) Housing.
        3) Accessories.
        4) Interior surfaces in contact with airstream.
    b. Coating system shall be air-dry epoxy and shall be in accordance with Article Corrosion Protection Coating.

F. Manufacturers and Products:

1. Greenheck; Model CUE (direct drive); CUBE (belt drive).
2. Aerovent: Model ATB.
3. Cook; Model ACRUD (direct drive); ACRUB (belt drive).

2.09 CORROSION PROTECTION COATING

A. General:

1. Factory-applied corrosion protection coating for application to fan components and accessories, where required by this section.
2. Quality Control:
   a. Verify dry film thickness before final baking.
   b. Finished coating system shall be free from voids, checks, cracks and blisters.
3. Surface Cleaning: Clean parts to be coated as follows:
   a. Immerse parts in heated cleaning solution to remove lubricants, machining oils, and residual factory contamination.
   b. Follow with immersion in potable water bath to neutralize and remove cleaning solution.
   c. Chemical Pretreatment: Immerse parts in heated chemical solution, iron phosphate for steel, clear/yellow chromate for aluminum.

B. Air-Dry Epoxy:

1. Material: Two-part catalyzed epoxy.
2. Surface Preparation: Clean surface to SSPC-SP 3.
3. Application: Standard air-pressurized spray equipment.
4. Curing: Air dry.
5. Finished Thickness: 4- to 6-mil dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
   a. Salt Spray Test: Minimum 1,500-hour duration, ASTM B117 test method.
   b. Pencil Hardness: H-2H, ASTM D3363 test method.
   c. Service Temperature: Maximum 150 degrees F, continuous.

2.10 MOTORS

A. General:

1. Fan motors shall comply with provisions of Section 26 20 00, Low-Voltage AC Induction Motors.
2. Provide integral self-resetting overload protection on single-phase motors.
3. Motors for fans specified for use with variable frequency drives shall be inverter duty type.
4. Motors shall not operate into service factor in any case.

B. Motor requirements shall be as follows, unless designated otherwise on Equipment Schedule:

1. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
2. Winding Thermal Protection: None.
3. Space Heater: No.
4. Number of Speeds: Single.
5. Number of Windings: One.
6. Motor Efficiency: Premium efficient.
7. Shaft Type: Solid, carbon steel.
8. Mounting: As required for fan arrangement.
9. Service Factor: 1.15.

2.11 ACCESSORIES

A. Equipment Identification Plates: Furnish 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 1/4-inch high engraved block type black enamel filled equipment identification number and letters indicated in this Specification and as shown on Drawings.

B. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.

2.12 SOURCE QUALITY CONTROL

A. General:

1. Fan shall operate at single stable point as indicated by fan curve. Fans having two potential operating points are not acceptable.
2. Fan and motor combination shall be capable of delivering 110 percent of scheduled air quantity and static pressure. Motor shall not operate into motor service factor in any listed case.
3. Consider drive efficiency in motor selection according to manufacturer's published recommendation or according to AMCA 203, Appendix L.

B. Testing Provisions:

1. Provide tachometer access holes large enough to accept standard tachometer drive shaft.
2. Center punch fan shaft to accommodate tachometer readings.

C. Acoustical Levels:

1. Perform noise tests in accordance with AMCA 300 and AMCA 301.
2. Fan sound power levels (dB, Reference 10^{-12} Watts) shall be no greater than scheduled values.

D. Balancing:

1. Unless noted otherwise, each fan wheel shall be statically and dynamically balanced to ASA S2.19 Grade G6.3.
2. Fans controlled by variable frequency drives shall be dynamically balanced at speeds 25, 50, 75, and 100 percent of design revolutions per minute.

E. Vibration Test:

1. Each fan furnished with a 5-hp or larger motor shall have factory run vibration test, including vibration signatures taken on each bearing in horizontal, vertical, and axial direction.
2. Vibration reading as measured at scheduled rotational speed shall not exceed the following values when fan is rigidly mounted:
   a. Belt Drive (except Vane Axial): 0.15 inch per second peak velocity.
   b. Belt Drive Vane Axial: 0.08 inch per second peak velocity.
   c. Direct Drive: 0.08 inch per second peak velocity.
3. Written records of run test and vibration test shall be made available upon request.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install fans level and plumb.

B. Secure roof-mounted fans to roof curbs with Type 316 stainless steel hardware.

C. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

D. Scroll Drains: Pipe drain connection through running trap to floor drain.

E. Labeling:

1. Label fans in accordance with Article Accessories.
2. Mark exhaust fans serving fume hoods with arrows to indicate proper direction of rotation, in accordance with NFPA 45.

F. Service Access: Locate units to provide access spaces required for motor, drive, bearing servicing, and fan shaft removal.

G. Equipment Support and Restraints:

1. Install floor-mounted units on concrete bases designed to withstand, without damage to equipment, the seismic force required by code.
2. Secure vibration controls to concrete bases using anchor bolts cast in concrete base.
3. Seismic Restraint Snubbers: Install with sufficient clearance so unit isolators are not restricted for proper free isolation but do limit movement in all directions.

H. Connections:

1. Refer to Section 23 31 13, Metal Ducts and Accessories.
2. Isolate duct connections to fans.
3. Install ductwork adjacent to fans to allow proper service and maintenance.

3.02 FIELD QUALITY CONTROL

A. Functional Tests:

1. Verify blocking and bracing used during shipping are removed.
2. Verify fan is secure on mountings and supporting devices, and connections to ducts and electrical components are complete.
3. Verify proper thermal-overload protection is installed in motors, starters, and disconnect switches.
4. Verify that cleaning and adjusting are complete.
5. Disconnect fan drive from motor; verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.
6. Reconnect fan drive system; align and adjust belts and install belt guards.
7. Verify lubrication for bearings and other moving parts.
8. Verify manual and automatic volume control and fire and smoke dampers in connected ductwork are in fully open position.

B. Performance Tests:

1. Starting Procedures:
   a. Energize motor and adjust fan to indicated revolutions per minute.
   b. Measure and record motor voltage and amperage.
2. Operational Test:
   a. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   b. Repair or replace malfunctioning units; retest as specified after repairs or replacement is made.
   c. Test and adjust control safeties.
   d. Replace damaged and malfunctioning controls and equipment.

3.03 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for specified component, subsystem, equipment, or system.

B. Manufacturer's Representative: Present at site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:

1. 1 person-day for installation assistance and inspection.
2. 5 person-days for prestartup classroom or site training.

C. Refer to Section 01 43 33, Manufacturers' Field Services.

3.04 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

D. Balancing:

1. Perform air system balancing as specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.
2. Replace fan and motor sheaves as required to achieve design airflow.

E. Vibration Testing:

1. Perform field testing on rotating equipment, where specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC, to determine actual operating vibration.
2. If vibration limits described therein are exceeded, rebalance equipment in-place until design tolerances are met.

3.05 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

B. On completion of installation, internally clean fans according to manufacturers' written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

END OF SECTION

SECTION 23 81 00
UNITARY AIR-CONDITIONING EQUIPMENT

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 210/240, Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
2. Air Moving and Conditioning Association (AMCA): Bulletin 300, Setup No. 1.
3. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
   a. 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
   b. 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
4. American Society of Mechanical Engineers (ASME): Section IX, Welding and Brazing Qualifications.
5. ASTM International (ASTM):
   a. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
   b. D2370, Standard Test Method for Tensile Properties of Organic Coatings.
   c. D4060, Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser.
   d. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
   e. G154, Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials.
6. Canadian Standards Association (CSA).
7. ETL Testing Laboratories (ETL).
8. International Organization for Standardization (ISO):
   a. 9001, Quality Management Systems - Requirements.
   b. 13256-1, Water-Source Heat Pumps—Testing and Rating for Performance—Part 1: Water-to-Air and Brine-to-Air Heat Pumps.
9. National Electrical Manufacturers Association (NEMA).
10. National Fire Protection Association (NFPA): 255, Standard Method of Test of Surface Burning Characteristics of Building Materials
11. UL: 94-5V, Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. AC: Air conditioning.
2. COP: Coefficient of performance.
3. EER: Energy efficiency ratio.
4. DX: Direct expansion.
5. HP: Heat pump.
6. IR: Infrared.
7. LED: Light-emitting diode.
8. PSC: Permanent split capacitor.
9. PTAC: Packaged terminal air conditioner.
10. SPST: Single-pole, single-throw.
11. TXV: Thermostatic expansion valve.
12. UV: Ultraviolet.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop drawings.
2. Complete specifications, descriptive drawings, catalog cuts, and descriptive literature which shall include make, model, dimensions, weight of equipment, and electrical schematics for all products specified.
3. Manufacturer's standard finish color selection for enclosure finishes.
4. Complete performance data that will indicate full compliance with the specifications:
   a. Include fan sound power level data (ref. 10 to 12 watts) at design operating point, based on AMCA Bulletin 300, Setup No. 1.
   b. Include heating and cooling performance data at design operating conditions.
5. Air Pressurization Unit: Documentation that media filter modules are UL-rated Class 1.
6. Factory dip-applied protective coating product data.

B. Informational Submittals:

1. Manufacturer's Certificates of Compliance and Proper Installation in accordance with Section 01 43 33, Manufacturers' Field Services, for heat pumps, air-conditioning units, and motors.
2. Detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement or details shown to equipment furnished.
3. Sample copy of guarantee.
4. Test reports.

5. Operation and maintenance data in conformance with Section 01 78 23, Operation and Maintenance Data.
    a. Include wiring and control diagrams for equipment.
    b. Include as-built version of equipment schedules.

1.04 QUALITY ASSURANCE

A. Heating and Cooling Equipment: Minimum operating efficiencies, defined as COP and EER, as specified in ASHRAE 90.1.

B. Unit shall be rated (when matched with appropriate outdoor unit) in accordance with AHRI 210/240.

C. Units shall be certified by UL and CSA and shall be UL- or ETL-listed and labeled.

D. Cooling performance rated in accordance with AHRI testing procedures.

E. Air Pressurization Unit:

1. Manufacturer shall have a minimum of 10 years' experience in design, fabrication and testing of systems that are 99.95 percent efficient in the removal of these gases.
2. Manufacturer shall be a single source provider of equipment, media, and testing services, and certified to ISO 9001 standards or adhere to quality standards equal to ISO 9001.
3. Welding procedure qualifications and welder performance qualifications shall conform to the requirements of Section IX of the ASME Code, latest edition. Welder's performance qualification records shall be made available to Engineer upon request.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Storage: Products shall be carefully stored in a manner that will prevent damage and in an area that is protected from the elements.

B. Protection of Equipment:

1. Box, crate, or otherwise protect from damage and moisture during shipment, handling, and storage.
2. Protect from exposure to corrosive fumes and keep thoroughly dry at all times.
3. Store motors, drives, electrical equipment, and other equipment with anti-friction or sleeve bearings in weathertight and heated storage facilities prior to installation.
4. For extended storage periods, plastic equipment wrappers shall not be used to prevent accumulation of condensate in gears and bearings.

1.06 SPECIAL GUARANTEE

A. Refrigerant Compressors: Furnish manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of compressors specified in this Specification section found defective during a period of 5 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in the General Conditions.

1.07 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following materials:

Item	Quantity
Fan belts	One complete set for each belt-driven fan
Filters	One complete set per unit

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 GENERAL

A. Specified components of this section, including insulation, facings, mastics, and adhesives, shall have fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke developed, as per test conducted in accordance with ASTM E84 and NFPA 255 methods.

B. Multiple Compressor Units:

1. Provide completely independent refrigeration circuits and controls.
2. Indoor unit air coils shall have intermingled circuits, unless specified otherwise.

2.02 EQUIPMENT SCHEDULES

A. Refer to Drawings.

2.03 SPLIT SYSTEM IN-CEILING CASSETTE AC UNIT, DUCTLESS

A. General:

1. Split system, indoor, DX, ductless, fan coil AC unit, complete with DX coil, fan, fan motor, piping connectors, electrical controls, condensate pump, and hanging brackets.
2. Suitable for use with air conditioner or heat pump outdoor unit.
3. Indoor unit shall be of the same manufacturer as the associated outdoor unit.

B. Unit Cabinet:

1. Constructed of zinc-coated steel.
2. Fully insulated.
3. Discharge and inlet grilles, high-impact polystyrene.
4. Adjacent room cooling to be provided by a simple knockout in cabinet side panel.

C. Evaporator Fan:

1. Centrifugal, direct-drive blower type with air intake in center of unit and discharge on perimeter.
2. Air louvers shall be adjustable for 2-, 3-, or 4-way discharge.
3. Motors:
   a. Totally enclosed and permanently lubricated with inherent protection.
   b. Three-speed.

D. DX Evaporator Coil:

1. Copper tube with aluminum fins and galvanized steel tube sheets.
2. Fins bonded to tubes by mechanical expansion.
3. Condensate Drip Pan: Locate under coil with drain connection for hose attachment to remove condensate.

E. Internal Condensate Pump:

1. To remove condensate from drain pan when gravity drainage cannot be used.
2. Lift capability of condensate pump shall be 18 inches.

F. Electric Heater: Units shall be equipped with factory-mounted electric heaters. Minimum protection shall include overcurrent and high temperature protection.

G. Controls:

1. Refrigerant Metering:
   a. Factory installed refrigerant metering device.
   b. Heat Pump Applications: Reverse flow bypass refrigerant metering device with internal check valves.
2. 24-volt wall-mounted thermostat with three fan speed selections and auto/manual switch.
3. Automatic restart after power failure at same operating conditions as at failure.
4. Float control in condensate sump to shut unit down in case of pump malfunction.
5. Evaporator coil freeze protection.

H. Air Filters: Filter tracks and cleanable filters, accessible from below with a 1/4-turn fastener.

I. System Controls:

1. Centralized Controller:

   a. This controller shall be wall mounted and hard wired to the outdoor unit/s via 16 AWG 2 wire shielded cable. It will be manufactured from ABS plastic and have an LCD display. The G-50 shall be capable of controlling up to 50 indoor units as a stand-alone controller and have an Ethernet input that will enable control of the indoor units from a local or offsite PC Web Browser. The G-50 controller will be capable of individually or collectively controlling the following normal operating functions of up to 50 indoor fan coil units as a stand-alone controller:
      1) ON/OFF.
      2) Temperature setting.
      3) Operation modes.
      4) Air direction setting.
      5) Fan speed.
      6) Prohibit local remote controller (on/off mode; temperature setting; Filter reset).
      7) Filter sign reset.
      8) External signal input interface.
   b. The controller shall also be capable of displaying the following information individually for up to 50 indoor fan coil units:
      1) ON/OFF.
      2) Operating mode.
      3) Set point.
      4) Return air temperature.
      5) Fan speed.

6) Timer settings.
7) Test run.
8) Fault diagnosis error report. Operating status (by group).

c. Pin Options: The following control options will be available by installing a pin code into the G-50 centralized controller to unlock each function.
1) BACnet® Interface: The BACnet® protocol will be in the form of PC. It will act as a gateway unit between the factory controls and the BACnet® EMCS (Energy Management Control System) side via the G-50 centralized controller. The BACnet® protocol converter shall be able to control up to 50 indoor units per G-50, to maximum of ten G-50 controllers equaling 500 indoor units.
2) PAC-SC50KUA-F (Power Supply): The power supply will be enclosed in a surface mounted metal box. It will supply 30V dc to the Centralized network and 12V dc to the G-50 control. One power supply will be used for every G-50 controller (50 indoor units). The Power supply feed will be 208-to-230-volt AC single phase.

d. Unit shall be controlled remotely by the DDC system.
1) Factory controls shall be capable of receiving the following inputs from the BACnet® of EMCS control system:
a) Unit enable/disable. The unit's factory controls will start the unit's internal components.
b) DX coil discharge air reset temperature.

e. Provide the following outputs to BACnet® of EMCS control system:
1) ON/OFF status for each compressor.
2) Common failure alarm.
3) Fan status.
4) Filter alarm.
5) Low temperature alarm.
6) Space Temperature.

J. Accessories: Provide as scheduled in equipment schedule and as follows.

1. Electronic Programmable Thermostat:
a. Commercial grade, 7-day, four-event scheduling.
b. Integral subbase, three-speed fan control, heating/cooling switchover capability, air sweep auto changeover.
c. Shall not require battery to retain memory.

K. Manufacturers and Products:

1. Mitsubishi; Mr. Slim.
2. Enviromaster International.
3. Carrier.

2.04 SPLIT SYSTEM AC OUTDOOR UNITS (UP TO 5 NOMINAL TONS)

A. General:

1. Units shall be completely factory assembled, wired, piped, precharged with R-410A or R-407C and fully tested in all modes of operation.
2. Match with associated indoor unit.
3. Units with multiple compressors shall have completely independent refrigeration circuits and controls to balance heat rejection of each compressor.
4. Factory test reports shall be available on request. Engineer reserves the right to witness factory performance testing.
5. Manufacturer shall have a minimum of 5 years' experience in the production of dehumidification systems.

B. Unit Cabinet:

1. Weatherproof.
2. Supported on steel full-length mounting rails.
3. Removable access panels to all internal components and the electrical panel without impairing unit operation.
4. Knockouts for unit electrical power.
5. Protective guards on each fan discharge and each coil inlet.
6. Unit shall be constructed of G-90 galvanized steel with minimum gauge thickness of:
   a. Bases: 16 gauge.
   b. Corner Posts and Tops: 18 gauge.
   c. Access Panels: 20 gauge.
7. Base:
   a. Unit base pan shall be poured with minimum 1/4-inch hot asphalt (tar) to prevent rain or condensate from contacting steel on bottom of base pan.
   b. Asphalt shall be poured prior to final factory assembly to assure protection of all steel areas.
8. Paint Finish:
   a. Painted internally and externally.
   b. Exterior parts shall be thoroughly cleaned chemically, zinc-phosphate coated, and sealed with chromic rinse.
   c. Paint shall be electrically deposited by immersion dipping in a cationic electro-deposition paint system.

d. Paint shall be baked for a minimum of twenty minutes at 400 degrees F.
e. MDFT: 1 mil.
f. Finish shall meet or exceed a 1,000-hour salt spray test in accordance with ASTM B117.
g. Cabinet Corrosion Protection:
1) Cabinet paint finish shall be coated with an acrylic resin that provides protection against UV, sea atmosphere, chlorine vapors, and chlorinated solvents.
2) Acrylic resin coating shall meet or exceed the following criteria:
a) Weatherability: 7 to 10 years in accordance with ASTM G154.
b) Abrasion: 1,120 cyc/mil in accordance with ASTM D4060.
c) Filtration: 230 percent in accordance with ASTM D2370.
d) Tensile Strength: 1,800 psi in accordance with ASTM D2370.
e) 3,600 hours Salt Spray Test in accordance with ASTM B117.
f) UV inhibited life of minimum 7 years when exposed to the sun.

9. Hardware:
a. Exterior nuts, bolts, and washers shall be Type 304 stainless steel.
b. Exterior screws shall be either Type 304 stainless steel or coated with an epoxy finish that meets or exceeds minimum 4,000-hour Salt Spray Test in accordance with ASTM B117.

C. Compressor:

1. Hermetic, reciprocating or scroll type.
2. Provide with crankcase heaters and motors equipped with internal overheat-overload protection.
3. Provide a 5-year compressor warranty.

D. Condenser Coil:

1. Coils shall be aluminum plate fins formed on multiple rows of seamless copper tubing arranged in a staggered tube configuration.
2. Tubes shall be mechanically expanded, firmly bonding tube to shoulder of each fin.
3. Coat entire coil with anti-corrosion protective coating, in accordance with Article Factory Dip-Applied Protective Coating.

E. Condenser Fan:

1. Propeller type, electronically balanced and direct driven by fan motor.
2. Motor:
   a. Fan motor(s) and compressor(s) shall be UL- or CSA-listed.
   b. Corrosion resistant motor shaft.
   c. Totally enclosed, Class B insulation, sealed ball bearings.
   d. Thermal overload protection.
3. Outdoor air shall be discharged through a vinyl coated fan guard.

F. Refrigeration Components:

1. Spring mounted hermetic compressor.
2. Crankcase heater.
3. Liquid line solenoid.
4. Suction line accumulator.
5. Condenser coil.
6. Rubber mounted upflow propeller condenser fans.
7. Connections for refrigerant piping and specialties.
8. Filter-drier.
9. Sight glass-moisture indicator.
10. Refrigerant pressure service valves.

G. Controls:

1. Factory adjusted and preset to design conditions.
2. Complete with transducers, thermostats, and electrical control circuit factory pre-wired in control panel.
3. Compressor and fan motor contactors or starters.
4. Terminal strip for connection of remote controls.
5. Refrigerant controls shall include a high-pressure control (manual-reset), low pressure control (auto-reset), head pressure control, field adjustable refrigerant system lock-out and compressor anti-short cycle timer.
6. Safeties:
   a. Compressor winding and overheat protection.
   b. Thermal protection (auto-reset) on all inductive loads.
   c. Overload protection in each leg.

H. Accessories: Provide as scheduled in equipment schedule and as follows.

1. Low-ambient Cooling Kit:
   a. Solid-state condenser fan motor fully modulating speed controller; responds to saturated condensing pressure/temperature of unit.
   b. Maintains a saturated condensing temperature of 100 degrees F plus or minus 10 degrees F with outdoor temperatures down to minus 20 degrees F.

c. Includes winter start control package, to bypass low-pressure switch temporarily to allow compressor start during low load conditions.
d. Includes ball bearing condenser fan motor.

2. Compressor Cycle Delay: Compressor prevented from restarting for a minimum of 5 minutes after shutdown.
3. Hot Gas Bypass: Cooling capacity modulation with hot-gas solenoid valve and bypass piping.
4. Evaporator Freeze Thermostat: SPST temperature activated switch, shuts down unit upon evaporator freeze-up.
5. Liquid Solenoid Valve: Electric operated shutoff valve, bi-flow for heat pumps, interlocked with compressor operation.

I. Manufacturers:

1. Mitsubishi; Mr. Slim.
2. Enviromaster International.
3. Carrier.

2.05 HARSH ENVIRONMENT CORROSION PROTECTION SYSTEM

A. General:

1. Corrosion protection system below shall be provided for equipment where indicated in this Specification.
2. Exterior and interior surfaces of unit cabinet/casing shall be coated with an anticorrosion protection coating as described below.
3. Protective coating to be applied to unit after factory assembly of equipment.

B. Coating Material: Use one of the following materials.

1. Epoxy-modified phenolic. Straight phenolic materials are not acceptable.
2. Epoxy or epoxy urethane.
3. Complex chain-linked polyelastomer material.

C. Cabinet Coating Process:

1. Unit Disassembly:
   a. Disassemble unit.
   b. Remove condenser fan motor.
   c. Mask or pull back all exterior wires.
2. Cabinet Cleaning:
   a. Clean surfaces by residue-free solvent wipe down or steam cleaner/ pressure washer with soap to remove lubricants, machining oils,

and residual factory contamination. Do not soak or damage unit insulation.

b. Rinse with clean potable water to remove cleaning solution.

3. Coating Application:
   a. Etch bare interior and exterior surfaces including compressor/ condenser section, base rails, and underside of unit. Rinse etched surfaces to remove etching solution and residue.
   b. Previously painted surfaces to be scuff sanded with 220- to 320-grit abrasive to remove gloss on original coating. Sanded surfaces to be cleaned with a residue-free solvent wipe down.
   c. Surfaces should be clean and allowed to dry.
   d. Base Coat: When cabinet is dry, apply primer to interior and exterior surfaces. Allow to dry minimum of 12 hours.
   e. Top Coat: When primer is dry, apply final protective coating to interior and exterior surfaces. Apply two coats for optimum protection.
   f. Allow coating to dry completely before reassembling the unit.
4. Quality Control: Free from voids, checks, cracks, and blisters.

D. Performance: Cabinet finish shall meet or exceed the following criteria.

1. Salt Spray Test: In accordance with ASTM B117, minimum 3,000-hour duration, with no corrosion or degradation.
2. Exposure to UV Light: UV inhibited life of minimum 10 years when exposed to sun.

E. Manufacturers and Products:

1. Aero-Marine Engineering Inc.; Technicoat 10-1.
2. AST ElectroFin Inc; Electrofin.
3. Blygold; Refamac.

F. Application of coating shall be done by companies certified by the product manufacturer.

1. Aero-Marine Engineering Inc.
2. MJC Inc.
3. AST ElectroFin Inc.

G. Refrigerant Coils: Condenser and evaporator coil(s) shall be coated with a corrosion protection coating in accordance with Article Factory Dip-Applied Protective Coating.

H. Fasteners: Replace factory fasteners with stainless steel components.

2.06 FACTORY DIP-APPLIED PROTECTIVE COATING

A. General:

1. Factory dip-applied protective coating for application to plate fin and tube coils.
2. Coil factory assembled and tested before coating application.
3. Coating suitable for coils with maximum 30 fins per inch fin density. Bridging of product across coil fins is unacceptable.
4. After application and proper curing, product shall endure bending of coil assembly in standard manufacturing process without cracking.
5. Apply coating to coil before final factory assembly of equipment. Coating process that requires disassembly of equipment for removal of coil to be coated is not acceptable.

B. Coating Material: Use one of the following materials.

1. Epoxy-modified phenolic. Straight phenolic materials are not acceptable.
2. Epoxy or epoxy urethane.
3. Polyelastomer: Complex chain linked polyelastomer material.

C. Coating Process:

1. Coil Inspection and Sealing:
   a. Inspect coil for open tubes, headers, capillary tubes; repair as necessary.
   b. Fill with dry nitrogen, cap and seal, to prevent contamination of internal coil surfaces with cleaning or coating solutions.
2. Coil Cleaning:
   a. Immerse coil in heated alkaline cleaning solution to remove lubricants, machining oils, and residual factory contamination.
   b. Followed with immersion in potable water bath to neutralize and remove cleaning solution.
3. Coating Application:
   a. Immerse coil assembly in coating bath, including headers, casing, and heat exchange surfaces.
   b. Coil shall be completely removed from equipment during coating application.
   c. Spray-on coatings are not acceptable.
4. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
5. Quality Control: Free from voids, checks, cracks and blisters.

D. Performance: Coil finish shall meet or exceed the following criteria.

1. Salt Spray Test: In accordance with ASTM B117, minimum 3,000-hour duration, with no fin corrosion or degradation.

2. Thermal Efficiency: Loss no greater than 1 percent after coating application.
3. Exposure to UV Light: UV inhibited life of minimum 10 years when exposed to sun in the State of Florida.

E. Manufacturers and Products:

1. Aero-Marine Engineering Inc.; Technicoat 10-1.
2. AST ElectroFin Inc; ElectroFin.
3. Bronzglow; F-875.

2.07 ELECTRICAL

A. General:

1. Units shall include high and low voltage terminal block connections.
2. Control voltage to indoor unit fan shall be 24 volts.
3. Motor Starters/Contactors: Factory installed with unitary equipment, unless otherwise noted.
4. Disconnects: Factory installed nonfused disconnects or circuit breakers on each unit, unless otherwise noted.

B. Motors:

1. Refer to Section 26 20 00, Low-Voltage AC Induction Motors, for general requirements.
2. Unless otherwise stated, electric motors shall comply with the following:
   a. Voltage, Phase, Horsepower, Synchronous Speed: Refer to Equipment Schedule for motor driven equipment.
   b. Enclosure: ODP, unless specified otherwise.
   c. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
   d. Winding Thermal Protection: Manufacturer’s standard.
   e. Space Heater: Manufacturer’s standard.
   f. Multispeed Motors, Synchronous Speed, Number of Windings: Manufacturer’s standard.
   g. Efficiency: Minimum efficiency as specified in Section 26 20 00, Low-Voltage AC Induction Motors.

2.08 ACCESSORIES

A. Lifting Lugs: Provide suitably attached for equipment assemblies and components weighing over 100 pounds.

B. Equipment Identification Plates: Furnish 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component

and control panel in a readily visible location. Plate shall bear 1/4-inch-high die-stamped block type black enamel-filled equipment identification number and letters indicated in this Specification.

C. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, 1/2-inch minimum diameter, and as specified in Section 05 50 00, Metal Fabrications. Quantity as recommended by manufacturer.

2.09 SOURCE QUALITY CONTROL

A. Factory Tests:

1. Direct expansion coils leak tested underwater with 200-psig air. Pressure tested to 450 psig.
2. Electric heating coils tested with 2,000-volt dielectric test.

PART 3 EXECUTION

3.01 INSTALLATION

A. Set and install equipment so that equipment is level and properly supported.

B. Make certain that piping connections to equipment do not cause any strain on equipment.

C. Make certain that vibration isolation has been installed per manufacturer's instructions and isolation devices are performing satisfactorily.

D. Install equipment in accordance with manufacturer's recommendations, and these Specifications.

E. Install all safety devices as recommended by manufacturer and/or required by code in these Specifications.

F. Initial equipment startup shall be made by an authorized representative of the unit manufacturer.

G. Air-cooled outdoor unit shall not be started without complete prestart checkout of entire refrigerant piping system and charging of system with refrigerant as recommended by equipment manufacturer.

H. Startup: Manufacturer shall provide a factory-trained representative employed by the equipment manufacturer to perform the following services. Supervision only, of Contractor personnel, will not be acceptable.

1. Leak test.
2. Refrigerant pressure test.
3. Evacuate (if required).

4. Dehydrate (if required).
5. Charge condensing unit with refrigerant and oil (if required).

I. Factory Checkout:

1. Contractor shall secure the services of a factory trained and qualified service engineer employed by the equipment manufacturer who shall inspect the installation including external interlock, power connections; supervise initial operation, calibration of operating and safety controls and supervise electrical testing including insulation resistance of motors and voltage balance between phases during starting and running.
2. This service engineer shall forward a report in three copies to Engineer when the unit is in safe and proper operating condition. This report shall contain all pressure and control settings, meg readings, voltage readings per phase during START and RUN, suction temperature and pressure, liquid temperature and pressure, and shall list minor discrepancies to be corrected which do not affect safe and reliable operation.
3. One additional copy of report shall be left in unit control panel. One copy of bound installation operation and maintenance service, and parts brochures, including applicable serial numbers, full unit description, parts ordering sources, shall be placed in the unit control panel at the time of starting.

J. Locate units to provide access for filter changing; motor, drive, and bearing servicing; and fan shaft and coil removal.

K. Seal outside air intake watertight to roof curb.

L. Isolate sheet metal duct connections from all portions of the unit not internally spring-isolated from fans, or other vibrating or rotating equipment.

M. Inspect internal casing insulation, seal all exposed edges, and butt joints with mastic to ensure insulation will not be loosened during operation.

3.02 ADJUSTING AND CLEANING

A. Air System Balancing: As specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

B. Lubricate unsealed bearings prior to startup.

C. Do not operate units until filters are installed. If operated without filters, completely clean ductwork, coils, and interior of units.

3.03 FILTERS

A. Install a complete set of filters in each unit before operating and leave in place during startup and testing to keep the equipment and ductwork clean.

B. Install a complete set of filters at the time of final cleaning as defined in Section 01 77 00, Contract Closeout.

3.04 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection, and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for specified equipment.

END OF SECTION

SECTION 23 82 00
TERMINAL HEATING AND COOLING UNITS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Moving and Conditioning Association (AMCA): 300, Reverberant Room Method for Sound Testing of Fans.
2. American Gas Association (AGA).
3. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): 90.1 IP/SI, Energy Standard for Buildings, Except Low-Rise Residential Buildings.
4. ASTM International (ASTM):
   a. A106/A106M, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
   b. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
5. Canadian Gas Association (CGA).
6. Electrical Test Laboratories (ETL).
7. National Electrical Manufacturer's Association (NEMA).
8. National Fire Protection Association (NFPA):
   a. 54, National Fuel Gas Code.
   b. 70, National Electrical Code (NEC).
   c. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
9. Sheet Metal and Air Conditioning Contractors' National Assoc., Inc. (SMACNA): Ducted Electric Heat Guide for Air Handling Systems.
10. UL: Product Directories.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. AC: Alternating current.
2. CISD: Chemical industry, severe-duty.
3. dB: Decibel.
4. DWDI: Double width, double inlet.
5. FRP: Fiberglass-reinforced plastic.
6. hp: Horsepower.
7. ODP: Open drip proof.
8. PSC: Permanent split capacitor.

9. SWSI: Single width, single inlet.
10. TEFC: Totally enclosed, fan-cooled.
11. UV: Ultraviolet.
12. XP: Explosion proof.

1.03 SUBMITTALS

A. Action Submittals:

1. Complete specifications, descriptive drawings, catalog cuts, and descriptive literature which shall include make, model, dimensions, weight of equipment, and electrical schematics for products specified.
2. Manufacturer's standard finish color selection for cabinet finishes.
3. Performance data, including sound power level data (ref. 10 to 12 watts) at design operating point, shall be based on AMCA 300.

B. Informational Submittals:

1. Manufacturer's test reports for cabinet unit heater electric heating coil.
2. Recommended procedures for protection and handling of equipment and materials prior to installation.
3. Manufacturer's Certificate of Proper Installation in accordance with Section 01 43 33, Manufacturers' Field Services.
4. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.

1.04 QUALITY ASSURANCE

A. Heating Equipment: Minimum operating efficiencies, specified in ASHRAE 90.1 IP/SI.

PART 2 PRODUCTS

2.01 EQUIPMENT

A. Equipment Schedules: Refer to Drawings.

2.02 UNIT HEATER, ELECTRIC, SUSPENDED, CORROSION-RESISTANT

A. Characteristics:

1. Factory-assembled, industrial grade, corrosion-resistant, including housing, heater, fan wheel, drive assembly, motor, controls, and accessories.
2. UL-listed.
3. Meet requirements of the National Electrical Code.
4. Three-phase heaters shall have balanced phases.

5. Rated by manufacturer for direct exposure to hose-directed water.
6. Single-point power connection.
7. Casing:
    a. Totally enclosed water-tight casing.
    b. Heavy-duty stainless-steel casing.
    c. Stainless steel individual adjustable discharge louvers and hardware.
    d. Draw through design.
    e. Chrome plated or stainless-steel inlet grille and fan guard.
8. Heating Elements: Chrome-plated finned tubular steel or Type 304 stainless steel finned tubular elements with watertight seals.
9. Fan and Motor:
    a. Totally enclosed, permanently lubricated motor, with corrosion-resistant windings.
    b. Direct drive fan.
    c. Epoxy-coated aluminum fan wheel.
10. Controls:
    a. Factory-installed NEMA 4X control panel and NEMA 4X junction box.
    b. Thermal overload protection with automatic reset.
    c. Controls, transformers and contactors shall be factory assembled.

B. Accessories and Features: Provide as scheduled in Equipment Schedule and as follows:

1. Stainless steel wall mounting bracket.
2. Adjustable built-in thermostat with a minimum temperature range of 40 to 85 degrees F.
3. NEMA 4X electrical disconnect.

C. Manufacturers and Products:

1. Indeeco; TRIAD.
2. Trane; Model UHRA.
3. Markel; Series 5500.
4. “Or-equal.”

2.03 ELECTRICAL

A. General:

1. Units shall include high- and low-voltage terminal block connections.
2. Control voltage to indoor unit fan shall be 24 volts.
3. Motor Starters/Contactors: Factory-installed with unitary equipment, unless otherwise noted.
4. Disconnects: Factory-installed nonfused disconnects or circuit breakers on each unit, unless otherwise noted.

B. Motors:

1. Unless otherwise stated, electric motors shall comply with the following:
   a. Voltage, Phase, Horsepower, Synchronous Speed: Refer to Equipment Schedule for motor driven equipment.
   b. Enclosure: ODP, unless specified otherwise.
   c. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
   d. Winding Thermal Protection: Manufacturer's standard.
   e. Space Heater: Manufacturer's standard.
   f. Multispeed Motors, Synchronous Speed, Number of Windings: Manufacturer's standard.

2.04 ACCESSORIES

A. Equipment Identification Plates: Furnish 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8-inch high engraved block-type black enamel-filled equipment identification tag number indicated in this Specification and as shown.

B. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.

2.05 SOURCE QUALITY CONTROL

A. Functional Test:

1. Perform manufacturer's standard factory test on equipment.
2. Test equipment actually furnished.
3. Equipment with Electric Resistance Heating Coils: Test with 2,000-volt dielectric test.

PART 3 EXECUTION

3.01 INSTALLATION

A. Fan Coil Units: Mount bottom of unit at 12 inches above ceiling, except where noted otherwise on Drawings or as detailed.

B. Electric Unit Heaters, All Types:

1. Install in strict compliance with manufacturer's instructions. Maintain clearances around unit as listed in manufacturer's recommendations.
2. Heater shall be permanently mounted in position indicated with a fixed power supply.

3. Install so obstructions do not block heater air inlet or outlet.

C. Convectors, Finned-Tube: Install in accordance with manufacturer's instructions.

3.02 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for specified equipment.

END OF SECTION

SECTION 26 05 02
BASIC ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.01 RELATED SECTIONS

A. Requirements specified within this section apply to Division 26, Electrical. Work specified herein shall be performed as if specified in the individual sections.

1.02 SUMMARY OF WORK

A. The project includes major electrical work.

B. See Section 01 31 13, Project Coordination.

1.03 SPECIAL PROJECT REQUIREMENTS

A. The project includes major electrical modifications that will require extensive coordination and sequencing of work to maintain normal plant operations. Due to the extensive electrical modifications required, the Contractor shall participate in two coordination meetings with the Engineer and Owner to review the proposed construction sequence and potential impacts to any part of normal plant operations. Each of these coordination meetings shall be held at the Project Site. The Contractor shall be prepared to discuss, in detail, the following:

1. A detailed construction sequence of how the Contactor plans to implement the Work. The proposed construction sequence provided shall include all means and methods to be used to keep any existing equipment fully operational while the modifications required are implemented. This will require testing of some existing equipment used for temporary power to verify proper operation.
2. A list of all loads impacted by the construction sequence and the proposed method of providing power to those loads.
3. The anticipated duration of any power outage for all facilities both new and existing.
4. At the completion of the coordination meeting, the Contractor shall provide a detailed submittal to the Engineer which outlines the items discussed above. As a minimum, the submittal shall contain the following:
    a. The proposed sequence of construction for the new and existing facilities.
    b. A list of outages, and anticipated duration of each outage, anticipated by implementing the proposed construction sequence.

B. The Contractor shall perform a short circuit, coordination, and arc flash study as specified only related to new Work. However, the contract documents will not include all of the necessary data required to perform these analysis. Field investigations may be required to complete the specified studies. Refer to Section 26 05 70, Electrical Systems Analysis, for additional detail.

1.04 SUBMITTALS

A. Action Submittals:

1. Provide manufacturers' data for the following:
   a. Electrical service components.
   b. Telephone service components.
   c. Nameplates, signs, and labels.

1.05 QUALITY ASSURANCE

A. Provide the Work in accordance with NFPA 70. Where required by Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ, in order to provide a basis for approval under the NEC.

B. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc. shall conform to those standards and shall have an applied UL listing mark or label.

C. Provide materials and equipment acceptable to AHJ for Class, Division, and Group of hazardous area indicated.

1.06 ENVIRONMENTAL CONDITIONS

A. The following areas are classified as indoor and dry: Process Air Compressor Building Compressor Room, Electrical Room, and Control Room.

B. The following areas are classified as indoor and wet: The 2 air plenums in the Process Air Compressor Building.

C. There are no hazardous and/or corrosive areas.

PART 2 PRODUCTS

2.01 GENERAL

A. Where two or more units of the same class of material or equipment are required, provide products of a single manufacturer. Component parts of materials or equipment need not be products of the same manufacturer.

B. Material and equipment installed in heated and ventilated areas shall be capable of continuous operation at their specified ratings within an ambient temperature range of 40 degrees F to 104 degrees F.

2.02 EQUIPMENT FINISH

A. Manufacturer's standard finish color, except where specific color is indicated.

2.03 NAMEPLATES

A. Material: Laminated plastic.

B. Attachment Screws: Stainless steel.

C. Color: Black, engraved to a white core.

D. Letter Height:

1. Pushbuttons/Selector Switches: 1/8 inch.
2. Other electrical equipment: 1/4 inch.

2.04 SIGNS AND LABELS

A. Sign size, lettering, and color shall be in accordance with NEMA Z535.4.

PART 3 EXECUTION

3.01 GENERAL

A. Electrical Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned. Contractor shall be responsible for actual location of equipment and devices and for proper routing and support of raceways, subject to approval of Engineer.

B. Check approximate locations of light fixtures, switches, electrical outlets, equipment, and other electrical system components shown on Drawings for conflicts with openings, structural members, and components of other systems and equipment having fixed locations. In the event of conflicts, notify Engineer in writing.

C. Install work in accordance with NECA Standard of Installation, unless otherwise specified.

D. Keep openings in boxes and equipment closed during construction.

E. Lay out work carefully in advance. Do not cut or notch any structural member or building surface without specific approval of Engineer. Carefully perform cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, paving, or other surfaces required for the installation, support, or anchorage of

conduit, raceways, or other electrical materials and equipment. Following such work, restore surfaces to original condition.

3.02 ANCHORING AND MOUNTING

A. Equipment anchoring and mounting shall be in accordance with manufacturer's requirements for seismic zone criteria given in Section 01 61 00, Common Product Requirements.

3.03 COMBINING CIRCUITS INTO COMMON RACEWAY

A. Drawings show each homerun circuit to be provided. Do not combine power or control circuits into common raceways without authorization of Engineer.

B. Power circuits from loads in same general area to same source location (such as: panelboard, switchboard, low voltage motor control center).

1. Lighting Circuits: Combine no more than three circuits to a single raceway. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.
2. Receptacle Circuits, 120-Volt Only: Combine no more than three circuits to a single raceway. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.
3. All Other Power Circuits: Do not combine power circuits without authorization of Engineer.

3.04 NAMEPLATES, SIGNS, AND LABELS

A. Equipment Nameplates:

1. Provide a nameplate to label electrical equipment including panelboards, motor starters, transformers, terminal junction boxes, disconnect switches, and switches.
2. Transformer and terminal junction box nameplates shall include equipment designation.
3. Disconnect switch and starter nameplates shall include name and number of equipment powered or controlled by that device.
4. Panelboard nameplates shall include equipment designation, service voltage, and phases.

3.05 LOAD BALANCE

A. Drawings and Specifications indicate circuiting to electrical loads and distribution equipment.

B. Balance electrical load between phases as nearly as possible on panelboards and other equipment where balancing is required.

C. When loads must be reconnected to different circuits to balance phase loads, maintain accurate record of changes made, and provide circuit directory that lists final circuit arrangement.

3.06 CLEANING AND TOUCHUP PAINTING

A. Cleaning: Throughout the Work, clean interior and exterior of devices and equipment by removing debris and vacuuming.

B. Touchup Paint:

1. Touchup scratches, scrapes and chips on exterior and interior surfaces of devices and equipment with finish matching type, color, and consistency and type of surface of original finish.
2. If extensive damage is done to equipment paint surfaces, refinish entire equipment in a manner that provides a finish equal to or better than factory finish, that meets requirements of Specification, and is acceptable to Engineer.

3.07 PROTECTION FOLLOWING INSTALLATION

A. Protect materials and equipment from corrosion, physical damage, and effects of moisture on insulation and contact surfaces.

B. When equipment intended for indoor installation is installed at Contractor's convenience in areas where subject to dampness, moisture, dirt or other adverse atmosphere until completion of construction, ensure adequate protection from these atmospheres is provided and acceptable to Engineer.

END OF SECTION

SECTION 26 05 04
BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Provide manufacturers' data for the following:
   a. Control devices.
   b. Control relays.
   c. Circuit breakers.
   d. Fused switches.
   e. Nonfused switches.
   f. Timers.
   g. Fuses.
   h. Magnetic contactors.
   i. Enclosures: Include enclosure data for products having enclosures.
2. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.

1.02 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts and special tools:

1. Fuses, 0 to 600 Volts: Six of each type and each current rating installed.

PART 2 PRODUCTS

2.01 MOLDED CASE CIRCUIT BREAKER THERMAL MAGNETIC, LOW VOLTAGE

A. General:

1. Type: Molded case.
2. Trip Ratings: 15-800 amps.
3. Voltage Ratings: 120, 240, 277, 480, and 600V ac.
4. Suitable for mounting and operating in any position.
5. NEMA AB 1 and UL 489.

B. Operating Mechanism:

1. Overcenter, trip-free, toggle type handle.
2. Quick-make, quick-break action.
3. Locking provisions for padlocking breaker in open position.
4. ON/OFF and TRIPPED indicating positions of operating handle.
5. Operating handle to assume a center position when tripped.

C. Trip Mechanism:

1. Individual permanent thermal and magnetic trip elements in each pole.
2. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
3. Two and three pole, common trip.
4. Automatically opens all poles when overcurrent occurs on one pole.
5. Test button on cover.
6. Calibrated for 40 degrees C ambient, unless shown otherwise.
7. Do not provide single-pole circuit breakers with handle ties where multi-pole circuit breakers are shown.
8. For CB-58-1 and CB-58-2, provide ambient insensitive solid-state trips that have the current sensors and logic circuits integral in the breaker frame. Provide solid-state current control with adjustable ampere setting, adjustable long-time delay, and adjustable instantaneous trip, and adjustable ground fault. Setting adjustments to be covered by the compartment door. Locate trip button on front cover of breaker to permit mechanical simulation overcurrent tripping for test purposes and to trip breaker quickly in emergency situation.

D. Short Circuit Interrupting Ratings:

1. Equal to, or greater than, available fault current or interrupting rating as determined by the short circuit study specified to be performed. Provide 42,000 ampere rms interrupting rating for CB-58-1 and CB-58-2.
2. Series Connected Ratings: Do not apply series connected short circuit ratings.

E. Ground Fault Circuit Interrupter (GFCI): Where indicated, equip breaker as specified above with ground fault sensor and rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel).

1. Ground fault sensor shall be rated same as circuit breaker.
2. Push-to-test button.

F. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker specified above with ground fault sensor and rated to trip on 30-mA ground fault (UL-listed for equipment ground fault protection).

G. Magnetic Only Type Breakers: Where shown; instantaneous trip adjustment which simultaneously sets magnetic trip level of each individual pole continuously through a 3X to 10X trip range.

H. Accessories: Shunt trip, auxiliary switches, handle lock ON devices, mechanical interlocks, key interlocks, unit mounting bases, double lugs as shown or otherwise required. Shunt trip operators shall be continuous duty rated or have coil-clearing contacts.

I. Connections:

1. Supply (line side) at either end.
2. Mechanical wire lugs, except crimp compression lugs where shown.
3. Lugs removable/replaceable for breaker frames greater than 100 amperes.
4. Suitable for 75 degrees C rated conductors without derating breaker or conductor ampacity.
5. Use bolted bus connections, except where bolt-on is not compatible with existing breaker provisions.

J. Enclosures for Independent Mounting:

1. See Article Enclosures.
2. Service Entrance Use: Breakers in required enclosure and required accessories shall be UL 489 listed.
3. Interlock: Enclosure and switch shall interlock to prevent opening cover with switch in the ON position. Provide bypass feature for use by qualified personnel.

2.02 FUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

A. UL 98 listed for use and location of installation.

B. NEMA KS 1.

C. Short Circuit Rating: 200,000 amps RMS symmetrical with Class R, Class J, or Class L fuses installed.

D. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

E. Connections:

1. Mechanical lugs, except crimp compression lugs where shown.
2. Lugs removable/replaceable.
3. Suitable for 75 degrees C rated conductors at NEC 75 degrees C ampacity.

F. Fuse Provisions:

1. 30-amp to 600-amp rated shall incorporate rejection feature to reject all fuses except Class R.
2. 601-amp rated and greater shall accept Class L fuses, unless otherwise shown.

G. Enclosures: See Article Enclosures.

H. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.03 NONFUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

A. NEMA KS 1.

B. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

C. Lugs: Suitable for use with 75 degrees C wire at NEC 75 degrees C ampacity.

D. Auxiliary Contact:

1. Operation: Make before power contacts make and break before power contacts break.
2. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.

E. Enclosures: See Article Enclosures.

F. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.04 FUSE, 250-VOLT AND 600-VOLT

A. Power Distribution, General:

1. Current-limiting, with 200,000 ampere rms interrupting rating.
2. Provide to fit mountings specified with switches.
3. UL 248.

B. Power Distribution, Ampere Ratings 1 Amp to 600 Amps:

1. Class: RK-1.
2. Type: Dual element, with time delay.

3. Manufacturers and Products:
    a. Bussmann; Types LPS-RK (600 volts) and LPN-RK (250 volts).
    b. Littelfuse; Types LLS-RK (600 volts) and LLN-RK (250 volts).
    c. "Or-equal."

C. Power Distribution, Ampere Ratings 601 Amps to 6,000 Amps:

1. Class: L.
2. Double O-rings and silver links.
3. Manufacturers and Products:
    a. Bussmann; Type KRP-C.
    b. Littelfuse, Inc.; Type KLPC.
    c. "Or-equal."

D. Cable Limiters:

1. 600V or less; crimp to copper cable, bolt to bus or terminal pad.
2. Manufacturer and Product:
    a. Bussmann; K Series.
    b. Mersen, AMP-TRAP CP.
    c. "Or-equal."

E. Ferrule:

1. 600V or less, rated for applied voltage, small dimension.
2. Ampere Ratings: 1/10 amp to 30 amps.
3. Dual-element time-delay, time-delay, or nontime-delay as required.
4. Provide with blocks or holders as indicated and suitable for location and use.
5. Manufacturers:
    a. Bussmann.
    b. Littelfuse, Inc.
    c. "Or-equal."

2.05 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

A. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.

B. Selector Switch Operating Lever: Standard.

C. Indicating Light: Push-to-test.

D. Pushbutton Color:

1. ON or START: Black.
2. OFF or STOP: Red.

E. Pushbutton and selector switch lockable in OFF position where indicated.

F. Legend Plate:

1. Material: Aluminum.
2. Engraving: Enamel filled in high contrasting color.
3. Text Arrangement: 11-character/spaces on one line, 14-character/spaces on each of two lines, as required, indicating specific function.
4. Letter Height: 7/64-inch.

G. Manufacturers and Products:

1. Heavy-Duty, Oil-Tight Type:
   a. General Electric Co.; Type CR 104P.
   b. Square D Co.; Type T.
   c. Eaton/Cutler-Hammer; Type 10250T.
   d. "Or-equal."
2. Heavy-duty, Watertight, and Corrosion-resistant Type:
   a. Square D Co.; Type SK.
   b. General Electric Co.; Type CR 104P.
   c. Eaton/Cutler-Hammer; Type E34.
   d. Crouse-Hinds; Type NCS.
   e. "Or-equal."

2.06 TERMINAL BLOCK, 600 VOLTS

A. UL 486E and UL 1059.

B. Size components to allow insertion of necessary wire sizes.

C. Capable of termination of control circuits entering or leaving equipment, panels, or boxes.

D. Screw clamp compression, dead front barrier type, with current bar providing direct contact with wire between compression screw and yoke.

E. Yoke, current bar, and clamping screw of high strength and high conductivity metal.

F. Yoke shall guide all strands of wire into terminal.

G. Current bar shall ensure vibration-proof connection.

H. Terminals:

1. Capable of wire connections without special preparation other than stripping.
2. Capable of jumper installation with no loss of terminal or rail space.
3. Individual, rail mounted.

I. Marking system, allowing use of preprinted or field-marked tags.

J. Manufacturers:

1. Weidmuller, Inc.
2. Ideal.
3. Electrovert USA Corp.
4. "Or-equal."

2.07 MAGNETIC CONTROL RELAY

A. Industrial control with field convertible contacts rated 10 amps continuous, 7,200VA make, 720VA break.

B. NEMA ICS 2, Designation: A600 (600 volts).

C. Time Delay Relay Attachment:

1. Pneumatic type, timer adjustable as shown.
2. Field convertible from ON delay to OFF delay and vice versa.

D. Latching Attachment: Mechanical latch, having unlatching coil and coil clearing contacts.

E. Manufacturers and Products:

1. Eaton/Cutler-Hammer; Type M-600.
2. General Electric Co.; Type CR120B.
3. "Or-equal."

2.08 TIME DELAY RELAY

A. Industrial relay with contacts rated 5 amps continuous, 3,600VA make, 360VA break.

B. NEMA ICS 2 Designation: B150 (150 volts).

C. Solid-state electronic, field convertible ON/OFF delay.

D. One normally open and one normally closed contact (minimum).

E. Repeat accuracy plus or minus 2 percent.

F. Timer adjustment from 1 second to 60 seconds, unless otherwise indicated on Drawings.

G. Manufacturers and Products:

1. Square D Co.; Type F.
2. Eaton/Cutler-Hammer.
3. General Electric Co.
4. "Or-equal."

2.09 SUPPORT AND FRAMING CHANNELS

A. Carbon Steel Framing Channel:

1. Material: Rolled, mild strip steel, 12-gauge minimum, ASTM A1011/A1011M, Grade 33.
2. Finish: Hot-dip galvanized after fabrication.

B. Paint-coated Framing Channel: Carbon steel framing channel with electro-deposited rust inhibiting acrylic or epoxy paint.

C. PVC-coated Framing Channel: Carbon steel framing channel with 40-mil polyvinyl chloride coating.

D. Stainless Steel Framing Channel: Rolled, ASTM A167, Type 316 stainless steel, 12-gauge minimum.

E. Extruded Aluminum Framing Channel:

1. Material: Extruded from Type 6063-T6 aluminum alloy.
2. Fittings fabricated from Alloy 5052-H32.

F. Nonmetallic Framing Channel:

1. Material: Fire retardant, fiber reinforced vinyl ester resin.
2. Channel fitting of same material as channel.
3. Nuts and bolts of long glass fiber reinforced polyurethane.

G. Manufacturers:

1. B-Line Systems, Inc.
2. Unistrut Corp.
3. Aickinstrut.
4. "Or-equal."

2.10 SWITCHBOARD MATTING

A. Provide matting having a breakdown of 20 kV minimum. Provide in front of new switchgear.

2.11 FIRESTOPS

A. General:

1. Provide UL 1479 classified hourly fire-rating equal to, or greater than, the assembly penetrated.
2. Prevent the passage of cold smoke, toxic fumes, and water before and after exposure to flame.
3. Sealants and accessories shall have fire-resistance ratings as established by testing identical assemblies in accordance with ASTM E814, by UL or other testing and inspection agency acceptable to authorities having jurisdiction.

B. Comply with Section 07 84 00, Firestopping.

C. Firestop System:

1. Formulated for use in through-penetration firestopping around cables, conduit, pipes, and duct penetrations through fire-rated walls and floors.
2. Fill, Void, or Cavity Material: 3M Brand Fire Barrier Caulk CP25, Putty 303, Wrap/Strip FS195, Composite Sheet CS195 and Penetration Sealing Systems 7902 and 7904 Series.

2.12 ENCLOSURES

A. Finish: Sheet metal structural and enclosure parts shall be completely painted using an electrodeposition process so interior and exterior surfaces as well as bolted structural joints have a complete finish coat on and between them.

B. Color: Manufacturer’s standard color (gray) baked-on enamel, unless otherwise shown.

C. Barriers: Provide metal barriers within enclosures to separate wiring of different systems and voltage.

D. Enclosure Selections: Except as shown otherwise, provide electrical enclosures according to the following table:

ENCLOSURES			
Location	**Finish**	**Environment**	**NEMA 250 Type**
Indoor	Finished	Dry	12
Indoor	Unfinished	Dry	12
Indoor	Unfinished	Industrial Use	12
Outdoor	Any	Wet	4X Type 316 stainless steel

PART 3 EXECUTION

3.01 GENERAL

A. Install equipment in accordance with manufacturer's recommendations.

3.02 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

A. Unless otherwise shown, install heavy-duty, oil-tight type in nonhazardous, indoor, dry locations, including motor control centers, control panels, and individual stations.

B. Unless otherwise shown, install heavy-duty, watertight and corrosion-resistant type in nonhazardous, outdoor, or normally wet areas.

3.03 SUPPORT AND FRAMING CHANNEL

A. Install where required for mounting and supporting electrical equipment, raceway, and cable tray systems.

B. Channel Type:

1. Interior, Wet or Dry (Noncorrosive) Locations:
   a. Aluminum Raceway: Extruded aluminum.
   b. PVC-coated Conduit: PVC coated.
   c. Steel Raceway and Other Systems Not Covered: Carbon steel or paint coated.
2. Interior, Corrosive (Wet or Dry) Locations:
   a. Aluminum Raceway: Extruded aluminum.
   b. PVC Conduit: Type 316 stainless steel or nonmetallic.
   c. PVC-coated Steel Conduit and Other Systems Not Covered: Type 316 stainless steel, nonmetallic, or PVC-coated steel.

3. Outdoor, Noncorrosive Locations:
    a. Steel Raceway: Carbon steel or paint coated framing channel, except where mounted on aluminum handrail, then use aluminum framing channel.
    b. Aluminum Raceway and Other Systems Not Covered: Aluminum framing channel.
    c. PVC-coated Steel Conduit and Other Systems Not Covered: Type 316 stainless steel, nonmetallic, or PVC coated steel.

C. Paint cut ends prior to installation with the following:

1. Carbon Steel Channel: Zinc-rich primer.
2. Painted Channel: Rust-inhibiting epoxy or acrylic paint.
3. Nonmetallic Channel: Epoxy resin sealer.
4. PVC-coated Channel: PVC patch.

3.04 SWITCHBOARD MATTING

A. Install 36-inch width at switchgear, switchboard, motor control centers, and panelboards.

B. Matting shall run full length of all sides of equipment that have operator controls or afford access to devices.

3.05 FIRESTOPS

A. Install in strict conformance with manufacturer's instructions. Comply with installation requirements established by testing and inspecting agency.

B. Sealant: Install sealant, including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide firestops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs.

END OF SECTION

SECTION 26 05 05
CONDUCTORS

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Product Data:
   a. Wire and cable.
   b. Wire and cable accessories.
   c. Cable fault detection system.
2. Manufactured Wire Systems:
   a. Product data.
   b. Rating information.
   c. Dimensional drawings.
   d. Special fittings.
3. Busway:
   a. Product data.
   b. Rating information.
   c. Dimensional drawings.
   d. Special fitting.
   e. Equipment interface information for equipment to be connected to busways.

B. Informational Submittals:

1. Journeyman lineman or electrician splicing credentials.
2. Factory Test Report for conductors 600 volts and below.
3. Certified Factory Test Report per AEIC CS 8, including AEIC qualification report for conductors above 600 volts.

1.02 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70. Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc. shall conform to those standards and shall have an applied UL listing mark.

B. Terminations and Splices for Conductors above 600 Volts: Work shall be done by journeyman lineman with splicing credentials or electrician certified to use materials approved for cable splices and terminations.

PART 2 PRODUCTS

2.01 CONDUCTORS 600 VOLTS AND BELOW

A. Conform to applicable requirements of NEMA WC 70.

B. Conductor Type:

1. 120-Volt and 277-Volt Lighting, 10 AWG and Smaller: Solid copper.
2. 120-Volt Receptacle Circuits, 10 AWG and Smaller: Solid copper.
3. All Other Circuits: Stranded copper.

C. Insulation: Type THHN/THWN-2, except for sizes No. 6 and larger, with XHHW-2 insulation.

2.02 CONDUCTORS ABOVE 600 VOLTS

A. EPR Insulated Cable:

1. Extrusion: Single-pass, triple-tandem, of conductor screen, insulation, and insulation screen.
2. Type: 15 kV, shielded, UL 1072, Type MV-105.
3. Conductors: Copper, concentric lay Class B round stranded in accordance with ASTM B3, ASTM B8, and ASTM B496.
4. Conductor Screen: Extruded, semiconducting ethylene-propylene rubber in accordance with NEMA WC 71 and AEIC CS 8.
5. Insulation: 133 percent insulation level, ethylene-propylene rubber (EPR) containing no polyethylene, in accordance with NEMA WC 71, and AEIC CS 8.
6. Insulation Thickness: 220-mil, 15 kV, nominal.
7. Insulation Screen: Thermosetting, semiconducting ethylene-propylene rubber (EPR), extruded directly over insulation in accordance with NEMA WC 74 and AEIC CS 8.
8. Metallic Shield: Uncoated, 5-mil, copper shielding tape, helically applied with 12-1/2 percent minimum overlap.
9. Jacket: Extruded polyvinyl chloride (PVC) compound applied in accordance with NEMA WC 71 or NEMA WC 74.
10. Operating Temperature: 105 degrees C continuous normal operations, 130 degrees C emergency operating conditions, and 250 degrees C short-circuit conditions.

11. Manufacturers:
    a. Okonite Co.
    b. Kerite.
    c. Prysmian.
    d. "Or-equal."

2.03 600-VOLT RATED CABLE

A. General:

1. Type TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 70,000 Btu per hour, and NFPA 70, Article 340, or UL 13 meeting requirements of NFPA 70, Article 725.
2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
3. Suitable for installation in open air, in cable trays, or conduit.
4. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations.
5. Overall Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.

B. Type 1, Multiconductor Control Cable:

1. Conductors:
    a. 14 AWG, seven-strand copper.
    b. Insulation: 15-mil PVC with 4-mil nylon.
    c. UL 1581 listed as Type THHN/THWN rated VW-1.
    d. Conductor group bound with spiral wrap of barrier tape.
    e. Color Code: In accordance with ICEA S-58-679, Method 1, Table 2.
2. Cable: Passes the ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
3. Cable Sizes:

No. of Conductors	Max. Outside Diameter (inches)	Jacket Thickness (mils)
3	0.41	45
5	0.48	45
7	0.52	45
12	0.72	60
19	0.83	60
25	1.00	60
37	1.15	80

4. Manufacturers:
   a. Okonite Co.
   b. Southwire.
   c. "Or-equal."

C. Type 2, Multiconductor Power Cable:

1. General:
   a. Meet or exceed UL 1581 for cable tray use.
   b. Meet or exceed UL 1277 for direct burial and sunlight-resistance.
   c. Overall Jacket: PVC.
2. Conductors:
   a. Class B stranded, coated copper.
   b. Insulation: Chemically cross-linked ethylene-propylene or cross-linked polyethylene.
   c. UL rated VW-1 or listed Type XHHW-2.
   d. Color Code:
      1) Conductors, size 8 AWG and smaller, colored conductors, ICEA S-58-679, Method 1, Table 1.
      2) Conductors, size 6 AWG and larger, ICEA S-73-532, Method 4.
3. Cable shall pass ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
4. Cable Sizes:

Conductor Size	Minimum Ground Wire Size	No. of Current Carrying Conductors	Max. Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
12	12	2 3 4	0.42 0.45 0.49	45
10	10	2 3 4	0.54 0.58 0.63	60
8	10	3 4	0.66 0.75	60
6	8	3 4	0.74 0.88	60
4	6	3 4	0.88 1.04	60 80
2	6	3 4	1.01 1.16	80

Conductor Size	Minimum Ground Wire Size	No. of Current Carrying Conductors	Max. Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
1	6	3 4	1.10 1.25	80
1/0	6	3 4	1.22 1.35	80
2/0	4	3 4	1.32 1.53	80
3/0	4	3 4	1.40 1.60	80
4/0	4	3 4	1.56 1.78	80 110

5. Manufacturers:
   a. Okonite Co.
   b. Southwire.
   c. "Or-equal."

D. Type 3, 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1. Outer Jacket: 45-mil nominal thickness.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
3. Dimension: 0.31-inch nominal OD.
4. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
   b. 20 AWG, seven-strand tinned copper drain wire.
   c. Insulation: 15-mil nominal PVC.
   d. Jacket: 4-mil nominal nylon.
   e. Color Code: Pair conductors, black and red.
5. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Belden.
   d. "Or-equal."

E. Type 4, 16 AWG, Twisted, Shielded Triad Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1. Outer Jacket: 45-mil nominal.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
3. Dimension: 0.32-inch nominal OD.
4. Conductors:
    a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
    b. 20 AWG, seven-strand, tinned copper drain wire.
    c. Insulation: 15-mil nominal PVC.
    d. Jacket: 4-mil nylon.
    e. Color Code: Triad conductors black, red, and blue.
5. Manufacturers:
    a. Okonite Co.
    b. Alpha Wire Corp.
    c. Belden.
    d. “Or-equal.”

F. Type 5, 18 AWG, Multitwisted Shielded Pairs, with a Common Overall Shield, Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable, meeting NEMA WC 57 requirements.

1. Conductors:
    a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
    b. Tinned copper drain wires.
    c. Pair drain wire size AWG 20, group drain wire size AWG 18.
    d. Insulation: 15-mil PVC.
    e. Jacket: 4-mil nylon.
    f. Color Code: Pair conductors, black and red with red conductor numerically printed for group identification.
    g. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer.
2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.

3. Cable Sizes:

Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.50	45
8	0.68	60
12	0.82	60
16	0.95	80
24	1.16	80
36	1.33	80
50	1.56	80

4. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Belden.
   d. "Or-equal."

G. Type 6, 18 AWG, Multitwisted Pairs with Common Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable meeting NEMA WC 57.

1. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
   b. Tinned copper drain wire size AWG 18.
   c. Insulation: 15-mil nominal PVC.
   d. Jacket: 4-mil nylon.
   e. Color Code: Pair conductors, black and red with red conductor numerically printed for group identification.
2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.

Cable Sizes: Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.48	45
8	0.63	60
12	0.75	60
16	0.83	60

Cable Sizes: Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
24	1.10	80
36	1.21	80
50	1.50	80

3. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Belden.
   d. "Or-equal."

H. Type 7, Multiconductor Metal-Clad (UL Type MC) Power Cable:

1. Meeting requirements of UL 44 and UL 1569.
2. Conductors:
   a. Class B stranded, coated copper.
   b. Insulation: 600-volt cross-linked polyethylene, UL Type XHHW or EPR.
   c. Grounding Conductors: Bare, stranded copper.
3. Sheath:
   a. UL listed Type MC.
   b. Continuous welded, corrugated aluminum sheath.
   c. Suitable for use as grounding conductor.
4. Outer Jacket: PVC per UL 1569.
5. Cable shall pass ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
6. Cable Sizes:

Conductor Size	Minimum Ground Wire Size (AWG)	No. of Insulated Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
12 AWG	12 or 3x16	3 4	0.79 0.85	50
10 AWG	10 or 3x14	3 4	0.82 0.90	50
8 AWG	10 or 3x14	3 4	0.85 1.00	50
6 AWG	8 or 3x12	3 4	0.99 1.10	50
4 AWG	8 or 3x12	3 4	1.08 1.20	50

Conductor Size	Minimum Ground Wire Size (AWG)	No. of Insulated Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
2 AWG	6 or 3x10	3 4	1.24 1.45	50
1 AWG	6 or 3x10	3 4	1.40 1.55	50
1/0 KCM	6 or 3x10	3 4	1.52 1.60	50
2/0 AWG	4 or 3x8	3 4	1.67 1.75	50
4/0 AWG	4 or 3x8	3 4	1.93 2.10	60
250 KCM	4 or 3x8	3 4	2.11 2.20	60
350 KCM	3 or 3x8	3 4	2.39 2.50	60
500 KCM	2 or 3x8	3 4	2.80 2.90	75

7. Manufacturers and Products:
   a. Okonite Co.; Type CLX.
   b. Southwire Type MC.
   c. General Cable, CCW Armored Power.
   d. "Or-equal."

I. Type 8, Multiconductor Adjustable Frequency Drive Power Cable:

1. Conductors:
   a. Class B, stranded coated copper.
   b. Insulation: 600-volt cross-linked polyethylene, UL Type XHHW-2.
   c. Grounding Conductors: Insulated stranded copper.
2. Sheath:
   a. UL 1277 Type TC, 90 degrees C.
   b. Continuous shield, A1/polyester foil, drain wires, overall copper braid.
3. Outer Jacket: Polyvinyl chloride (PVC) per UL 1569.

4. Cable Sizes:

Conductor Size	Minimum Ground Wire Size (AWG)	No. of Insulated Conductors	Max. Outside Diameter (Inches)	Minimum Jacket Thickness (Mils)
12 AWG	12	4	0.655	50
10 AWG	10	4	0.769	50
8 AWG	8	4	0.940	50
6 AWG	6	4	1.038	50
4 AWG	4	4	1.180	50
2 AWG	2	4	1.351	50

5. Manufacturers and Products:
   a. Alpha Wire; Series V.
   b. Belden; Series 29500.
   c. LAPP USA; OLFLEX VFD Slim.
   d. "Or-equal."

J. Type 9, Multiconductor Metal-Clad (UL Type MC) Power Cable for Adjustable Frequency Drive Applications:

1. Meeting requirements of UL 44 and UL 1569.
2. Conductors:
   a. Class B, stranded coated copper.
   b. Insulation: 600-volt cross-linked polyethylene, UL Type XHHW or EPR.
   c. Grounding Conductors: Bare, stranded copper. Provide three symmetrical grounding conductors.
3. Sheath:
   a. UL listed Type MC.
   b. Continuous welded, corrugated aluminum sheath.
   c. Suitable for use as grounding conductor.
4. Outer Jacket: PVC per UL 1569.
5. Cable shall pass ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.

6. Cable Sizes:

Conductor Size	Minimum Ground Wire Size (AWG)	No. of Insulated Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
12 AWG	3x16	3 4	0.79 0.85	50
10 AWG	3x14	3 4	0.82 0.90	50
8 AWG	3x14	3 4	0.85 1.00	50
6 AWG	3x12	3 4	0.99 1.10	50
4 AWG	3x12	3 4	1.08 1.20	50
2 AWG	3x10	3 4	1.24 1.45	50
1 AWG	3x10	3 4	1.40 1.55	50
1/0 KCM	3x10	3 4	1.52 1.60	50
2/0 AWG	3x8	3 4	1.67 1.75	50
4/0 AWG	3x8	3 4	1.93 2.10	60
250 KCM	3x8	3 4	2.11 2.20	60
350 KCM	3x8	3 4	2.39 2.50	60
500 KCM	3x8	3 4	2.80 2.90	75

7. Manufacturer and Product:
   a. Okonite Co.; Type CLX MC-HL.
   b. Southwire Co.
   c. “Or-equal.”

2.04 300-VOLT RATED CABLE

A. General:

1. Type PLTC, meeting requirements of UL 13 and NFPA 70, Article 725.
2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
3. Suitable for installation in open air, in cable trays, or conduit.
4. Minimum Temperature Rating: 105 degrees C.
5. Passes Vertical Tray Flame Test.
6. Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.

B. Type 20, 16 AWG, Twisted, Shielded Pair Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57.

1. Outer Jacket: 35-mil nominal.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
3. Dimension: 0.26-inch nominal OD.
4. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, ASTM B8.
   b. 20 AWG, seven-strand tinned copper drain wire.
   c. Insulation: 15-mil PVC.
   d. Color Code: Pair conductors black and white.
5. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. "Or-equal."

C. Type 21, 16 AWG, Twisted, Shielded Triad Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting requirements of NEMA WC 57.

1. Outer Jacket: 35-mil nominal thickness.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
3. Dimension: 0.28-inch nominal OD.
4. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, ASTM B8.
   b. 20 AWG, seven-strand tinned copper drain wire.
   c. Insulation: 15-mil PVC.
   d. Color Code: Triad conductors; black, red, and white.

5. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. "Or-equal."

D. Type 22, 18 AWG, Multitwisted, Shielded Pairs with a Common Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable meeting NEMA WC 57.

1. Conductors:

   a. Bare soft annealed copper, Class B, seven-strand concentric, ASTM B8.
   b. Tinned copper drain wires.
   c. Pair drain wire size AWG 20, group drain wire size AWG 18.
   d. Insulation: 15-mil PVC.
   e. Color Code: Pair conductors black and white; white conductor numerically printed for group identification.
   f. Individual Pair Shield: 1.35-mil aluminum/mylar.
   g. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.

2. Cable Sizes:

Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.50	50
8	0.66	60
12	0.79	60
16	0.91	60
24	1.13	70
36	1.31	70
50	1.55	80

3. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Belden.
   d. "Or-equal."

E. Type 23, 18 AWG, Multitwisted Pairs with Common Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable meeting NEMA WC 57.

1. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, ASTM B8.
   b. Tinned copper.
   c. Group drain wire size AWG 20, minimum.
   d. Insulation: 15-mil PVC.
   e. Color Code: Pair conductors black and white; white conductor numerically printed for group identification.
   f. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.

2. Cable Sizes:

Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.48	50
8	0.63	60
12	0.73	60
16	0.77	60
24	0.96	70
36	1.09	70
50	1.45	50

3. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Belden.
   d. “Or-equal.”

F. Type 24, Twisted Pair Fire Alarm Cable, Shielded: Power limited fire protective signaling circuit cable meeting requirements of NFPA 70, Article 760.

1. Cable: Pass NFPA 262, 70,000 Btu flame test and listed by State Fire Marshall.
2. Outer Jacket: Red in color, identified along its entire length as fire protective signaling circuit cable.

3. Conductors:
   a. Solid, tinned, or bare copper, shielded, with stranded tinned copper drain wire.
   b. Insulation: 15-mil PVC.
   c. Shield: Aluminum/mylar spiral wound along entire length.
4. Cable Sizes:

Wire Size	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Inches)
12	0.36	0.042
14	0.32	0.042
16	0.26	0.037
18	0.23	0.037

5. Manufacturers:
   a. West Penn Wire.
   b. Coleman Cable, Inc.
   c. "Or-equal."

2.05 SPECIAL CABLES

A. Type 30, Unshielded Twisted Pair (UTP) Telephone and Data Cable, 600V:

1. Category 6 UTP, UL listed, and third party verified to comply with TIA/EIA 568-C Category 6 requirements.
2. Suitable for high speed network applications including gigabit ethernet and video. Cable shall be interoperable with other standards compliant products and shall be backward compatible with Category 5 and Category 5e.
3. Provide four each individually twisted pair, 23 AWG conductors, with FEP insulation and blue PVC jacket.
4. NFPA 70 Plenum (CMP) rated; comply with flammability plenum requirements of NFPA 70 and NFPA 262.
5. Cable shall withstand a bend radius of 1-inch minimum at a temperature of minus 20 degrees C maximum without jacket or insulation cracking.
6. Manufacturer and Product:
   a. Belden; 7852A.
   b. Siemon, 9C6P4.
   c. "Or-equal."

B. Type 35, meter cable, 600V, 18 AWG, twisted, shielded triad instrumentation cable: single triad designed for noise rejection for data transmission

applications meeting IECA S-82-552 90 degrees C wet or dry, 600 volt requirements.

1. Conductor: Tinned, annealed copper in accordance with ASTM B33, Class B stranding according to ASTM B8.
2. Insulation: Extruded flame-retardant cross-linked polyolefin (XLP).
3. Triad: Three conductors twisted together with a drain wire and aluminum Mylar shield.
4. Cable: Shielded triads cabled together with fillers as needed to form a round core. An overall aluminum Mylar shield and drain wire is applied over the core.
5. Color Code: Triads are black, white, and red with the triad number printed on the white conductor.
6. Jacket: Flame-retardant, sunlight-resistant, ER rated chlorinated polyethylene (CPE).
7. Manufacturers:
   a. Continental Wire and Cable.
   b. Belden.
   c. “Or-equal.”

2.06 GROUNDING CONDUCTORS

A. Equipment: Stranded copper with green, Type USE/RHH/RHW-XLPE or THHN/THWN, insulation.

B. Direct Buried: Bare stranded copper.

2.07 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

A. Tape:

1. General-purpose, Flame-retardant: 7-mil, vinyl plastic, rated for 90 degrees C minimum, meeting requirements of UL 510.
2. Flame-retardant, Cold- and Weather-resistant: 8.5-mil, vinyl plastic.
3. Arc and Fireproofing:
   a. 30-mil, elastomer.
   b. Manufacturers and Products:
      1) 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tapebinder.
      2) Plymouth; 53 Plyarc, with 77 Plyglas glass cloth tapebinder.

B. Identification Devices:

1. Sleeve:
   a. Permanent, PVC, yellow or white, with legible machine-printed black markings.

b. Manufacturers and Products:
1) Raychem; Type D-SCE or ZH-SCE.
2) Brady, Type 3PS.
3) "Or-equal."

2. Heat Bond Marker:
a. Transparent thermoplastic heat bonding film with acrylic pressure sensitive adhesive.
b. Self-laminating protective shield over text.
c. Machine printed black text.

3. Marker Plate: Nylon, with legible designations permanently hot stamped on plate.

4. Tie-on Cable Marker Tags:
a. Chemical-resistant white tag.
b. Size: 1/2 inch by 2 inches.

5. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum.

C. Connectors and Terminations:

1. Nylon, Self-Insulated Crimp Connectors:
a. Manufacturers and Products:
1) Thomas & Betts; Sta-Kon.
2) Burndy; Insulug.
3) ILSCO.

2. Nylon, Self-insulated, Crimp Locking-Fork, Torque-Type Terminator:
a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
b. Seamless.
c. Manufacturers and Products:
1) Thomas & Betts; Sta-Kon.
2) Burndy; Insulink.
3) ILSCO; ILSCONS.
4) "Or-equal."

3. Self-insulated, Freespring Wire Connector (Wire Nuts):
a. UL 486C.
b. Plated steel, square wire springs.
c. Manufacturers and Products:
1) Thomas & Betts.
2) Ideal; Twister.
3) "Or-equal."

4. Self-insulated, Set Screw Wire Connector:
a. Two piece compression type with set screw in brass barrel.
b. Insulated by insulator cap screwed over brass barrel.

c. Manufacturers:
1) 3M Co.
2) Thomas & Betts.
3) Marrette.
4) “Or-equal.”

D. Cable Lugs:

1. In accordance with NEMA CC 1.
2. Rated 600 volts of same material as conductor metal.
3. Uninsulated Crimp Connectors and Terminators:
a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
b. Manufacturers and Products:
1) Thomas & Betts; Color-Keyed.
2) Burndy; Hydent.
3) ILSCO.
4) “Or-equal.”
4. Uninsulated, Bolted, Two-way Connectors and Terminators:
a. Manufacturers and Products:
1) Thomas & Betts; Locktite.
2) Burndy; Quiklug.
3) ILSCO.
4) “Or-equal.”

E. Cable Ties: Nylon, adjustable, self-locking, and reusable.

F. Heat-shrinkable Insulation:

1. Thermally stabilized cross-linked polyolefin.
2. Single-wall for insulation and strain relief.
3. Dual-wall, adhesive sealant lined, for sealing and corrosion resistance.
4. Manufacturers and Products:
a. Thomas & Betts; SHRINK-KON.
b. Raychem; RNF-100 and ES-2000.
c. “Or-equal.”

2.08 ACCESSORIES FOR CONDUCTORS ABOVE 600 VOLTS

A. Molded Splice Kits:

1. Components necessary to provide insulation, metallic shielding and grounding systems, and overall jacket.
2. Capable of making splices with a current rating equal to, or greater than cable ampacity, conforming to IEEE 404.
3. Class 15 kV, with compression connector, EPDM semiconductive insert, peroxide-cured EPDM insulation, and EPDM molded semiconductive outer shield.

4. Premolded splice shall be rejacketed with a heat shrinkable adhesive-lined sleeve to provide a waterproof seal.
5. Manufacturers:
    a. Elastimold.
    b. Cooper Industries.
    c. “Or-equal.”

B. Heat-shrinkable Splice Kits:

1. Components necessary to provide insulation, metallic shielding and grounding systems, and overall jacket.
2. Capable of making splices with a current rating equal to, or greater than, cable ampacity, conforming to IEEE 404.
3. Class 15 kV, with compression connector, splice insulating and conducting sleeves, stress-relief materials, shielding braid and mesh, and abrasion-resistant heat shrinkable adhesive-lined rejacketing sleeve to provide a waterproof seal.
4. Manufacturers:
    a. Raychem.
    b. 3M Co.
    c. “Or-equal.”

C. Termination Kits:

1. Capable of terminating 15 kV, single-conductor, polymeric-insulated shielded cables plus a shield ground clamp.
2. Capable of producing a termination with a current rating equal to, or greater than, cable ampacity meeting Class 1 requirements of IEEE 48.
3. Capable of accommodating cable shielding or construction without need for special adapters or accessories.
4. Manufacturers:
    a. Raychem.
    b. 3M Co.
    c. “Or-equal.”

D. Bus Connection Insulation:

1. Heat-shrinkable tubing, tape, and sheets of flexible cross-linked polymeric material formulated for high dielectric strength.
2. Tape and sheet products to have coating to prevent adhesion to metal surfaces.
3. Insulating materials to be removable and reusable.

E. Elbow Connector Systems:

1. Molded, peroxide-cured, EPDM-insulated, Class 15 kV, 95 kV BIL, 600A, 40,000 rms nonload-break elbows, having copper current-carrying parts in accordance with IEEE 386.

2. Protective Caps: Class 15 kV, 95 kV BIL, 600 amperes, with molded EPDM insulated body.
3. Insulated Standoff Bushings: Class 15 kV, 95 kV BIL, 600 amperes, complete with EPDM rubber body, stainless steel eyebolt with brass pressure foot, and stainless steel base bracket.
4. Bushing Inserts: Class 15 kV, 95 kV BIL, 600 amperes, nonload-break with EPDM rubber body and all-copper, current-carrying parts.
5. Junctions: Class 15 kV, 95 kV four-way, 600 amperes, nonload-break, having EPDM rubber body mounted on adjustable bracket.
6. Mounting Plates: Four-way, ASTM A167 stainless steel, complete with universal mounting brackets, grounding lugs and two parking stands.
7. Manufacturers:
   a. Cooper Industries.
   b. Elastimold.
   c. "Or-equal."

F. Cable Lugs:

1. In accordance with NEMA CC1.
2. Rated 15 kV of same material as conductor metal.
3. Manufacturers and Products, Uninsulated Compression Connectors and Terminators:
   a. Burndy; Hydent.
   b. Thomas & Betts; Color-keyed.
   c. ILSCO.
   d. "Or-equal."
4. Manufacturers and Products, Uninsulated, Bolted, Two-way Connectors and Terminators:
   a. Thomas & Betts; Locktite.
   b. ILSCO.
   c. "Or-equal."

2.09 CABLE FAULT DETECTION SYSTEM

A. One fault sensor for each phase conductor prewired with lead cable extending to remote indicator target.

B. Magnetically operated, automatic indicator target.

C. Nonresettable, unless all three phases are fault free.

D. Sensor/indicator target sealed for submersible operation.

E. Trip Rating: 300 amperes.

F. Fault powered with a normal current flow rating in excess of 5 amperes.

G. Portable, Handheld Cable Fault Tester: One.

H. Equip each sensor with auxiliary relay contacts for remote monitoring.

I. Manufacturers and Products:

1. Cooper Industries; Type CR3.
2. AB Chance.
3. “Or-equal.”

2.10 PULLING COMPOUND

A. Nontoxic, noncorrosive, noncombustible, nonflammable, water-based lubricant; UL listed.

B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.

C. Approved for intended use by cable manufacturer.

D. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.

E. Manufacturers:

1. Ideal Co.
2. Polywater, Inc.
3. Cable Grip Co.
4. “Or-equal.”

2.11 BUSWAY

A. Low impedance, copper bus bar, indoor type with 1/2 neutral and internal ground bus.

B. UL listed for support and spacing provided, meeting NFPA 70 requirements, and totally enclosed throughout its length.

C. Suitable for mounting in vertical (edgewise) or horizontal position without derating, and capable of withstanding short-circuit of 100,000 amperes.

2.12 MANUFACTURED WIRING SYSTEMS

A. System Rating:

1. 20 amperes load-carrying capacity each phase with final assemblies consisting of maximum of three-phase conductors.
2. Composition: Type MC cable with 90 degrees C insulation and stranded copper conductors.

B. Cable Configuration: Three, single-phase, five-wire circuit with standard color wire coding:

1. 208/120 Volt: Black, red, blue, white, green.
2. 480/277 Volt: Brown, orange, yellow, white, green.

C. Locking Mechanism: Latch/strike with voltage clearly marked on latch.

D. NFPA 262 listed for use in air handling plenums, listed to connect or disconnect under load, and manufactured in accordance with NFPA 70, Article No. 604.

2.13 WARNING TAPE

A. As specified in Section 26 05 33, Raceway and Boxes.

2.14 SOURCE QUALITY CONTROL

A. Conductors 600 Volts and Below: Test in accordance with UL 44 and UL 854.

B. Conductors Above 600 Volts: Test in accordance with NEMA WC 71 and AEIC CS 8 partial discharge level test for EPR insulated cable.

PART 3 EXECUTION

3.01 GENERAL

A. Conductor installation shall be in accordance with manufacturer's recommendations.

B. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.

C. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii. Install cable using cable tension meter and record highest level during cable pull.

D. Terminate conductors and cables, unless otherwise indicated.

E. Tighten screws and terminal bolts in accordance with UL 486A-486B for copper conductors and aluminum conductors.

F. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.

G. Bundling: Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 18 inches on center.

H. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.

I. Concrete-Encased Raceway Installation: Prior to installation of conductors, pull through each raceway a mandrel approximately 1/4 inch smaller than raceway inside diameter.

J. Cable Tray Installation:

1. Install wire and cable parallel and straight in tray.
2. Bundle, in groups, wire and cable of same voltage having a common routing and destination; use cable ties, at maximum intervals of 8 feet.
3. Clamp cable bundles prior to making end termination connections.
4. Separate cables of different voltage rating in same cable tray with barriers.
5. Fasten wires, cables, and bundles to tray with nylon cable straps at the following maximum intervals:
   a. Horizontal Runs: 20 feet.
   b. Vertical Runs: 5 feet.

3.02 POWER CONDUCTOR COLOR CODING

A. Conductors 600 Volts and Below:

1. 6 AWG and Larger: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering area 1-1/2 inches to 2 inches wide.
2. 8 AWG and Smaller: Provide colored conductors.
3. Colors:

System	Conductor	Color
All Systems	Equipment Grounding	Green
240/120 Volts, Single-Phase, Three-Wire	Grounded Neutral One Hot Leg Other Hot Leg	White Black Red
208Y/120 Volts, Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Black Red Blue
240/120 Volts, Three-Phase, Four-Wire, Delta, Center Tap, Ground on Single-Phase	Grounded Neutral Phase A High (wild) Leg Phase C	White Black Orange Blue

System	Conductor	Color
480Y/277 Volts, Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Brown Orange Yellow
Note: Phase A, B, C implies direction of positive phase rotation.		

4. Tracer: Outer covering of white with identifiable colored strip, other than green, in accordance with NFPA 70.

B. Conductors Above 600 Volts:

1. Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering area 1-1/2 inches to 2 inches wide.
2. Colors:
   a. Grounded Neutral: White.
   b. Phase A: Brown.
   c. Phase B: Orange.
   d. Phase C: Yellow.

3.03 CIRCUIT IDENTIFICATION

A. Identify power, instrumentation, and control conductor circuits at each termination, and in accessible locations such as manholes, handholes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.

B. Circuits Appearing in Circuit Schedules: Identify using circuit schedule designations.

C. Circuits Not Appearing in Circuit Schedules:

1. Assign circuit name based on device or equipment at load end of circuit.
2. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.

D. Method:

1. Conductors 3 AWG and Smaller: Identify with sleeves or heat bond markers.
2. Cables and Conductors 2 AWG and Larger:
   a. Identify with marker plates or tie-on cable marker tags.
   b. Attach with nylon tie cord.
3. Taped-on markers or tags relying on adhesives not permitted.

3.04 CONDUCTORS 600 VOLTS AND BELOW

A. Install 10 AWG or 12 AWG conductors for branch circuit power wiring in lighting and receptacle circuits.

B. Do not splice incoming service conductors and branch power distribution conductors 6 AWG and larger, unless specifically indicated or approved by Engineer.

C. Connections and Terminations:

1. Install wire nuts only on solid conductors. Wire nuts are not allowed on stranded conductors.
2. Install nylon self-insulated crimp connectors and terminators for instrumentation and control, circuit conductors.
3. Install self-insulated, set screw wire connectors for two-way connection of power circuit conductors 12 AWG and smaller.
4. Install uninsulated crimp connectors and terminators for instrumentation, control, and power circuit conductors 4 AWG through 2/0 AWG.
5. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors 3/0 AWG and larger.
6. Install uninsulated terminators bolted together on motor circuit conductors 10 AWG and larger.
7. Place no more than one conductor in any single-barrel pressure connection.
8. Install crimp connectors with tools approved by connector manufacturer.
9. Install terminals and connectors acceptable for type of material used.
10. Compression Lugs:
    a. Attach with a tool specifically designed for purpose. Tool shall provide complete, controlled crimp and shall not release until crimp is complete.
    b. Do not use plier-type crimpers.

D. Do not use soldered mechanical joints.

E. Splices and Terminations:

1. Insulate uninsulated connections.
2. Indoors: Use general-purpose, flame-retardant tape or single wall heat shrink.
3. Outdoors, Dry Locations: Use flame-retardant, cold- and weather-resistant tape or single wall heat-shrink.
4. Below Grade and Wet or Damp Locations: Use dual wall heat-shrink.

F. Cap spare conductors with UL listed end caps.

G. Cabinets, Panels, and Motor Control Centers:

1. Remove surplus wire, bridle and secure.
2. Where conductors pass through openings or over edges in sheet metal, remove burrs, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.

H. Control and Instrumentation Wiring:

1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions.
3. Locate splices in readily accessible cabinets or junction boxes using terminal strips.
4. Where connections of cables installed under this section are to be made under Section 40 90 01, Instrumentation and Control for Process Systems, leave pigtails of adequate length for bundled connections.
5. Cable Protection:
   a. Under Infinite Access Floors: May install without bundling.
   b. All Other Areas: Install individual wires, pairs, or triads in flex conduit under floor or grouped into bundles at least 1/2 inch in diameter.
   c. Maintain integrity of shielding of instrumentation cables.
   d. Ensure grounds do not occur because of damage to jacket over shield.

I. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies.

3.05 CONDUCTORS ABOVE 600 VOLTS

A. Do not splice unless specifically indicated or approved by Engineer.

B. Make joints and terminations with splice and termination kits, in accordance with kit manufacturer's instructions.

C. Install splices or terminations as continuous operation in accessible locations under clean, dry conditions.

D. Single Conductor Cable Terminations: Provide heat shrinkable stress control and outer nontracking insulation tubings, high relative permittivity stress relief mastic for insulation shield cutback treatment, and a heat-activated sealant for environmental sealing, plus a ground braid and clamp.

E. Install terminals or connectors acceptable for type of conductor material used.

F. Provide outdoor rain skirts for riser pole and outdoor switchgear terminations.

G. Provide shield termination and grounding for terminations.

H. Provide necessary mounting hardware, covers, and connectors.

I. Where elbow connectors are specified, install in accordance with manufacturer's instructions.

J. Connections and Terminations:

1. Install uninsulated crimp connectors and terminators for power circuit conductors 4 AWG and larger.
2. Install uninsulated, bolted, two-way connectors for motor circuit conductors No. 12 and larger.
3. Insulate bus connections with heat shrinking tubing, tape, and sheets.
4. Make bus connections removable and reusable in accordance with manufacturer's instructions.

K. Give 2 working days' notice to Engineer prior to making splices or terminations.

3.06 CONDUCTOR ARC AND FIREPROOFING

A. Install arc and fireproofing tape on 15 kV cables in manholes, handholes, vaults, cable trays, and other indicated locations.

B. Wrap conductors of same circuit entering from separate conduit together as single cable.

C. Follow tape manufacturer's installation instructions.

D. Secure tape at intervals of 10 feet with bands of tapebinder. Each band to consist of a minimum of two wraps directly over each other.

3.07 CABLE FAULT DETECTION SYSTEM

A. Install remote indicator target, externally exposed, on side of equipment enclosure in which cable terminates.

B. Mounting Height: Minimum 36 inches, maximum 60 inches from floor.

3.08 BUSWAY

A. Install in strict accordance with manufacturer's recommendations and NFPA 70.

B. Maximum Support Spacing: 5 feet.

3.09 UNDERGROUND DIRECT BURIAL CABLE

A. Install in trench as specified in Section 31 23 23.15, Trench Backfill.

B. Warning Tape: Install approximately 6 inches above cable, aligned parallel to, and within 12 inches of centerline of the run.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SYSTEM DESCRIPTION

A. Section includes grounding and bonding systems and equipment.

B. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Ground bonding common with lightning protection system.
3. Foundation steel electrodes.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Product data for the following:
   a. Exothermic weld connectors.
   b. Mechanical connectors.
   c. Compression connectors.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

PART 2 PRODUCTS

2.01 GROUND ROD

A. Material: Copper-clad steel.

B. Diameter: Minimum 3/4 inch.

C. Length: 10 feet.

2.02 GROUND CONDUCTORS

A. Insulated Conductors: tinned-copper wire or cable insulated for 600V, unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B3.
2. Stranded Conductors: ASTM B8.
3. Tinned Conductors: ASTM B33.
4. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 inch by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches (28 mm) apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600V and shall be Lexan or PVC, impulse tested at 5,000V.

2.03 CONNECTORS

A. Exothermic Weld Type:

1. Outdoor Weld: Suitable for exposure to elements or direct burial.
2. Indoor Weld: Use low-smoke, low-emission process.
3. Manufacturers:
   a. Erico Products, Inc.; Cadweld and Cadweld Exolon.
   b. Thermoweld.
   c. “Or-equal.”

B. Compression Type:

1. Compress-deforming type; wrought copper extrusion material.
2. Single indentation for conductors 6 AWG and smaller.
3. Double indentation with extended barrel for conductors 4 AWG and larger.
4. Barrels prefilled with oxide-inhibiting and antiseizing compound and sealed.
5. Manufacturers:
   a. Burndy Corp.
   b. Thomas and Betts Co.
   c. ILSCO.
   d. “Or-equal.”

C. Mechanical Type: Split-bolt, saddle, or cone screw type; copper alloy material.

1. Manufacturers:
   a. Burndy Corp.
   b. Thomas and Betts Co.
   c. “Or-equal.”

2.04 GROUNDING WELLS

A. Ground rod box complete with cast iron riser ring and traffic cover marked GROUND ROD.

B. Manufacturers and Products:

1. Christy Co.; No. G5.
2. Lightning and Grounding Systems, Inc.; I-R Series.
3. “Or-equal.”

PART 3 EXECUTION

3.01 GENERAL

A. Grounding shall be in compliance with NFPA 70 and IEEE C2.

B. Ground electrical service neutral at service entrance equipment to supplementary grounding electrodes.

C. Ground each separately derived system neutral to nearest effectively grounded building structural steel member or separate grounding electrode.

D. Bond together system neutrals, service equipment enclosures, exposed noncurrent-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems.

E. Shielded Power Cables: Ground shields at each splice or termination in accordance with recommendations of splice or termination manufacturer.

F. Shielded Instrumentation Cables:

1. Ground shield to ground bus at power supply for analog signal.
2. Expose shield minimum 1 inch at termination to field instrument and apply heat-shrink tube.
3. Do not ground instrumentation cable shield at more than one point.

G. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each above ground portion of gas piping system downstream from equipment shutoff valve.

3.02 WIRE CONNECTIONS

A. Ground Conductors: Install in conduit containing power conductors and control circuits above 50 volts.

B. Nonmetallic Raceways and Flexible Tubing: Install equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.

C. Connect ground conductors to raceway grounding bushings.

D. Extend and connect ground conductors to ground bus in all equipment containing a ground bus.

E. Connect enclosure of equipment containing ground bus to that bus.

F. Bolt connections to equipment ground bus.

G. Bond grounding conductors to metallic enclosures at each end, and to intermediate metallic enclosures.

H. Junction Boxes: Furnish materials and connect to equipment grounding system with grounding clips mounted directly on box, or with 3/8-inch machine screws.

3.03 MOTOR GROUNDING

A. Extend equipment ground bus via grounding conductor installed in motor feeder raceway; connect to motor frame.

B. Nonmetallic Raceways and Flexible Tubing: Install an equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.

C. Motors Less Than 10 hp: Furnish compression, spade-type terminal connected to conduit box mounting screw.

D. Motors 10 hp and Above: Tap motor frame or equipment housing; furnish compression, one-hole, lug type terminal connected with minimum 5/16-inch brass threaded stud with bolt and washer.

E. Circuits 20 Amps or Above: Tap motor frame or equipment housing; install solderless terminal with minimum 5/16-inch diameter bolt.

3.04 GROUND RODS

A. Install full length with conductor connection at upper end.

B. Install with connection point below finished grade, unless otherwise shown.

C. Space multiple ground rods by one rod length.

3.05 GROUNDING WELLS

A. Install where shown on Drawings.

B. Place 9 inches of crushed rock in bottom of each well.

3.06 CONNECTIONS

A. General:

1. Abovegrade Connections: Install exothermic weld, mechanical, or compression-type connectors; or brazing.
2. Belowgrade Connections: Install exothermic weld type connectors.
3. Remove paint, dirt, or other surface coverings at connection points to allow good metal-to-metal contact.
4. Notify Engineer prior to backfilling ground connections.

B. Exothermic Weld Type:

1. Wire brush or file contact point to bare metal surface.
2. Use welding cartridges and molds in accordance with manufacturer's recommendations.
3. Avoid using badly worn molds.
4. Mold to be completely filled with metal when making welds.
5. After completed welds have cooled, brush slag from weld area and thoroughly clean joint.

C. Compression Type:

1. Install in accordance with connector manufacturer's recommendations.
2. Install connectors of proper size for grounding conductors and ground rods specified.
3. Install using connector manufacturer's compression tool having proper sized dies.

D. Mechanical Type:

1. Apply homogeneous blend of colloidal copper and rust and corrosion inhibitor before making connection.
2. Install in accordance with connector manufacturer's recommendations.
3. Do not conceal mechanical connections.

3.07 METAL STRUCTURE GROUNDING—NEW BUILDINGS

A. Ground metal sheathing and exposed metal vertical structural elements to grounding system.

B. Bond electrical equipment supported by metal platforms to the platforms.

C. Provide electrical contact between metal frames and railings supporting pushbutton stations, receptacles, and instrument cabinets, and raceways carrying circuits to these devices.

D. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

E. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building.

1. Install tinned-copper conductor not less than 4/0 AWG for ground ring and for taps to building steel.
2. Bury ground ring not less than 24 inches from building's foundation.

F. Concrete-encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4/0 AWG.

1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and

connect to building's grounding grid or to grounding electrode external to concrete.

3.08 MANHOLE AND HANDHOLE GROUNDING

A. Grounding Manholes and Handholes: Install two driven ground rods adjacent to manhole or handhole close to wall. If necessary, install ground rod before manhole is placed and provide No. 4/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Install No. 4/0 AWG bare copper ground ring around entire manhole strapped to inside wall. Protect ground rods passing through concrete with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal opening with waterproof, nonshrink grout.

B. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4/0 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

3.09 TRANSFORMER GROUNDING

A. Bond neutrals of transformers within buildings to system ground network, and to any additional indicated grounding electrodes.

B. Bond neutrals of substation transformers to substation grounding grid and system grounding network.

C. Bond neutrals of pad-mounted transformers to four locally driven ground rods and buried ground wire encircling transformer and system ground network.

D. Pad-Mounted Transformers and Switches: Install four ground rods and ground ring at minimum of 2 feet below grade around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with transformers and switches by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring no less than 6 inches from the foundation.

3.10 SURGE PROTECTION EQUIPMENT GROUNDING

A. Connect surge arrestor ground terminals to equipment ground bus.

END OF SECTION

SECTION 26 05 33
RACEWAY AND BOXES

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Manufacturer's Literature:
   a. Rigid galvanized steel conduit.
   b. Rigid aluminum conduit.
   c. Electric metallic tubing.
   d. PVC Schedule 40 conduit.
   e. PVC-coated rigid galvanized steel conduit, submittal to include copy of manufacturer's warranty.
   f. Flexible metal, liquid-tight conduit.
   g. Flexible, nonmetallic, liquid-tight conduit.
   h. Flexible metal, nonliquid-tight conduit.
   i. Conduit fittings.
   j. Wireways.
   k. Surface metal raceway.
   l. Device boxes for use in hazardous areas.
   m. Junction and pull boxes used at or below grade.
   n. Large junction and pull boxes.
   o. Terminal junction boxes.
2. Equipment and machinery proposed for bending metal conduit.
3. Method for bending PVC conduit less than 30 degrees.
4. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.
5. Conduit Layout:
   a. Provide drawings for conduit installations underground and concealed conduits including, but not limited to duct banks, under floor slabs, concealed in floor slabs, and concealed in walls.
   b. Provide plan and section showing arrangement and location of conduit and duct bank required for:
      1) Low and medium voltage feeder and branch circuits.
      2) Instrumentation and control systems.
      3) Communications systems.
      4) Empty conduit for future use.
   c. Electronic CAD; scale not greater than 1 inch equals 20 feet.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
3. Manufacturer's certification of training for PVC-coated rigid galvanized steel conduit installer.

1.02 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

B. PVC-Coated, Rigid Galvanized Steel Conduit Installer: Certified by conduit manufacturer as having received minimum 2 hours of training on installation procedures.

PART 2 PRODUCTS

2.01 CONDUIT AND TUBING

A. Rigid Galvanized Steel Conduit (RGS):

1. Meet requirements of NEMA C80.1 and UL 6.
2. Material: Hot-dip galvanized with chromated protective layer.

B. Rigid Aluminum Conduit:

1. Meet requirements of NEMA C80.5 and UL 6A.
2. Material: Type 6063, copper-free aluminum alloy.

C. PVC Schedule 40 Conduit:

1. Meet requirements of NEMA TC 2 and UL 651.
2. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors.

D. PVC-coated Rigid Galvanized Steel Conduit:

1. Meet requirements of NEMA RN 1.
2. Material:
   a. Meet requirements of NEMA C80.1 and UL 6.
   b. Exterior Finish: PVC coating, 40-mil nominal thickness; bond to metal shall have tensile strength greater than PVC.
   c. Interior finish: Urethane coating, 2-mil nominal thickness.
3. Threads: Hot-dipped galvanized and factory coated with urethane.
4. Bendable without damage to interior or exterior coating.

E. Flexible Metal, Liquid-tight Conduit:

1. UL 360 listed for 105 degrees C insulated conductors.
2. Material: Galvanized steel with extruded PVC jacket.

F. Flexible Metal, Nonliquid-tight Conduit:

1. Meet requirements of UL 1.
2. Material: Galvanized steel.

G. Flexible, Nonmetallic, Liquid-tight Conduit:

1. Material: PVC core with fused flexible PVC jacket.
2. UL 1660 listed for:
   a. Dry Conditions: 80 degrees C insulated conductors.
   b. Wet Conditions: 60 degrees C insulated conductors.
3. Manufacturers and Products:
   a. Carlon; Carflex or X-Flex.
   b. T & B; Xtraflex LTC or EFC.
   c. "Or-equal."

2.02 FITTINGS

A. Rigid Galvanized Steel Conduit:

1. General:
   a. Meet requirements of UL 514B.
   b. Type: Threaded, galvanized. Set screw and threadless compression fittings not permitted.
2. Bushing:
   a. Material: Malleable iron with integral insulated throat, rated for 150 degrees C.
   b. Manufacturers and Products:
      1) Appleton; Series BU-I.
      2) O-Z/Gedney; Type HB.
      3) "Or-equal."

3. Grounding Bushing:
    a. Material: Malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs.
    b. Manufacturers and Products:
        1) Appleton; Series GIB.
        2) O-Z/Gedney; Type HBLG.
        3) “Or-equal.”
4. Conduit Hub:
    a. Material: Malleable iron with insulated throat with bonding screw.
    b. UL listed for use in wet locations.
    c. Manufacturers and Products:
        1) Appleton, Series HUB-B.
        2) O-Z/Gedney; Series CH.
        3) Meyers; ST Series.
        4) “Or-equal.”
5. Conduit Bodies:
    a. Sized as required by NFPA 70.
    b. Manufacturers and Products (For Normal Conditions):
        1) Appleton; Form 35 threaded unilets.
        2) Crouse-Hinds; Form 7 or Form 8 threaded condulets.
        3) Killark; Series O electrolets.
        4) Thomas & Betts; Form 7 or Form 8.
        5) “Or-equal.”
    c. Manufacturers (For Hazardous Locations):
        1) Appleton.
        2) Crouse-Hinds.
        3) Killark.
        4) “Or-equal.”
6. Couplings: As supplied by conduit manufacturer.
7. Unions:
    a. Concrete tight, hot-dip galvanized malleable iron.
    b. Manufacturers and Products:
        1) Appleton; Series SCC bolt-on coupling or Series EC three-piece union.
        2) O-Z/Gedney; Type SSP split coupling or Type 4 Series, three-piece coupling.
        3) “Or-equal.”
8. Conduit Sealing Fitting:
    a. Manufacturers and Products:
        1) Appleton; Type EYF, EYM, or ESU.
        2) Crouse-Hinds; Type EYS or EZS.
        3) Killark; Type EY or Type EYS.
        4) “Or-equal.”

9. Drain Seal:
    a. Manufacturers and Products:
        1) Appleton; Type EYD.
        2) Crouse-Hinds; Type EYD or Type EZD.
        3) "Or-equal."
10. Drain/Breather Fitting:
    a. Manufacturers and Products:
        1) Appleton; Type ECDB.
        2) Crouse-Hinds; ECD.
        3) "Or-equal."
11. Expansion Fitting:
    a. Manufacturers and Products:
        1) Deflection/Expansion Movement:
            a) Appleton; Type DF.
            b) Crouse-Hinds; Type XD.
            c) "Or-equal."
        2) Expansion Movement Only:
            a) Appleton; Type XJ.
            b) Crouse-Hinds; Type XJ.
            c) Thomas & Betts; XJG-TP.
            d) "Or-equal."
12. Cable Sealing Fitting:
    a. To form watertight nonslip cord or cable connection to conduit.
    b. For Conductors with OD of 1/2 inch or Less: Neoprene bushing at connector entry.
    c. Manufacturers and Products:
        1) Appleton; CG-S.
        2) Crouse-Hinds; CGBS.
        3) "Or-equal."

B. Rigid Aluminum Conduit:
1. General:
    a. Meet requirements of UL 514B.
    b. Type: Threaded, copper-free. Set screw and threadless compression fittings not permitted.
2. Insulated Bushing:
    a. Material: Cast aluminum with integral insulated throat, rated for 150 degrees C.
    b. Manufacturers and Products:
        1) O-Z/Gedney; Type AB.
        2) "Or-equal."
3. Grounding Bushing:
    a. Material: Cast aluminum with integral insulated throat rated for 150 degrees C, with solderless lugs.
    b. Manufacturers and Products:
        1) O-Z/Gedney; Type ABLG.
        2) "Or-equal."

4. Conduit Hub:
    a. Material: Cast aluminum with insulated throat with bonding screw.
    b. UL listed for use in wet locations.
    c. Manufacturers and Products:
        1) O-Z/Gedney; Series CHA.
        2) Meyers; SA Series.
        3) “Or-equal.”
5. Conduit Bodies:
    a. Sized as required by NFPA 70.
    b. Manufacturers and Products (For Normal Conditions):
        1) Appleton; Form 85 threaded unilets.
        2) Crouse-Hinds; Form 9 or Form 7-SA threaded condulets.
        3) Killark; Series O electrolets.
        4) “Or-equal.”
6. Couplings: As supplied by conduit manufacturer.
7. Unions:
    a. Cast aluminum.
    b. Manufacturers and Products:
        1) Appleton.
        2) O-Z/Gedney.
        3) “Or-equal.”
8. Conduit Sealing Fitting:
    a. Manufacturers and Products:
        1) Appleton; Type EYF-AL, EYM-AL.
        2) Crouse-Hinds; Type EYS-SA or EZS-SA.
        3) Killark; Type EY or Type EYS.
        4) “Or-equal.”
9. Drain Seal:
    a. Manufacturers and Products:
        1) Appleton; Type EYDM-A.
        2) Crouse-Hinds; Type EYD-SA or Type EZD-SA.
        3) “Or-equal.”
10. Drain/Breather Fitting:
    a. Manufacturers and Products:
        1) Appleton; Type ECDB.
        2) Crouse-Hinds; ECD.
        3) “Or-equal.”
11. Expansion Fitting:
    a. Manufacturers and Products:
        1) Deflection/Expansion Movement:
            a) Steel City Type DF-A.
            b) “Or-equal.”
        2) Expansion Movement Only:
            a) Steel City Type AF-A.
            b) “Or-equal.”

12. Cable Sealing Fitting:
    a. To form watertight nonslip cord or cable connection to conduit.
    b. For Conductors with OD of 1/2 inch or Less: Neoprene bushing at connector entry.
    c. Manufacturers and Products:
        1) Appleton; CG-S.

C. PVC Conduit and Tubing:

1. Meet requirements of NEMA TC 3.
2. Type: PVC, slip-on.

D. PVC-Coated Rigid Galvanized Steel Conduit:

1. Meet requirements of UL 514B.
2. Fittings: Rigid galvanized steel type, PVC coated by conduit manufacturer.
3. Conduit Bodies: Cast metal hot-dipped galvanized or urethane finish. Cover shall be of same material as conduit body. PVC coated by conduit manufacturer.
4. Finish: 40-mil PVC exterior, 2-mil urethane interior.
5. Overlapping pressure-sealing sleeves.
6. Conduit Hangers, Attachments, and Accessories: PVC-coated.
7. Manufacturers:
    a. Robroy Industries.
    b. Ocal.
    c. “Or-equal.”
8. Expansion Fitting:
    a. Manufacturer and Product:
        1) Ocal; OCAL-BLUE XJG.
        2) PERMA-COTE.
        3) “Or-equal.”

E. Flexible Metal, Liquid-tight Conduit:

1. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C.
2. Insulated throat and sealing O-rings.
3. Manufacturers and Products:
    a. Thomas & Betts; Series 5331.
    b. O-Z/Gedney; Series 4Q.
    c. “Or-equal.”

F. Flexible Metal, Nonliquid-tight Conduit:

1. Meet requirements of UL 514B.
2. Body: Galvanized steel.
3. Throat: Nylon insulated.

4. 1-1/4-Inch Conduit and Smaller: One screw body.
5. 1-1/2-Inch Conduit and Larger: Two screw body.
6. Manufacturer and Product:
    a. Appleton; Series 7400.
    b. Flex Tubes, Series GFC.
    c. "Or-equal."

G. Flexible, Nonmetallic, Liquid-tight Conduit:

1. Meet requirements of UL 514B.
2. Type: High strength plastic body, complete with lock nut, O-ring, threaded ferrule, sealing ring, and compression nut.
3. Body/compression nut (gland) design to ensure high mechanical pullout strength and watertight seal.
4. Manufacturers and Products:
    a. Carlon; Type LT.
    b. O-Z/Gedney; Type 4Q-P.
    c. Thomas & Betts; Series 6300.
    d. "Or-equal."

H. Flexible Coupling, Hazardous Locations:

1. Approved for use in atmosphere involved.
2. Rating: Watertight and UL listed for use in Class I, Division 1 and 2 areas.
3. Outer bronze braid and an insulating liner.
4. Conductivity equal to a similar length of rigid metal conduit.
5. Manufacturers and Products:
    a. Crouse-Hinds; Type ECGJH or Type ECLK.
    b. Appleton; EXGJH or EXLK.
    c. "Or-equal."

I. Watertight Entrance Seal Device:

1. New Construction:
    a. Material: Oversized sleeve, malleable iron body with sealing ring, pressure ring, grommet seal, and pressure clamp.
    b. Manufacturer and Product:
        1) O-Z/Gedney; Type FSK or Type WSK, as required.
        2) Thunderline, Link-Seal.
        3) "Or-equal."

2. Cored-hole Application:
    a. Material: Assembled dual pressure disks, neoprene sealing ring, and membrane clamp.
    b. Manufacturer and Product:
        1) O-Z/Gedney; Series CSM.
        2) Thunderline, Link-Seal.
        3) "Or-equal."

2.03 OUTLET AND DEVICE BOXES

A. Sheet Steel: One-piece drawn type, zinc-plated or cadmium-plated.

B. Cast Metal:

1. Box: Malleable iron.
2. Cover: Gasketed, weatherproof, malleable iron, with stainless steel screws.
3. Hubs: Threaded.
4. Lugs: Cast mounting.
5. Manufacturers and Products, Nonhazardous Locations:
    a. Crouse-Hinds; Type FS or Type FD.
    b. Appleton; Type FS or Type FD.
    c. Killark.
    d. "Or-equal."
6. Manufacturers and Products, Hazardous Locations:
    a. Crouse-Hinds; Type GUA or Type EAJ.
    b. Appleton; Type GR.
    c. "Or-equal."

C. PVC-Coated Cast Metal:

1. Type: One-piece.
2. Material: Malleable iron, cast ferrous metal, or cast aluminum.
3. Coating:
    a. Exterior Surfaces: 40-mil PVC.
    b. Interior Surfaces: 2-mil urethane.
4. Manufacturers:
    a. Robroy Industries.
    b. Ocal.
    c. "Or-equal."

D. Nonmetallic:

1. Box: PVC.
2. Cover: PVC, weatherproof, with stainless steel screws.

2.04 JUNCTION AND PULL BOXES

A. Outlet Box Used as Junction or Pull Box: As specified under Article Outlet and Device Boxes.

B. Conduit Bodies Used as Junction Boxes: As specified under Article Fittings.

C. Large Sheet Steel Box:

1. NEMA 250, Type 1.
2. Box: Code-gauge, galvanized steel.
3. Cover: Full access, screw type.
4. Machine Screws: Corrosion-resistant.

D. Large Cast Metal Box:

1. NEMA 250, Type 4.
2. Box: Cast malleable iron, with drilled and tapped conduit entrances and exterior mounting lugs.
3. Cover: Nonhinged screws.
4. Gasket: Neoprene.
5. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
6. Manufacturers and Products, Surface-mounted Nonhinged Type:
   a. Crouse-Hinds; Series W.
   b. O-Z/Gedney; Series Y.
   c. "Or-equal."
7. Manufacturer and Product, Surface-mounted, Hinged Type: O-Z/Gedney; Series YW; "or-equal."
8. Manufacturers and Products, Recessed Type:
   a. Crouse-Hinds; Type WJBF.
   b. O-Z/Gedney; Series YR.
   c. "Or-equal."

E. Large Cast Metal Box, Hazardous Locations:

1. NEMA 250 Type 7 or Type 9 as required for Class, Division, and Group involved.
2. Box: Cast ferrous metal, electro-galvanize finished or copper-free aluminum with drilled and tapped conduit entrances.
3. Cover: Hinged with screws.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers and Products:
   a. Crouse-Hinds; Type EJB.
   b. Appleton; Type AJBEW.
   c. "Or-equal."

F. Large Stainless Steel Box:

1. NEMA 250 Type 4X.
2. Box: 14-gauge, ASTM A240/A240M, Type 316 stainless steel.
3. Cover: Hinged with screws.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers:
   a. Hoffman Engineering Co.
   b. Robroy Industries.
   c. Wiegman.
   d. "Or-equal."

G. Concrete Box, Nontraffic Areas:

1. Box: Reinforced, cast concrete with extension.
2. Cover: Steel diamond plate with locking bolts.
3. Cover Marking: ELECTRICAL, TELEPHONE, or as shown.
4. Size: 10 inches by 17 inches, minimum.
5. Manufacturers and Products:
   a. Utility Vault Co.; Series 36-1017.
   b. Christy, Concrete Products, Inc.; N9.
   c. Quazite; "PG" Style.
   d. "Or-equal."

H. Concrete Box, Traffic Areas:

1. Box: Reinforced, cast concrete with extension and bottom slab.
2. Cover: Steel checked plate; H/20 loading with screw down.
3. Cover Marking: ELECTRICAL, TELEPHONE, or as shown.
4. Manufacturers and Products:
   a. Christy, Concrete Products, Inc.; B1017BOX.
   b. Utility Vault Co.; 3030 SB.
   c. "Or-equal."

2.05 TERMINAL JUNCTION BOX

A. Cover: Hinged, unless otherwise shown.

B. Interior Finish: Paint with white enamel or lacquer.

C. Terminal Blocks:

1. Separate connection point for each conductor entering or leaving box.
2. Spare Terminal Points: 25 percent, minimum.

2.06 METAL WIREWAYS

A. Meet requirements of UL 870.

B. Type: Steel-enclosed, lay-in type.

C. Cover: Hinged with friction latch.

D. Rating: Outdoor raintight.

E. Finish: Rust inhibiting phosphatizing primer and gray baked enamel.

F. Hardware: Plated to prevent corrosion; screws installed toward the inside protected by spring nuts or otherwise guarded to prevent wire insulation damage.

G. Knockouts: Without knockouts, unless otherwise indicated.

H. Manufacturers:

1. Circle AW.
2. Hoffman.
3. Square D.
4. "Or-equal."

2.07 NONMETALLIC WIREWAY

A. Rating: Outdoor, corrosion resistant, raintight, NEMA Type 12 and Type 3R.

B. Type: Fiberglass-enclosed, with removable cover.

C. Captivated, corrosion-resistant cover screws.

D. Oil-resistant gaskets.

E. Meet UL cold impact test to minus 35 degrees C.

F. Manufacturer:

1. Hoffman.
2. Wiremold.
3. "Or-equal."

2.08 ACCESSORIES

A. Duct Bank Spacers:

1. Modular Type:
   a. Nonmetallic, interlocking, for multiple conduit sizes.
   b. Suitable for all types of conduit.
   c. Manufacturers:
      1) Underground Device, Inc.
      2) Carlon.
      3) "Or-equal."
2. Template Type:
   a. Nonmetallic, custom made one-piece spacers.
   b. Suitable for all types of conduit.
   c. Material: HDPE or polypropylene, 1/2-inch minimum thickness.
   d. Conduit openings cut 1 inch larger than conduit outside diameter.
   e. Additional openings for stake-down, rebar, and concrete flow through as required.
   f. Manufacturer and Product:
      1) SP Products; Quik Duct.
      2) Arizona Templates.
      3) "Or-equal."

B. Identification Devices:

1. Raceway Tags:
   a. Material: Permanent, nonferrous metal.
   b. Shape: Round.
   c. Raceway Designation: Pressure stamped, embossed, or engraved.
   d. Tags relying on adhesives or taped-on markers not permitted.
2. Warning Tape:
   a. Material: Polyethylene, 4-mil gauge with detectable strip.
   b. Color: Red.
   c. Width: Minimum 3 inches.
   d. Designation: Warning on tape that electric circuit is located below tape.
   e. Identifying Letters: Minimum 1-inch-high permanent black lettering imprinted continuously over entire length.
   f. Manufacturers and Products:
      1) Panduit; Type HTDU.
      2) Reef Industries; Terra Tape.
      3) "Or-equal."

3. Buried Raceway Marker:
    a. Material: Sheet bronze, consisting of double-ended arrows, straight for straight runs and bent at locations where runs change direction.
    b. Designation: Engrave to depth of 3/32 inch; ELECTRIC CABLES, in letters 1/4-inch high.
    c. Minimum Dimension: 1/4 inch thick, 10 inches long, and 3/4 inch wide.

C. Raceway Coating: Clean and paint in accordance with Section 09 90 00, Painting and Coating.

D. Heat-shrinkable Tubing:

1. Material: Heat-shrinkable, cross-linked polyolefin.
2. Semi-flexible with meltable adhesive inner liner.
3. Color: Black.
4. Manufacturers:
    a. Raychem.
    b. 3M.
    c. “Or-equal.”

E. Wraparound Duct Band:

1. Material: Heat-shrinkable, cross-linked polyolefin, precoated with hot-melt adhesive.
2. Width: 50 mm minimum.

PART 3 EXECUTION

3.01 GENERAL

A. Conduit and tubing sizes shown are based on use of copper conductors.

B. Comply with NECA Installation Standards.

C. Crushed or deformed raceways not permitted.

D. Maintain raceway entirely free of obstructions and moisture.

E. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.

F. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.

G. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.

H. Group raceways installed in same area.

I. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.

J. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.

K. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.

L. Block Walls: Do not install raceways in same horizontal course or vertical cell with reinforcing steel.

M. Install watertight fittings in outdoor, underground, or wet locations.

N. Paint threads and cut ends, before assembly of fittings, galvanized conduit, or PVC-coated galvanized conduit installed in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.

O. Metal conduit shall be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.

P. Do not install raceways in concrete equipment pads, foundations, or beams without Engineer approval.

Q. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.

R. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.

S. Install conduits for fiber optic cables, telephone cables, and Category 6 data cables in strict conformance with the requirements of TIA 569B.

3.02 REUSE OF EXISTING CONDUITS

A. Where Drawings indicate existing conduits may be reused, they may be reused only where they meet the following criteria.

1. Conduit is in useable condition with no deformation, corrosion, or damage to exterior surface.
2. Conduit is sized in accordance with the NEC.
3. Conduit is of the type specified in Contract Documents.
4. Conduit is supported as specified in Contract Documents.

B. Conduit shall be reamed with wire brush, then with a mandrel approximately 1/4 inch smaller than raceway inside diameter then cleaned prior to pulling new conductors.

3.03 INSTALLATION IN CAST-IN-PLACE STRUCTURAL CONCRETE

A. Minimum Cover: 2 inches, including fittings.

B. Conduit placement shall not require changes in reinforcing steel location or configuration.

C. Provide nonmetallic support during placement of concrete to ensure raceways remain in position.

D. Conduit larger than 1 inch shall not be embedded in concrete slabs, walls, foundations, columns, or beams unless approved by Engineer.

E. Slabs and Walls (Requires Engineer Approval):

1. Trade size of conduit not to exceed one-fourth of slab or wall thickness.
2. Install within middle two-fourths of slab or wall.
3. Separate conduit less than 2-inch trade size by a minimum ten times conduit trade size, center-to-center, unless otherwise shown.
4. Separate conduit 2-inch and greater trade size by a minimum eight times conduit trade size, center-to-center, unless otherwise shown.
5. Cross conduit at an angle greater than 45 degrees, with minimum separation of 1 inch.
6. Separate conduit by a minimum six times the outside dimension of expansion/deflection fittings at expansion joints.
7. Conduit shall not be installed below the maximum water surface elevation in walls of water holding structures.

F. Columns and Beams (Requires Engineer Approval):

1. Trade size of conduit not to exceed one-fourth of beam thickness.
2. Conduit cross-sectional area not to exceed 4 percent of beam or column cross section.

3.04 CONDUIT APPLICATION

A. Diameter: Minimum 3/4 inch.

B. Exterior, Exposed: Rigid aluminum.

C. Interior, Exposed:

1. Rigid aluminum.
2. Electric metallic tubing for concealed ceiling portion of lighting circuits.

D. Interior, Concealed (Not Embedded in Concrete): Rigid galvanized steel.

E. Aboveground, Embedded in Concrete Walls, Ceilings, or Floors: PVC Schedule 40, except as noted in paragraph AFD Conduits and paragraph Analog Conduits that follow.

F. Direct Earth Burial: PVC-coated rigid galvanized steel.

G. Concrete-encased Duct Bank: PVC Schedule 40, except as noted in paragraph AFD Conduits and paragraph Analog Conduits that follow.

H. Under Slabs-on-grade: PVC-coated rigid galvanized steel.

I. Transition from Underground or Concrete Embedded to Exposed: PVC-coated rigid steel conduit minimum 6 inches below concrete to 12 inches above concrete.

J. Under Equipment Mounting Pads: PVC-coated rigid steel conduit.

K. Exterior Light Pole Foundations: PVC-coated rigid steel conduit.

L. Corrosive Areas: PVC Schedule 40, except as noted in paragraph AFD Conduits and paragraph Analog Conduits that follow.

M. Hazardous Gas Areas: Rigid galvanized steel.

N. AFD Conduits: All exposed conduits from adjustable frequency drives (AFDs) to the associated motor shall be rigid aluminum. If conduit is direct buried or concrete encased, provide PVC-coated RGS conduit.

O. Analog Conduits: All conduits that contain signal and communication (i.e., analog) cables shall be rigid aluminum. If conduit is direct buried or concrete encased, provide PVC-coated RGS conduit.

3.05 FLEXIBLE CONNECTIONS

A. For motors, wall or ceiling mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other locations approved by Engineer where flexible connection is required to minimize vibration:

1. Conduit Size 4 Inches or Less: Flexible, liquid-tight conduit.
2. Conduit Size Over 4 Inches: Nonflexible.
3. Wet or Corrosive Areas: Flexible, nonmetallic or flexible metal liquid-tight.
4. Dry Areas: Flexible, metallic liquid-tight.
5. Hazardous Areas: Flexible coupling suitable for Class I, Division 1 and 2 areas.

B. Suspended Lighting Fixtures in Dry Areas: Flexible steel, nonliquid-tight conduit.

C. Outdoor Areas, Process Areas Exposed to Moisture, and Areas Required to be Oiltight and Dust-tight: Flexible metal, liquid-tight conduit.

D. Flexible Conduit Length: 18 inches minimum, 60 inches maximum; sufficient to allow movement or adjustment of equipment.

3.06 PENETRATIONS

A. Make at right angles, unless otherwise shown.

B. Notching or penetration of structural members, including footings and beams, not permitted.

C. Fire-rated Walls, Floors, or Ceilings: Firestop openings around penetrations to maintain fire-resistance rating using fire penetration seal as specified in Section 07 92 00, Joint Sealants.

D. Apply heat-shrinkable tubing or single layer of wraparound duct band to metallic conduit protruding through concrete floor slabs to a point 2 inches above and 2 inches below concrete surface.

E. Concrete Walls, Floors, or Ceilings (Aboveground): Provide nonshrink grout dry-pack, or use watertight seal device.

F. Entering Structures:

1. General: Seal raceway at first box or outlet with oakum or expandable plastic compound to prevent entrance of gases or liquids from one area to another.
2. Concrete Roof or Membrane Waterproofed Wall or Floor:
   a. Provide a watertight seal.
   b. Without Concrete Encasement: Install watertight entrance seal device on each side.
   c. With Concrete Encasement: Install watertight entrance seal device on accessible side.
   d. Securely anchor malleable iron body of watertight entrance seal device into construction with one or more integral flanges.
   e. Secure membrane waterproofing to watertight entrance seal device in a permanent, watertight manner.
3. Heating, Ventilating, and Air-conditioning Equipment:
   a. Penetrate equipment in area established by manufacturer.
   b. Terminate conduit with flexible metal conduit at junction box or condulet attached to exterior surface of equipment prior to penetrating equipment.
   c. Seal penetration with Type 5 sealant, as specified in Section 07 92 00, Joint Sealants.

4. Corrosive-sensitive Areas:
    a. Seal conduit passing through room walls.
    b. Seal conduit entering equipment panel boards and field panels containing electronic equipment.
    c. Seal penetration with Type 5 sealant, as specified in Section 07 92 00, Joint Sealants.
5. Existing or Precast Wall (Underground): Core drill wall and install watertight entrance seal device.
6. Nonwaterproofed Wall or Floor (Underground, without Concrete Encasement):
    a. Provide Schedule 40 galvanized pipe sleeve, or watertight entrance seal device.
    b. Fill space between raceway and sleeve with expandable plastic compound or oakum and lead joint, on each side.
7. Manholes and Handholes:
    a. Metallic Raceways: Provide insulated grounding bushings.
    b. Nonmetallic Raceways: Provide bell ends flush with wall.
    c. Install such that raceways enter as near as possible to one end of wall, unless otherwise shown.

3.07 SUPPORT

A. Support from structural members only, at intervals not exceeding NFPA 70 requirements. Do not exceed 10 feet in any application. Do not support from piping, pipe supports, or other raceways.

B. Multiple Adjacent Raceways: Provide ceiling trapeze. For trapeze-supported conduit, allow 25 percent extra space for future conduit.

C. Application/Type of Conduit Strap:

1. Aluminum Conduit: Aluminum or stainless steel.
2. Rigid Steel or EMT Conduit: Zinc coated steel, pregalvanized steel or malleable iron.
3. PVC-coated Rigid Steel Conduit: PVC-coated metal.
4. Nonmetallic Conduit: Nonmetallic or PVC-coated metal.

D. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:

1. Wood: Wood screws.
2. Hollow Masonry Units: Toggle bolts.
3. Concrete or Brick: Expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts.
4. Steelwork: Machine screws.
5. Location/Type of Hardware:
    a. Dry, Noncorrosive Areas: Galvanized.
    b. Wet, Noncorrosive Areas: Stainless steel.
    c. Corrosive Areas: Stainless steel.

E. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.

F. Support aluminum conduit on concrete surfaces with stainless steel or nonmetallic spacers, or aluminum or nonmetallic framing channel.

3.08 BENDS

A. Install concealed raceways with a minimum of bends in the shortest practical distance.

B. Make bends and offsets of longest practical radius. Bends in conduits and ducts being installed for fiber optic cables shall be not less than 20 times cable diameter, 15 inches minimum.

C. Install with symmetrical bends or cast metal fittings.

D. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.

E. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.

F. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.

G. PVC Conduit:

1. Bends 30 Degrees and Larger: Provide factory-made elbows.
2. 90-Degree Bends: Provide rigid steel elbows, PVC-coated where direct buried.
3. Use manufacturer's recommended method for forming smaller bends.

H. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

3.09 EXPANSION/DEFLECTION FITTINGS

A. Provide on raceways at structural expansion joints and in long tangential runs.

B. Provide expansion/deflection joints for 50 degrees F maximum temperature variation.

C. Install in accordance with manufacturer's instructions.

3.10 PVC CONDUIT

A. Solvent Welding:

1. Apply manufacturer recommended solvent to joints.
2. Install in order that joint is watertight.

B. Adapters:

1. PVC to Metallic Fittings: PVC terminal type.
2. PVC to Rigid Metal Conduit: PVC female adapter.

C. Belled-end Conduit: Bevel unbelled end of joint prior to joining.

3.11 PVC-COATED RIGID STEEL CONDUIT

A. Install in accordance with manufacturer's instructions.

B. Tools and equipment used in cutting, bending, threading and installation of PVC-coated rigid conduit shall be designed to limit damage to PVC coating.

C. Provide PVC boot to cover exposed threading.

3.12 WIREWAYS

A. Install in accordance with manufacturer's instructions.

B. Locate with cover on accessible vertical face of wireway, unless otherwise shown.

C. Applications:

1. Metal wireway in indoor dry locations.
2. Nonmetallic wireway in indoor wet, outdoor, and corrosive locations.

3.13 TERMINATION AT ENCLOSURES

A. Cast Metal Enclosure: Install manufacturer's premolded insulating sleeve inside metallic conduit terminating in threaded hubs.

B. Nonmetallic, Cabinets, and Enclosures:

1. Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.
2. Metallic Conduit: Provide ground terminal for connection to maintain continuity of ground system.

C. Sheet Metal Boxes, Cabinets, and Enclosures:

1. General:
   a. Install insulated bushing on ends of conduit where grounding is not required.
   b. Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.
   c. Use sealing locknuts or threaded hubs on sides and bottom of NEMA 3R and NEMA 12 enclosures.
   d. Terminate conduits at threaded hubs at the tops of NEMA 3R and NEMA 12 boxes and enclosures.
   e. Terminate conduits at threaded conduit hubs at NEMA 4 and NEMA 4X boxes and enclosures.
2. Rigid Galvanized Conduit:
   a. Provide one lock nut each on inside and outside of enclosure.
   b. Install grounding bushing at source enclosure.
   c. Provide bonding jumper from grounding bushing to equipment ground bus or ground pad.
3. Electric Metallic Tubing: Provide gland compression, insulated connectors.
4. Flexible Metal Conduit: Provide two screw type, insulated, malleable iron connectors.
5. Flexible, Nonmetallic Conduit: Provide nonmetallic, liquid-tight strain relief connectors.
6. PVC-coated Rigid Galvanized Steel Conduit: Provide PVC-coated, liquid-tight, metallic connector.
7. PVC Schedule 40 Conduit: Provide PVC terminal adapter with lock nut, except where threaded hubs required above.

D. Motor Control Center, Switchboard, Switchgear, and Freestanding Enclosures:

1. Terminate metal conduit entering bottom with grounding bushing; provide grounding jumper extending to equipment ground bus or grounding pad.
2. Terminate PVC conduit entering bottom with bell end fittings.

3.14 UNDERGROUND RACEWAYS

A. Grade: Maintain minimum grade of 4 inches in 100 feet, either from one manhole, handhole, or pull box to the next, or from a high point between them, depending on surface contour.

B. Cover: Maintain minimum 2-foot cover above conduit and concrete encasement, unless otherwise shown.

C. Make routing changes as necessary to avoid obstructions or conflicts.

D. Couplings: In multiple conduit runs, stagger so couplings in adjacent runs are not in same transverse line.

E. Union type fittings not permitted.

F. Spacers:

1. Provide preformed, nonmetallic spacers designed for such purpose, to secure and separate parallel conduit runs in a trench or concrete encasement.
2. Install at intervals not greater than that specified in NFPA 70 for support of the type conduit used, but in no case greater than 10 feet.

G. Support conduit so as to prevent bending or displacement during backfilling or concrete placement.

H. Transition from Underground to Exposed: PVC-coated rigid steel conduit.

I. Installation with Other Piping Systems:

1. Crossings: Maintain minimum 12-inch vertical separation.
2. Parallel Runs: Maintain minimum 12-inch separation.
3. Installation over valves or couplings not permitted.

J. Metallic Raceway Coating: Along entire length, apply wraparound duct band with one-half tape width overlap to obtain two complete layers.

K. Provide expansion fittings that allow minimum of 4 inches of movement in vertical conduit runs from underground where exposed conduit will be fastened to or will enter building or structure.

L. Provide expansion/deflection fittings in conduit runs that exit building or structure below grade. Conduit from building wall to fitting shall be PVC-coated rigid steel.

M. Concrete Encasement:

1. Concrete Color: Trowel in red dye on top and sides of concrete.

N. Backfill:

1. As specified in Section 31 23 23.15, Trench Backfill.
2. Do not backfill until inspected by Engineer.

3.15 UNDER SLAB RACEWAYS

A. Make routing changes as necessary to avoid obstructions or conflicts.

B. Support raceways so as to prevent bending or displacement during backfilling or concrete placement.

C. Install raceways with no part embedded within slab and with no interference with slab on grade construction.

D. Raceway spacing, in a single layer or multiple layers:

1. 3 inches clear between adjacent 2-inch or larger raceway.
2. 2 inches clear between adjacent 1-1/2-inch or smaller raceway.

E. Multiple Layers of Raceways: Install under slab on grade in trench below backfill zone, as specified in Section 31 23 23.15, Trench Backfill.

F. Individual Raceways and Single-layer Multiple Raceways: Install at lowest elevation of backfill zone with spacing as specified herein. Where conduits cross at perpendicular orientation, installation of conduits shall not interfere with placement of under slab fill that meets compaction and void limitations of earthwork specifications.

G. Under slab raceways that emerge from below slab to top of slab as exposed, shall be located to avoid conflicts with structural slab rebar. Coordinate raceway stub ups with location of structural rebar.

H. Fittings:

1. Union type fittings are not permitted.
2. Provide expansion/deflection fittings in raceway runs that exit building or structure below slab. Locate fittings 18 inches, maximum, beyond exterior wall. Raceway type between building exterior wall to fitting shall be PVC-coated rigid steel.
3. Couplings: In multiple raceway runs, stagger so couplings in adjacent runs are not in same traverse line.

3.16 OUTLET AND DEVICE BOXES

A. General:

1. Install plumb and level.
2. Install suitable for conditions encountered at each outlet or device in wiring or raceway system, sized to meet NFPA 70 requirements.
3. Open no more knockouts in sheet steel device boxes than are required; seal unused openings.
4. Install galvanized mounting hardware in industrial areas.

B. Size:

1. Depth: Minimum 2 inches, unless otherwise required by structural conditions. Box extensions not permitted.
   a. Hollow Masonry Construction: Install with sufficient depth such that conduit knockouts or hubs are in masonry void space.
2. Ceiling Outlet: Minimum 4-inch octagonal device box, unless otherwise required for installed fixture.
3. Switch and Receptacle: Minimum 2-inch by 4-inch device box.

C. Locations:

1. Drawing locations are approximate.
2. To avoid interference with mechanical equipment or structural features, relocate outlets as directed by Engineer.
3. Light Fixture: Install in symmetrical pattern according to room layout, unless otherwise shown.

D. Mounting Height:

1. General:
   a. Dimensions given to centerline of box.
   b. Where specified heights do not suit building construction or finish, adjust up or down to avoid interference.
   c. Do not straddle CMU block or other construction joints.
2. Light Switch:
   a. 48 inches above floor.
   b. When located next to door, install on lock side of door.
3. Thermostat: 54 inches above floor.
4. Telephone Outlet:
   a. 15 inches above floor.
   b. 6 inches above countertops.
   c. Wall-mounted: 52 inches above floor.
5. Convenience Receptacle:
   a. General Interior Areas: 15 inches above floor.
   b. General Interior Areas (Countertops): Install device plate bottom or side flush with top of backsplash, or 6 inches above countertops without backsplash.
   c. Industrial Areas, Workshops: 48 inches above floor.
   d. Outdoor Areas: 24 inches above finished grade.
6. Special-purpose Receptacle: 24 inches above floor or as shown.
7. Switch, Motor Starting: 48 inches above floor, unless otherwise indicated on Drawings.

E. Flush-mounted:

1. Install with concealed conduit.
2. Install proper type extension rings or plaster covers to make edges of boxes flush with finished surface.
3. Holes in surrounding surface shall be no larger than required to receive box.

F. Supports:

1. Support boxes independently of conduit by attachment to building structure or structural member.
2. Install bar hangers in frame construction or fasten boxes directly as follows:
   a. Wood: Wood screws.
   b. Concrete or Brick: Bolts and expansion shields.
   c. Hollow Masonry Units: Toggle bolts.
   d. Steelwork: Machine screws.
3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
4. Provide plaster rings where necessary.
5. Boxes embedded in concrete or masonry need not be additionally supported.

G. Install separate junction boxes for flush or recessed lighting fixtures where required by fixture terminal temperature.

H. Boxes Supporting Fixtures: Provide means of attachment with adequate strength to support fixture.

3.17 JUNCTION AND PULL BOXES

A. General:

1. Install plumb and level.
2. Installed boxes shall be accessible.
3. Do not install on finished surfaces.
4. Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.
5. Use conduit bodies as junction and pull boxes where no splices are required and allowed by applicable codes.
6. Install pull boxes where necessary in raceway system to facilitate conductor installation.
7. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.
8. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.

B. Flush-mounted:

1. Install with concealed conduit.
2. Holes in surrounding surface shall be no larger than required to receive box.
3. Make edges of boxes flush with final surface.

C. Mounting Hardware:

1. Noncorrosive Dry Areas: Galvanized.
2. Noncorrosive Wet Areas: Stainless steel.
3. Corrosive Areas: Stainless steel.

D. Supports:

1. Support boxes independently of conduit by attachment to building structure or structural member.
2. Install bar hangers in frame construction or fasten boxes directly as follows:
   a. Wood: Wood screws.
   b. Concrete or Brick: Bolts and expansion shields.
   c. Hollow Masonry Units: Toggle bolts.
   d. Steelwork: Machine screws.
3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
4. Boxes embedded in concrete or masonry need not be additionally supported.

E. At or Below Grade:

1. Install boxes for below grade conduit flush with finished grade in locations outside of paved areas, roadways, or walkways.
2. If adjacent structure is available, box may be mounted on structure surface just above finished grade in accessible but unobtrusive location.
3. Obtain Engineer's written acceptance prior to installation in paved areas, roadways, or walkways.
4. Use boxes and covers suitable to support anticipated weights.

F. Install Drain/breather fittings in NEMA 250 Type 4 and Type 4X enclosures.

3.18 MANHOLES AND HANDHOLES

A. Excavate, shore, brace, backfill, and final grade in accordance with Section 31 23 16, Excavation, and Section 31 23 23.15, Trench Backfill.

B. Do not install until final raceway grading has been determined.

C. Install such that raceway enters at nearly right angle and as near as possible to end of wall, unless otherwise shown.

D. Grounding: As specified in Section 26 05 26, Grounding and Bonding for Electrical Systems.

E. Identification: Field stamp covers with manhole or handhole number as shown. Stamped numbers to be 1-inch minimum height.

3.19 EMPTY RACEWAYS

A. Provide permanent, removable cap over each end.

B. Provide PVC plug with pull tab for underground raceways with end bells.

C. Provide nylon pull cord.

D. Identify, as specified in Article Identification Devices, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

3.20 IDENTIFICATION DEVICES

A. Raceway Tags:

1. Identify origin and destination.
2. For exposed raceways, install tags at each terminus, near midpoint, and at minimum intervals of every 50 feet, whether in ceiling space or surface mounted.
3. Install tags at each terminus for concealed raceways.
4. Provide noncorrosive wire for attachment.

B. Warning Tape: Install approximately 18 inches above underground or concrete-encased raceways. Align parallel to, and within 12 inches of, centerline of run.

C. Buried Raceway Marker:

1. Install at grade to indicate direction of underground raceway.
2. Install at bends and at intervals not exceeding 100 feet in straight runs.
3. Embed and secure to top of concrete base, sized 14 inches long, 6 inches wide, and 8 inches deep; top set flush with finished grade.

3.21 PROTECTION OF INSTALLED WORK

A. Protect products from effects of moisture, corrosion, and physical damage during construction.

B. Provide and maintain manufactured watertight and dust-tight seals over conduit openings during construction.

C. Touch up painted conduit threads after assembly to cover nicks or scars.

D. Touch up coating damage to PVC-coated conduit with patching compound approved by manufacturer. Compound shall be kept refrigerated according to manufacturers' instructions until time of use.

END OF SECTION

SECTION 26 05 70
ELECTRICAL SYSTEMS ANALYSIS

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Short circuit study.
2. Protective Device Coordination Study: Submit within 90 days after approval of short circuit study.
3. Arc flash study.
4. Arc flash warning labels.

1.02 AREAS TO PERFORM ELECTRICAL SYSTEM ANALYSIS

A. Electrical system analysis has already been performed on most of the plant during previous contract. Perform analysis on the following:

1. New Substation No. 7 Transformers TL7 and TR7 and all equipment downstream.
2. Existing Substation No. 2 Replacement Transformers TL2 and TR2 and all equipment downstream.

1.03 QUALITY ASSURANCE

A. Short circuit, protective device coordination, and arc flash studies shall be prepared by a professional electrical engineer registered in the State of Connecticut.

1.04 SEQUENCING AND SCHEDULING

A. Initial complete short circuit study shall be submitted, reviewed, and approved before Engineer will review Shop Drawings for any electrical equipment.

B. The information provided within these Contract Documents will not be sufficient to perform the specified electrical analysis. All available documentation on the previous construction projects for this facility will be made available to the Contractor upon request. However, the costs for the reproduction of any existing construction documents shall be borne entirely by the Contractor. Additionally, it is expected that field investigations will be required by the Contractor to obtain all the necessary information required to perform the specified electrical analysis. All labor, materials, and other incidental materials required to perform the specified analysis shall be included within the Bid provided by the Contractor.

C. In addition to the field investigations outlined above, it is expected that one coordination meeting with the plant staff and the Engineer will be required to review and confirm the data obtained by the Contractor as part of the field investigations performed. The Contractor shall lead the coordination meetings with the Owner and Engineer in which the data obtained as part of the field investigations is presented to the Owner and the Engineer. The Contractor shall provide detailed one-line diagrams of those facilities studied that includes all loads that are fed from the new and existing equipment. The equipment names and the associated equipment tag numbers for all new and existing equipment shall be discussed as part of the review meeting. The Owner and Engineer shall be afforded 21 calendar days upon receipt of the initial submittal to review the data provided to verify the information presented is an accurate representation of the proposed electrical distribution system that incorporates all new and existing equipment as well as all demolition that is included as part of this project.

D. Initial complete protective device coordination and arc flash studies shall be submitted within 90 days after approval of initial short circuit study.

E. Revised short circuit, protective device coordination, and arc flash studies, and arc flash labels shall be submitted 10 days before energizing any equipment that is to be provided as part of this project.

F. Final short circuit, protective device coordination, and arc flash studies shall be completed prior to Project Substantial Completion. Final version of study shall include as-installed equipment, materials, and parameter data or settings entered into equipment based on study.

G. Submit and install final arc flash labels described herein and in compliance with NEMA Z535.4 prior to Project Substantial Completion.

1.05 GENERAL STUDY REQUIREMENTS

A. Equipment and component titles used in the studies shall be identical to equipment and component titles shown on Drawings.

B. Perform studies using one of the following electrical engineering software packages:

1. SKM Power Tools for Windows.
2. ETAP.
3. EDSA.
4. Easy Power.

C. Perform complete fault calculations for each existing and ultimate source combination.

1. Source combination may include present and future power company supply circuits, large motors, or generators.

D. Use proposed and existing load data for study obtained from Contract Documents and extensive field investigations that are to be performed by the Contractor.

E. Existing System and Equipment:

1. Extent of existing system to be included in study shall include all of the existing system and equipment.
2. Include fault contribution of existing motors and equipment in study.
3. Include impedance elements that affect new system and equipment.
4. Include protective devices in series with new equipment.

F. Device coordination time-current curves for medium and low voltage distribution system; include individual protective device time-current characteristics.

1.06 SHORT CIRCUIT STUDY

A. General:

1. Prepare in accordance with IEEE 399.
2. Use cable impedances based on copper conductors, except where aluminum conductors are specified or shown.
3. Use bus impedances based on copper bus bars, except where aluminum bus bars are specified or shown.
4. Use cable and bus resistances calculated at 25 degrees C.
5. Use medium-voltage cable reactances based on use of typical dimensions of shielded cables with 133 percent insulation levels.
6. Use 600-volt cable reactances based on use of typical dimensions of THHN/THWN conductors.
7. Use transformer impedances 92.5 percent of “nominal” impedance based on tolerances specified in IEEE C57.12.00.

B. Provide:

1. Calculation methods and assumptions.
2. Typical calculation.
3. Tabulations of calculated quantities.
4. Results, conclusions, and recommendations.
5. Selected base per unit quantities.
6. One-line diagrams.

7. Source impedance data, including electric utility system and motor fault contribution characteristics.
8. Impedance diagrams.
9. Zero-sequence impedance diagrams.

C. Calculate short circuit interrupting and momentary (when applicable) duties for an assumed three-phase bolted fault at each:

1. Electric utility's supply termination point.
2. Main switchgear.
3. Unit substation primary and secondary terminals.
4. Low-voltage switchgear and switchboards.
5. Low and medium voltage motor control centers.
6. Industrial control panels with motor starters.
7. Pad-mounted switchgear and pad-mounted switches.
8. Standby generators.
9. Branch circuit panelboards.
10. Future load contributions as shown on one-line diagram.

D. Provide bolted line-to-ground fault current study for areas as defined for three-phase bolted fault short circuit study.

E. Provide bolted line-to-line fault current study for areas as defined for three-phase bolted fault short circuit study.

F. Verify:

1. Equipment and protective devices are applied within their ratings.
2. Adequacy of all new and existing equipment bus bars to withstand short circuit stresses.
3. Adequacy of new and existing transformer windings to withstand short circuit stresses.
4. Cable and busway sizes for ability to withstand short circuit heating, in addition to normal load currents.

G. Tabulations:

1. General Data:
   a. Short circuit reactances of rotating machines.
   b. Cable and conduit material data.
   c. Bus data.
   d. Transformer data.
   e. Circuit resistance and reactance values.
2. Short Circuit Data (for each source combination):
   a. Fault impedances.
   b. X to R ratios.
   c. Asymmetry factors.
   d. Motor contributions.

e. Short circuit kVA.
f. Symmetrical and asymmetrical fault currents.

3. Equipment Evaluation:
   a. Equipment bus bracing, equipment short circuit rating, transformer, cable, busway.
   b. Maximum fault current available.

H. Written Summary:

1. Scope of studies performed.
2. Explanation of bus and branch numbering system.
3. Prevailing conditions.
4. Selected equipment deficiencies.
5. Results of short circuit study.
6. Comments or suggestions.

I. Suggest changes and additions to equipment rating and/or characteristics.

J. Notify Engineer in writing of existing circuit protective devices improperly rated for new fault conditions.

K. Revise data for “as-installed” condition.

1.07 PROTECTIVE DEVICE COORDINATION STUDY

A. General:

1. Prepare in accordance with IEEE 242.
2. Proposed protective device coordination time-current curves for distribution system, graphically displayed on conventional log-log curve sheets.
   a. Provide separate curve sheets for phase and ground fault coordination for each scenario.
   b. Each curve sheet to have title and one-line diagram that applies to specific portion of system associated with time-current curves on that sheet. Limit number of devices shown to four to six.
   c. Identify device associated with each curve by manufacturer type, function, and, if applicable, recommended tap, time delay, instantaneous and other settings recommended.
   d. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.
   e. Apply motor protection methods that comply with NFPA 70.

B. Plot Characteristics on Curve Sheets:

1. Low-voltage equipment circuit breaker trip devices, including manufacturers tolerance bands.
2. Pertinent transformer full-load currents at 100 percent.
3. Transformer magnetizing inrush currents.
4. Transformer damage curves; appropriate for system operation and location.
5. ANSI transformer withstand parameters.
6. Significant symmetrical and asymmetrical fault currents.
7. Motor overload relay settings for motors greater than 40 horsepower.
8. Ground fault protective device settings.
9. Other system load protective devices for largest branch circuit and feeder circuit breaker in each motor control center.

C. Primary Protective Device Settings for Delta-Wye Connected Transformer:

1. Secondary Line-to-Ground Fault Protection: Primary protective device operating band within transformer's characteristics curve, including a point equal to 58 percent of IEEE C57.12.00 withstand point.
2. Secondary Line-To-Line Faults: 16 percent current margin between primary protective device and associated secondary device characteristic curves.

D. Tabulate Recommended Protective Device Settings:

1. Relays:
   a. Current tap.
   b. Time dial.
   c. Instantaneous pickup.
   d. Electronic settings data file.
2. Circuit Breakers:
   a. Adjustable pickups.
   b. Adjustable time-current characteristics.
   c. Adjustable time delays.
   d. Adjustable instantaneous pickups.
   e. I^2t In/Out.
   f. Zone interlocking.
   g. Electronic settings data file.

E. Written Summary:

1. Scope of studies performed.
2. Summary of protective device coordination methodology.
3. Prevailing conditions.
4. Selected equipment deficiencies.
5. Results of coordination study.
6. Appendix of complete relay and circuit breaker electronic setting files.
7. Comments or suggestions.

1.08 ARC FLASH STUDY

A. Perform arc flash hazard study after short circuit and protective device coordination study has been completed, reviewed and accepted.

B. Perform arc flash study in accordance with NFPA 70E, OSHA 29 CFR, Part 1910 Subpart S, and IEEE 1584.

C. Base Calculation: The arc flash analysis required shall include all new and existing electrical equipment. As indicated above, the Contract Documents and all previous available documentation for this facility will not contain all of the necessary information to perform the specified analysis. Therefore, the Contractor shall be responsible for performing extensive field investigations, as required, to obtain all of the necessary information to complete the specified analysis. Additionally, the Contractor shall also be required to provide documentation of the field investigations via high resolution digital photographs and detailed equipment data sheets to outline all of the existing equipment that is installed at the facility. For each new and existing piece of electrical equipment, the Contractor shall determine the following:

1. Flash hazard protection boundary.
2. Limited approach boundary.
3. Restricted approach boundary.
4. Prohibited approach boundary.
5. Incident energy level.
6. Personal protection equipment (PPE) hazard/risk category.
7. Type of PPE required.

D. Produce arc flash warning labels for all new and existing electrical equipment. The new and existing electrical equipment, which shall be provided with an arc flash label shall include, but not be limited to, the following equipment:

1. Panelboards.
2. Individual motor starters.
3. Switchboards.
4. Standalone adjustable frequency drives (AFDs).
5. Industrial control panels.
6. Low voltage motor control centers.

7. Low voltage switchgear.
8. Unit substations (different arc flash labels for the primary and secondary equipment).
9. Oil-filled transformers.

E. Produce arc flash warning labels that list items in Paragraph Base Calculation and the following additional items.

1. Bus name.
2. Bus voltage.

F. Produce bus detail sheets that list items in Paragraph Base Calculation and the following additional items:

1. Bus name.
2. Upstream protective device name, type, and settings.
3. Bus line-to-line voltage.

G. Produce arc flash evaluation summary sheet listing the following additional items:

1. Bus name.
2. Upstream protective device name, type, settings.
3. Bus line-to-line voltage.
4. Bus bolted fault.
5. Protective device bolted fault current.
6. Arcing fault current.
7. Protective device trip/delay time.
8. Breaker opening time.
9. Solidly grounded column.
10. Equipment type.
11. Gap.
12. Arc flash boundary.
13. Working distance.
14. Incident energy.
15. Required protective fire rated clothing type and class.

H. Analyze short circuit, protective device coordination, and arc flash calculations and highlight equipment that is determined to be underrated or causes incident energy values greater than 40 cal/cm^2. Propose approaches to reduce energy levels.

I. Prepare report summarizing arc flash study with conclusions and recommendations which may affect integrity of electric power distribution system. As a minimum, include the following:

1. Equipment manufacturer’s information used to prepare study.
2. Assumptions made during study.

3. Reduced copy of one-line drawing; 11 inches by 17 inches maximum.
4. Arc flash evaluations summary spreadsheet.
5. Bus detail sheets.
6. Arc flash warning labels printed in color on adhesive backed labels.

PART 2 PRODUCTS

2.01 ARC FLASH WARNING LABELS

A. Printed in multicolor on laminated plastic and be riveted on equipment. An example label is located following end of section in Figure 1.

PART 3 EXECUTION

3.01 GENERAL

A. Adjust relay and protective device settings according to values established by coordination study.

B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

C. Notify Engineer in writing of required major equipment modifications.

D. Provide laminated one-line diagrams (minimum size 11 inches by 17 inches) to post on interior of electrical room doors.

E. Provide arc flash warning labels on equipment as specified in this section.

3.02 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this Specification:

1. Figure 1: Example Arc Flash Label.

END OF SECTION

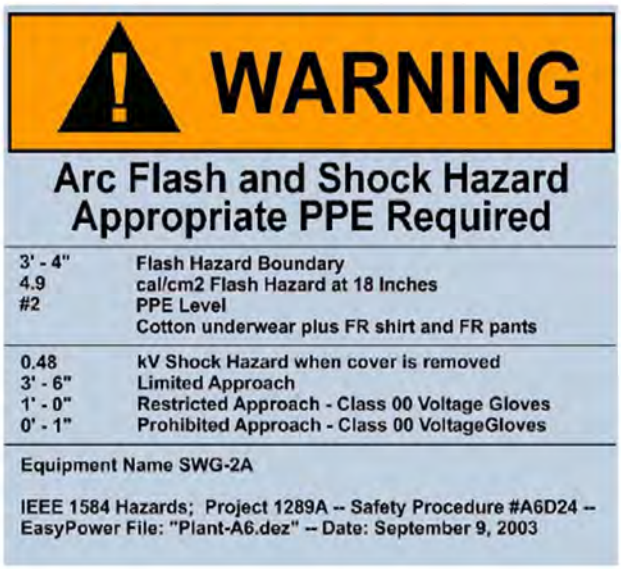


Figure 1
Example Arc Flash Label

SECTION 26 08 00
COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Submit 60 days prior to performing inspections or tests:
   a. Schedule for performing inspection and tests.
   b. List of references to be used for each test.
   c. Sample copy of equipment and materials inspection form(s).
   d. Sample copy of individual device test form.
   e. Sample copy of individual system test form.
2. Submit test or inspection reports and certificates for each electrical item tested within 30 days after completion of test:
3. Operation and Maintenance Data:
   a. In accordance with Section 01 78 23, Operation and Maintenance Data.
   b. After test or inspection reports and certificates have been reviewed by Engineer and returned, insert a copy of each in operation and maintenance manual.

1.02 QUALITY ASSURANCE

A. Testing Firm Qualifications:

1. Corporately and financially independent organization functioning as an unbiased testing authority.
2. Professionally independent of manufacturers, suppliers, and installers of electrical equipment and systems being tested.
3. Employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems.
4. Supervising engineer accredited as Certified Electrical Test Technologist by NICET or NETA and having a minimum of 5 years' testing experience on similar projects.
5. Technicians certified by NICET or NETA.
6. Assistants and apprentices assigned to Project at ratio not to exceed two certified to one noncertified assistant or apprentice.
7. Registered Professional Engineer to provide comprehensive Project report outlining services performed, results of such services, recommendations, actions taken, and opinions.
8. In compliance with OSHA CFR 29, Part 1910.7 criteria for accreditation of testing laboratories or a full member company of NETA.

B. Test equipment shall have an operating accuracy equal to or greater than requirements established by NETA ATS.

C. Test instrument calibration shall be in accordance with NETA ATS.

1.03 SEQUENCING AND SCHEDULING

A. Perform inspection and electrical tests after equipment listed herein has been installed.

B. Perform tests with apparatus de-energized whenever feasible.

C. Inspection and electrical tests on energized equipment shall be:

1. Scheduled with Engineer and Owner prior to de-energization.
2. Minimized to avoid extended period of interruption to the operating plant equipment.

D. Notify Engineer and Owner at least 72 hours prior to performing tests on energized electrical equipment.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Perform tests in accordance with requirements of Section 01 91 14, Equipment Testing and Facility Startup.

B. Tests and inspections shall establish:

1. Electrical equipment is operational within industry and manufacturer's tolerances and standards.
2. Installation operates properly.
3. Equipment is suitable for energization.
4. Installation conforms to requirements of Contract Documents and NFPA 70, NFPA 70E, NFPA 101, and IEEE C2.

C. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.

D. Set, test, and calibrate protective relays, circuit breakers, fuses, power monitoring meters, and other applicable devices in accordance with values established by short circuit, coordination, and harmonics studies as specified in Section 26 05 70, Electrical Systems Analysis.

E. Adjust mechanisms and moving parts of equipment for free mechanical movement.

F. Adjust and set electromechanical electronic relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

G. Verify nameplate data for conformance to Contract Documents and approved Submittals.

H. Realign equipment not properly aligned and correct unlevelness.

I. Properly anchor electrical equipment found to be inadequately anchored.

J. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench/screw driver to manufacturer's recommendations, or as otherwise specified in NETA ATS.

K. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

L. Provide proper lubrication of applicable moving parts.

M. Inform Engineer of working clearances not in accordance with NFPA 70.

N. Investigate and repair or replace:

1. Electrical items that fail tests.
2. Active components not operating in accordance with manufacturer's instructions.
3. Damaged electrical equipment.

O. Electrical Enclosures:

1. Remove foreign material and moisture from enclosure interior.
2. Vacuum and wipe clean enclosure interior.
3. Remove corrosion found on metal surfaces.
4. Repair or replace, as determined by Engineer and Owner, door and panel sections having dented surfaces.
5. Repair or replace, as determined by Engineer and Owner, poor fitting doors and panel sections.
6. Repair or replace improperly operating latching, locking, or interlocking devices.
7. Replace missing or damaged hardware.
8. Finish:
    a. Provide matching paint and touch up scratches and mars.
    b. If required due to extensive damage, as determined by Engineer, refinish entire assembly.

P. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents or approved submittals.

Q. Replace transformer insulating oil not in compliance with ASTM D923.

3.02 CHECKOUT AND STARTUP

A. Voltage Field Test:

1. Check voltage at point of termination of power company supply system to Project when installation is essentially complete and is in operation.
2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
3. Record supply voltage (all three phases simultaneously on same graph) for 24 hours during normal working day.
    a. Submit voltage field test report within 5 days of test.
4. Unbalance Corrections:
    a. Make written request to power company to correct condition if balance (as defined by NEMA) exceeds 1 percent, or if voltage varies throughout the day and from loaded to unloaded condition more than plus or minus 4 percent of nominal.
    b. Obtain written certification from responsible power company official that voltage variations and unbalance are within their normal standards if corrections are not made.

B. Equipment Line Current Tests:

1. Check line current in each phase for each piece of equipment.
2. Make line current check after power company has made final adjustments to supply voltage magnitude or balance.
3. If phase current for a piece of equipment is above rated nameplate current, prepare equipment line phase current report that identifies cause of problem and corrective action taken.

3.03 SWITCHGEAR AND SWITCHBOARD ASSEMBLIES

A. Visual and Mechanical Inspection:

1. Insulator damage and contaminated surfaces.
2. Proper barrier and shutter installation and operation.
3. Proper operation of indicating devices.
4. Improper blockage of air-cooling passages.
5. Proper operation of drawout elements.
6. Integrity and contamination of bus insulation system.

7. Check door and device interlocking system by:
    a. Closure attempt of device when door is in OFF or OPEN position.
    b. Opening attempt of door when device is in ON or CLOSED position.
8. Check key interlocking systems for:
    a. Key captivity when device is in ON or CLOSED position.
    b. Key removal when device is in ON or CLOSED position.
    c. Closure attempt of device when key has been removed.
    d. Correct number of keys in relationship to number of lock cylinders.
    e. Existence of other keys capable of operating lock cylinders: Destroy duplicate sets of keys.
9. Check nameplates for proper identification of:
    a. Equipment title and tag number with latest one-line diagram.
    b. Pushbutton.
    c. Control switch.
    d. Circuit breaker.
    e. Indicating meter.
10. Verify fuse and circuit breaker ratings, sizes, and types conform to those specified.
11. Check bus and cable connections for high resistance by calibrated torque wrench and thermographic survey applied to bolted joints.
    a. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
    b. Thermographic survey temperature gradient of 2 degrees C, or less.
12. Check operation and sequencing of electrical and mechanical interlock systems by:
    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
    c. Key exchange to operate devices in OFF-NORMAL positions.
13. Verify performance of each control device and feature.
14. Control Wiring:
    a. Compare wiring to local and remote control and protective devices with elementary diagrams.
    b. Proper conductor lacing and bundling.
    c. Proper conductor identification.
    d. Proper conductor lugs and connections.
15. Exercise active components.
16. Perform phasing check on double-ended equipment to ensure proper bus phasing from each source.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
   b. Each phase of each bus section.
   c. Phase-to-phase and phase-to-ground for 1 minute.
   d. With switches and breakers open.
   e. With switches and breakers closed.
   f. Control wiring except that connected to solid state components.
   g. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Overpotential Tests:
   a. Applied ac voltage and test procedure in accordance with NETA ATS, Table 100.2.
   b. Each phase of each bus section.
   c. Phase-to-phase and phase-to-ground for 1 minute.
   d. Test results evaluated on a pass/fail basis.
3. Current Injection Tests:
   a. For entire current circuit in each section.
   b. Secondary injection for current flow of 1 ampere.
   c. Test current at each device.
4. Control Wiring:
   a. Apply secondary voltage to control power and potential circuits.
   b. Check voltage levels at each point on terminal boards and each device terminal.
5. Operational Test:
   a. Initiate control devices.
   b. Check proper operation of control system in each section.

3.04 PANELBOARDS

A. Visual and Mechanical Inspection: Include the following inspections and related work:

1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.
2. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer's instruction manual.
3. Check panelboard mounting, area clearances, and alignment and fit of components.
4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.

5. Perform visual and mechanical inspection for overcurrent protective devices.

B. Electrical Tests: Include the following items performed in accordance with manufacturer's instruction:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
   b. Each phase of each bus section.
   c. Phase-to-phase and phase-to-ground for 1 minute.
   d. Control wiring except that connected to solid state components.
   e. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Ground continuity test ground bus to system ground.

3.05 DRY TYPE TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Physical and insulator damage.
2. Proper winding connections.
3. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
4. Defective wiring.
5. Proper operation of fans, indicators, and auxiliary devices.
6. Removal of shipping brackets, fixtures, or bracing.
7. Free and properly installed resilient mounts.
8. Cleanliness and improper blockage of ventilation passages.
9. Verify tap-changer is set at correct ratio for rated output voltage under normal operating conditions.
10. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.5 for each:
      1) Winding-to-winding.
      2) Winding-to-ground.
   b. Test Duration: 10 minutes with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
   c. Results temperature corrected in accordance with NETA ATS, Table 100.14.
   d. Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.

e. Insulation resistance test results to compare within 1 percent of adjacent windings.

2. Perform tests and adjustments for fans, controls, and alarm functions as suggested by manufacturer.

3.06 LIQUID-FILLED TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Physical and insulator damage.
2. Proper winding connections.
3. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
4. Defective wiring.
5. Proper operation of fans, indicators, and auxiliary devices.
6. Effective core and equipment grounding.
7. Removal of shipping brackets, fixtures, or bracing.
8. Tank leaks and proper liquid level.
9. Integrity and contamination of bus insulation system.
10. Verify tap-changer is set at correct ratio for rated voltage under normal operating conditions.
11. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.5 for each:
      1) Winding-to-winding.
      2) Winding-to-ground.
   b. Test Duration: 10 minutes with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
   c. Results temperature corrected in accordance with NETA ATS, Table 100.14.
   d. Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
   e. Insulation resistance test results to compare within 1 percent of adjacent windings.
2. Perform tests and adjustments for fans, controls, and alarm functions as suggested by manufacturer.
3. Sample insulating oil in accordance with ASTM D923 and have laboratory test for:
   a. Dielectric breakdown voltage in accordance with ASTM D877 or ASTM D1816.
   b. Acid neutralization number in accordance with ASTM D974.

c. Interfacial tension in accordance with ASTM D971.
d. Color in accordance with ASTM D1500.
e. Visual condition in accordance with ASTM D1524.
f. Specific gravity in accordance with ASTM D1298.
g. Water content, in parts per million, in accordance with ASTM D1533.
h. Dielectric fluid test results in accordance with NETA ATS, Table 100.4.
i. Power factor at 25 degrees C and at 100 degrees, in accordance with ASTM D924.
j. Maximum power factor, corrected to 20 degrees C, in accordance with manufacturer's specifications.

3.07 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect each individual exposed power cable No. 4 and larger for:
   a. Physical damage.
   b. Proper connections in accordance with single-line diagram.
   c. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.
   d. Color coding conformance with specification.
   e. Proper circuit identification.
2. Mechanical Connections for:
   a. Proper lug type for conductor material.
   b. Proper lug installation.
   c. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
3. Shielded Instrumentation Cables for:
   a. Proper shield grounding.
   b. Proper terminations.
   c. Proper circuit identification.
4. Control Cables for:
   a. Proper termination.
   b. Proper circuit identification.
5. Cables Terminated Through Window Type CTs: Verify neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests for Conductors No. 4 and Larger:

1. Insulation Resistance Tests:
   a. Use 1,000V dc megohmmeter for 600-volt insulated conductors and 500V dc megohmmeter for 300-volt insulated conductors.
   b. Test each conductor with respect to ground and to adjacent conductors for 1 minute.

c. Evaluate ohmic values by comparison with conductors of same length and type.
d. Investigate values less than 50 megohms.

2. Continuity test by ohmmeter method to ensure proper cable connections.

C. Low-voltage cable tests may be performed by installer in lieu of independent testing firm.

3.08 MEDIUM-VOLTAGE CABLES, 15 KV MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect each individual exposed cable for:
   a. Physical damage plus jacket and insulation condition.
   b. Proper connections in accordance with single-line diagram or approved Submittals.
   c. Proper shield grounding.
   d. Proper cable support.
   e. Proper cable termination.
   f. Cable bends not in conformance with manufacturer's minimum allowable bending radius.
   g. Proper arc and fireproofing in common cable areas.
   h. Proper circuit and phase identification.
2. Mechanical Connections:
   a. Proper lug type for conductor material.
   b. Proper lug installation.
   c. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturers.
3. Conductors Terminated Through Window Type CTs: Verify neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Use 5,000-volt megohmmeter for 8 kV and 15 kV conductors.
   b. Test each cable individually with remaining cables and shields grounded.
   c. Test each conductor with respect to ground and to adjacent conductors for 1 minute.
   d. Evaluate ohmic values by comparison with conductors of same length and type.
   e. Investigate values less than 50 megohms.

2. Shield Continuity Tests:
    a. By ohmmeter method on each section of conductor.
    b. Investigate values in excess of 10 ohms per 1,000 feet of conductors.
3. Acceptance Tests:
    a. In accordance with IEEE 400, ICEA S-93-639, NEMA WC 74, ICEA S-94-649, and ICEA S-97-682 for insulated conductors.
    b. Each conductor section tested with:
        1) Splices and terminations in place but disconnected from equipment.
        2) Remaining conductors and shields grounded in accordance with IEEE 400.
    c. Apply maximum test voltage per NETA ATS, Table 100.6, based on method (DC, AC, PD or VLF) used.
    d. Measure only leakage current associated with conductor.
    e. Use guard ring or field reduction sphere to suppress corona at disconnected terminations.
    f. Maximum test voltage shall not exceed limits for terminators specified in IEEE 48, IEEE 386, or manufacturer's specifications.
    g. Apply test voltage in a minimum of five equal increments until maximum acceptable test voltage is reached.
        1) Increments not to exceed ac voltage rating of conductor.
        2) Record dc leakage current at each step after a constant stabilization time consistent with system charging current.
    h. Raise conductor to specified maximum test voltage and hold for 15 minutes or as specified by conductor manufacturer. Record leakage current at 30 seconds and 1 minute, and at 1-minute intervals, thereafter.
    i. Immediately following test, ground conductor for adequate time period to drain insulation stored charge.
    j. Test results evaluated on a pass/fail basis.
4. New Conductors Spliced to Existing Conductors:
    a. Prior to performing splices, high potential dc test new conductor sections.
    b. After splicing new conductors to existing conductors, disconnect existing conductors and perform the following tests:
        1) Shield continuity test.
        2) Insulation resistance test.
        3) High potential test with test voltage not to exceed 60 percent of applied acceptance dc test voltage.

3.09 SAFETY SWITCHES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Proper blade pressure and alignment.
2. Proper operation of switch operating handle.
3. Adequate mechanical support for each fuse.
4. Proper contact-to-contact tightness between fuse clip and fuse.
5. Cable connection bolt torque level in accordance with NETA ATS, Table 100.12.
6. Proper phase barrier material and installation.
7. Verify fuse sizes and types correspond to one-line diagram or approved submittals.
8. Perform mechanical operational test and verify electrical and mechanical interlocking system operation and sequencing.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
   b. Phase-to-phase and phase-to-ground for 1 minute on each pole.
   c. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Contact Resistance Tests:
   a. Contact resistance in microhms across each switch blade and fuse holder.
   b. Investigate deviation of 50 percent or more from adjacent poles or similar switches.

3.10 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers rated 100 amperes and larger and to motor circuit protector breakers rated 100 amperes and larger.

B. Visual and Mechanical Inspection:

1. Proper mounting.
2. Proper conductor size.
3. Feeder designation according to nameplate and one-line diagram.
4. Cracked casings.
5. Connection bolt torque level in accordance with NETA ATS, Table 100.12.
6. Operate breaker to verify smooth operation.

7. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.
8. Verify that terminals are suitable for 75 degrees C rated insulated conductors.

C. Electrical Tests:

1. Insulation Resistance Tests:
   a. Use 1,000V dc megohmmeter for 480-volt and 600-volt circuit breakers 500V dc megohmmeter for 240-volt circuit breakers.
   b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
   c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
   d. Test values to comply with NETA ATS, Table 100.1.
2. Contact Resistance Tests:
   a. Contact resistance in microhms across each pole.
   b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
3. Primary Current Injection Test to Verify:
   a. Long-time minimum pickup and delay.
   b. Short-time pickup and delay.
   c. Ground fault pickup and delay.
   d. Instantaneous pickup by run-up or pulse method.
   e. Trip characteristics of adjustable trip breakers shall be within manufacturer's published time-current characteristic tolerance band, including adjustment factors.
   f. Trip times shall be within limits established by NEMA AB 4, Table 5-3. Alternatively, use NETA ATS, Table 100.7.
   g. Instantaneous pickup value shall be within values established by NEMA AB 4, Table 5-4. Alternatively, use NETA ATS, Table 100.8.

3.11 LOW VOLTAGE POWER CIRCUIT BREAKERS

A. Visual and Mechanical Inspection:

1. Proper mounting, cell fit, and element alignment.
2. Proper operation of racking interlocks.
3. Check for damaged arc chutes.
4. Proper contact condition.
5. Bolt torque level in accordance with NETA ATS, Table 100.12.
6. Perform mechanical operational and contact alignment tests in accordance with manufacturer's instructions.

7. Check operation of closing and tripping functions of trip devices by activating ground fault relays, undervoltage shunt relays, and other auxiliary protective devices.
8. Verify primary and secondary contact wipe, gap setting, and other dimensions vital to breaker operation are correct.
9. Check charging motor, motor brushes, associated mechanism, and limit switches for proper operation and condition.
10. Check operation of electrically operated breakers in accordance with manufacturer's instructions.
11. Check for adequate lubrication on contact, moving, and sliding surfaces.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Use 1,000V dc megohmmeter for 480-volt and 600-volt circuit breakers.
   b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
   c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
   d. Test values to comply with NETA ATS, Table 100.1.
2. Contact Resistance Tests:
   a. Contact resistance in microhms across each pole.
   b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
3. Primary Current Injection Test to Verify:
   a. Long-time minimum pickup and delay.
   b. Short-time pickup and delay.
   c. Ground fault pickup and delay.
   d. Instantaneous pickup by run-up or pulse method.
   e. Trip characteristic when adjusted to setting sheet parameters shall be within manufacturer's published time-current tolerance band.

3.12 PROTECTIVE RELAYS

A. Visual and Mechanical Inspection:

1. Visually check each relay for:
   a. Tight cover gasket and proper seal.
   b. Unbroken cover glass.
   c. Condition of spiral spring and contacts.
   d. Disc clearance.
   e. Condition of case shorting contacts if present.
2. Mechanically check each relay for:
   a. Freedom of movement.
   b. Proper travel and alignment.

3. Verify each relay:
    a. Complies with Contract Documents, approved Submittal, and application.
    b. Is set in accordance with recommended settings from Coordination Study.

B. Electrical Tests:

1. Insulation resistance test on each circuit to frame, except for solid state devices.
2. Test on nominal recommended setting for:
    a. Pickup parameters on each operating element.
    b. Timing at three points on time-current curve.
    c. Pickup target and seal-in units.
    d. Special tests as required to check operation of restraint, directional, and other elements in accordance with manufacturer's instruction manual.
3. Phase angle and magnitude contribution tests on differential and directional relays after energization to vectorially verify proper polarity and connections.
4. Current Injection Tests:
    a. For entire current circuit in each section.
    b. Secondary injection for current flow of 1 ampere.
    c. Test current at each device.

3.13 INSTRUMENT TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Visually check current, potential, and control transformers for:
    a. Cracked insulation.
    b. Broken leads or defective wiring.
    c. Proper connections.
    d. Adequate clearances between primary and secondary circuit wiring.
2. Verify mechanically:
    a. Grounding and shorting connections have good contact.
    b. Withdrawal mechanism and grounding operation, when applicable, operate properly.
3. Verify proper primary and secondary fuse sizes for potential transformers.

B. Electrical Tests:

1. Current Transformer Tests:
   a. Insulation resistance test of transformer and wiring-to-ground at 1,000 volts dc for 30 seconds.
   b. Polarity test.
2. Potential Transformer Tests:
   a. Insulation resistance test at test voltages in accordance with NETA ATS, Table 100.9, for 1 minute on:
      1) Winding-to-winding.
      2) Winding-to-ground.
   b. Polarity test to verify polarity marks or H1-X1 relationship as applicable.
3. Insulation resistance measurement on instrument transformer shall not be less than that shown in NETA ATS, Table 100.5.

3.14 METERING

A. Visual and Mechanical Inspection:

1. Verify meter connections in accordance with appropriate diagrams.
2. Verify meter multipliers.
3. Verify meter types and scales conform to Contract Documents.
4. Check calibration of meters at cardinal points.
5. Check calibration of electrical transducers.

3.15 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

1. Equipment and circuit grounds in motor control center, panelboard, switchboard, and switchgear assemblies for proper connection and tightness.
2. Ground bus connections in motor control center, panelboard, switchboard, and switchgear assemblies for proper termination and tightness.
3. Effective transformer core and equipment grounding.
4. Accessible connections to grounding electrodes for proper fit and tightness.
5. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

B. Electrical Tests:

1. Fall-of-potential Test:
   a. In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system's resistance.
   b. Main ground electrode system resistance to ground to be no greater than 1 ohm.
2. Two-point Direct Method Test:
   a. In accordance with IEEE 81, Section 8.2.1.1 for measurement of ground resistance between main ground system, equipment frames, and system neutral and derived neutral points.
   b. Equipment ground resistance shall not exceed main ground system resistance by 0.50 ohm.

3.16 GROUND FAULT SYSTEMS

A. Inspection and testing limited to:

1. Zero sequence grounding systems.
2. Residual ground fault systems.

B. Visual and Manual Inspection:

1. Neutral main bonding connection to ensure:
   a. Zero sequence sensing system is grounded ahead of neutral disconnect link.
   b. Ground strap sensing system is grounded through sensing device.
   c. Neutral ground conductor is solidly grounded.
2. Verify control power has adequate capacity for system.
3. Manually operate monitor panels for:
   a. Trip test.
   b. No trip test.
   c. Nonautomatic rest.
4. Zero sequence system for symmetrical alignment of core balance transformers about current carrying conductors.
5. Relay check for pickup and time under simulated ground fault conditions.
6. Verify nameplate identification by device operation.

C. Electrical Tests:

1. Test system neutral insulation resistance with neutral ground link removed; minimum 1 megohm.
2. Determine relay pickup by primary current injection at the sensor. Relay pickup current within plus or minus 10 percent of device dial or fixed setting.

3. Test relay timing by injecting 300 percent of pick-up current or as specified by manufacturer. Relay operating time in accordance with manufacturer's time-current characteristic curves.
4. Test system operation at 55 percent rated control voltage, if applicable.
5. Test zone interlock system by simultaneous sensor current injection and monitoring zone blocking functions.

3.17 AC INDUCTION MOTORS

A. General: Inspection and testing limited to motors rated 5 horsepower and larger.

B. Visual and Mechanical Inspection:

1. Proper electrical and grounding connections.
2. Shaft alignment.
3. Blockage of ventilating air passageways.
4. Operate motor and check for:
   a. Excessive mechanical and electrical noise.
   b. Overheating.
   c. Correct rotation.
   d. Check vibration detectors, resistance temperature detectors, or motor inherent protectors for functionability and proper operation.
   e. Excessive vibration, in excess of values in NETA ATS, Table 100.10.
5. Check operation of space heaters.

C. Electrical Tests:

1. Insulation Resistance Tests:
   a. In accordance with IEEE 43 at test voltages established by NETA ATS, Table 100.1 for:
      1) Motors above 200 horsepower for 10-minute duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
      2) Motors 200 horsepower and less for 1-minute duration with resistances tabulated at 30 seconds and 60 seconds.
   b. Insulation resistance values equal to, or greater than, ohmic values established by manufacturers.
2. Calculate polarization index ratios for motors above 200 horsepower. Investigate index ratios less than 1.5 for Class A insulation and 2.0 for Class B insulation.
3. Insulation resistance test on insulated bearings in accordance with manufacturer's instructions.
4. Measure running current and voltage, and evaluate relative to load conditions and nameplate full-load amperes.

5. Overpotential Tests:
    a. Applied dc voltage in accordance with IEEE 95.
    b. Limited to 4,000-volt motors rated 1,000 horsepower and greater.
    c. Test results evaluated on pass/fail basis.

3.18 LOW-VOLTAGE MOTOR CONTROL

A. Visual and Mechanical Inspection:

1. Proper barrier and shutter installation and operation.
2. Proper operation of indicating and monitoring devices.
3. Proper overload protection for each motor.
4. Improper blockage of air-cooling passages.
5. Proper operation of drawout elements.
6. Integrity and contamination of bus insulation system.
7. Check door and device interlocking system by:
    a. Closure attempt of device when door is in OFF or OPEN position.
    b. Opening attempt of door when device is in ON or CLOSED position.
8. Check key interlocking systems for:
    a. Key captivity when device is in ON or CLOSED position.
    b. Key removal when device is in OFF or OPEN position.
    c. Closure attempt of device when key has been removed.
    d. Correct number of keys in relationship to number of lock cylinders.
    e. Existence of other keys capable of operating lock cylinders; destroy duplicate sets of keys.
9. Check nameplates for proper identification of:
    a. Equipment title and tag number with latest one-line diagram.
    b. Pushbuttons.
    c. Control switches.
    d. Control relays.
    e. Circuit breakers.
    f. Indicating meters.
10. Verify fuse and circuit breaker sizes and types conform to Contract Documents.
11. Verify current and potential transformer ratios conform to Contract Documents.
12. Check bus connections for high resistance by calibrated torque wrench applied to bolted joints and thermographic survey:
    a. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
    b. Thermographic survey temperature gradient of 2 degrees C, or less per NETA ATS, Table 100.18.

13. Check operation and sequencing of electrical and mechanical interlock systems by:
    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
    c. Key exchange to operate devices in OFF-NORMAL positions.
14. Verify performance of each control device and feature furnished as part of motor control center.
15. Control Wiring:
    a. Compare wiring to local and remote control, and protective devices with elementary diagrams.
    b. Check for proper conductor lacing and bundling.
    c. Check for proper conductor identification.
    d. Check for proper conductor lugs and connections.
16. Exercise active components.
17. Inspect contactors for:
    a. Correct mechanical operations.
    b. Correct contact gap, wipe, alignment, and pressure.
    c. Correct torque of connections.
18. Compare overload heater rating with full-load current for proper size.
19. Compare motor protector and circuit breaker with motor characteristics for proper size.
20. Perform phasing check on double-ended motor control centers to ensure proper bus phasing from each source.

B. Electrical Tests:

1. Insulation Resistance Tests:
    a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
    b. Bus section phase-to-phase and phase-to-ground for 1 minute on each phase.
    c. Contactor phase-to-ground and across open contacts for 1 minute on each phase.
    d. Starter section phase-to-phase and phase-to-ground on each phase with starter contacts closed and protective devices open.
    e. Test values to comply with NETA ATS, Table 100.1.
2. Current Injection through Overload Unit at 300 Percent of Motor Full-Load Current and Monitor Trip Time:
    a. Trip time in accordance with manufacturer's published data.
    b. Investigate values in excess of 120 seconds.
3. Control Wiring Tests:
    a. Apply secondary voltage to control power and potential circuits.
    b. Check voltage levels at each point on terminal board and each device terminal.

c. Insulation resistance test at 1,000 volts dc on control wiring, except that connected to solid state components; 1 megohm minimum insulation resistance.

4. Operational test by initiating control devices to affect proper operation.

3.19 AUTOMATIC TRANSFER SWITCHES

A. Visual and Mechanical Inspection:

1. Check doors and panels for proper interlocking.
2. Check connections for high resistance by calibrated torque wrench applied to bolted joints.
3. Check positive mechanical and electrical interlock between normal and alternate sources.
4. Check for proper operation:
   a. Manual transfer function switch.
   b. Generator under load and nonload conditions.
   c. Auto-exerciser of generator under load and no-load conditions.
5. Verify settings and operation of control devices.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1, for each phase with switch CLOSED in both source positions.
   b. Phase-to-phase and phase-to-ground for 1 minute.
   c. Test values in accordance with manufacturer's published data.
2. Contact Resistance Test:
   a. Contact resistance in microhms across each switch blade for both source positions.
   b. Investigate values exceeding 500 micro-ohms.
   c. Investigate values deviating from adjacent pole by more than 50 percent.
3. Set and calibrate in accordance with Specifications, manufacturer's recommendations, and Coordination Study.
   a. Voltage and frequency sensing relays.
   b. Time delay relays.
   c. Engine start and shutdown relays.
4. Perform automatic transfer tests by:
   a. Simulating loss of normal power.
   b. Return to normal power.
   c. Simulating loss of alternate power.
   d. Simulating single-phase conditions for normal and alternate sources.

5. Monitor and verify operation and timing of:
    a. Normal and alternate voltage sensing relays.
    b. Engine-start sequence.
    c. Timing delay upon transfer and retransfer.
    d. Engine cool down and shutdown.
    e. Interlocks and limit switch functions.
    f. Engine cool down and shutdown feature.

3.20 LOW VOLTAGE SURGE ARRESTORS

A. Visual and Mechanical Inspection:

1. Adequate clearances between arrestors and enclosures.
2. Ground connections to ground bus.

B. Electrical Tests:

1. Varistor Type Arrestors:
    a. Clamping voltage test.
    b. Rated RMS voltage test.
    c. Rated dc voltage test.
    d. Varistor arrestor test values in accordance with IEEE C62.33, Section 4.4 and Section 4.9.

3.21 THERMOGRAPHIC SURVEY

A. Provide thermographic survey per NETA ATS Table 100.18 of connections associated with incoming service conductors, bus work, and branch feeder conductors No. 2 and larger at each:

1. Medium-voltage and low-voltage switchgear.
2. Low-voltage and medium-voltage motor control center.
3. Panelboard.
4. Automatic transfer switch.

B. Provide thermographic survey of feeder conductors No. 4 and larger terminating at:

1. Motors 50 hp and larger.
2. Low voltage disconnect switches.
3. Transfer switches.

C. Remove necessary enclosure metal panels and covers prior to performing survey.

D. Perform with equipment energized during periods of maximum possible loading per NFPA 70B, Section 20.17.

E. Do not perform survey on equipment operating at less than 20 percent of rated load.

F. Use thermographic equipment capable of:

1. Detecting emitted radiation.
2. Converting detected radiation to visual signal.
3. Detecting 1 degree C temperature difference between subject area and reference point of 30 degrees C.

G. Temperature Gradients:

1. 3 degrees C to 7 degrees C indicates possible deficiency that warrants investigation.
2. 7 degrees C to 15 degrees C indicates deficiency that is to be corrected as time permits.
3. 16 degrees C and above indicates deficiency that is to be corrected immediately.

H. Provide written report of:

1. Areas surveyed and the resultant temperature gradients.
2. Locations of areas having temperature gradients of 3 degrees C or greater.
3. Cause of heat rise and actions taken to correct cause of heat rise.
4. Detected phase unbalance.

END OF SECTION

SECTION 26 09 13
POWER MEASUREMENT AND CONTROL

PART 1 GENERAL

1.01 SUMMARY

A. This section includes the following for monitoring and control of electrical power system:

1. Monitoring required and parameters historically logged, alarmed and reported.
2. Communication network and interface modules for RS-485, Modbus and TCP/IP data transmission protocols.
3. Control of electrical power systems.
4. Replacement of existing desktop personal computer located in existing electrical building control room. Provide latest software and modifications to include new work.
5. Special Note: The existing plant-wide power measurement and control system is based on GE Industrial Solutions PMCS. Any additions shall be compatible with that system. GE Requisition No. 302EW210-PM. Note that these systems are now recently provided by ABB.

1.02 DEFINITIONS

A. AFD: Adjustable frequency drive.

B. CT: Current transformer.

C. DNP: Distributed network protocol.

D. Ethernet: Local area network based on IEEE 802.3i, 802.3u, 802.3ab and 802.3z standards. 10 Base T, 100 Base T, and Gigabyte Plus capable TCP/IP.

E. LAN: Local area network; sometimes plural as “LANs.”

F. LCD: Liquid crystal display.

G. LED: Light-emitting diode.

H. Modbus, TCP/IP: Open protocols for exchange of process data.

I. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

J. MPR: Motor protection relay.

K. PC: Personal computer; sometimes plural as “PCs.”

L. PLC: Programmable logic controller.

M. rms: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

N. RS-232: A TIA standard for asynchronous serial data communications between terminal devices.

O. RS-485: A TIA standard for multipoint communications using one or two twisted-pairs.

P. RTD: Resistance temperature detectors.

Q. TCP/IP: Transport control protocol/internet protocol as incorporated into the Internet.

R. UCA: Utility communications architecture.

S. VT: Voltage transformer.

1.03 SUBMITTALS

A. Action Submittals:

1. Product Data: For each type of product indicated.
2. Shop Drawings: For power monitoring and control equipment. Include plans, elevations, sections, details, and attachments to other work.
   a. Outline Drawings: Indicate arrangement of components and clearance and access requirements.
   b. Block Diagram: Show interconnections between components specified in this section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
   c. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   d. Wiring Diagrams: Power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
3. Field Quality-control Test Reports:
   a. System overview diagram of devices, computers, printers and gateways in the system.
      1) Device address, baud rate, parity, and IP addresses to be noted on diagram.

b. System reports/configuration information detailing.
   1) Meter Setup Information: Voltage, CT ratio, system wiring configuration.
   2) Alarming and Historical Data Logging configurations.
c. Screen captures of actual graphic screens – with technician sign off that value blocks have been verified to ensure correct meter displayed.
d. Communication test reports demonstrating all devices are communicating.

4. Operation and Maintenance Data: For power monitoring and control units, to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23, Operation and Maintenance Data, include the following:
   a. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy submittal.
5. Other Informational Submittals: System installation and setup guides, with data forms to plan and record options and setup decisions.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: A firm experienced in manufacturing power monitoring and control equipment similar to that indicated for this Project and with a record of successful in-service performance.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.05 COORDINATION

A. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.

   1. Match components and interconnections for optimum performance of specified functions.

B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

1.06 SOFTWARE SERVICE AGREEMENT

A. Configure metering and devices to the new facilities software.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include only the following:

1. GE/ABB. Special Note: The existing plant-wide power measurement and control system is based on GE Industrial Solutions PMCS. Any additions shall be compatible with that system. GE Requisition No. 302EW210-PM.

2.02 FUNCTIONAL DESCRIPTION

A. Power monitoring system is a multipurpose system that provides engineering, operations and maintenance personnel vital information in regard to load, availability and quality of the electrical power within buildings on the Project.

B. The EPMS system monitors for electrical power disturbances from the utility, or internal campus sources. Electrical power quality metering shall provide waveform captures and information details on disturbances such as voltage sags and swells including an analysis as to the direction of the disturbance flow in the electrical system. In addition it will provide load and status information from key breakers, automatic transfer switches, UPS and static transfer switches and some mechanical loads depending on the facility and the importance of any of this information to the site personnel.

C. Information for the EPMS system is displayed in easy-to-view formats, showing real time values for many electrical parameters, including graphic screens of equipment layout, on the PowerLogic system manager software power monitoring system application.

D. Information is logged on a periodic schedule based upon the equipment according to pre-established time period and alarmed to the EPMS system when preset parameters are exceeded or conditions change. Periodic reports and screen captures are scheduled to be run and printed out to give operators and engineer's information for future load planning and maintenance.

E. When an electrical disturbance or excessive electrical harmonic conditions occur the system is set to capture and download to the server a snap shot of the electrical waveform showing the problem in enough detail to help develop plans for avoiding or limiting the impact of the disturbance in the future and understanding how the currently designed system responded to the problem.

F. All information is accessible using Microsoft Internet Explorer 8.0 web browser and requires a “User Name” and Log In ID to access. Much of the

electrical equipment involved in the EPMS system is integral to the electrical equipment supplied in the project and the EPMS system networks these devices together and conditions the information for display and use.

G. A stable source of control power is required for all the devices being networked so as to provide information and data integrity during and after an electrical disturbance. This stable source of power will be provided with the substation switchgear, secondary substation main service entrance switchgear, and with the generator switchgear.

H. Power Quality Monitoring: Identify power system anomalies and measure, display, and record trends and alarms of the following power quality parameters.

1. Voltage regulation and unbalance.
2. Continuous three-phase rms voltage.
3. Periodic maximum/minimum/avgerage samples.
4. Harmonics.
5. Voltage excursions (including sag/swell disturbances).

2.03 SYSTEM REQUIREMENTS

A. Addressable Devices: All transmitters and receivers shall communicate unique device identification and status reports to monitoring and control clients.

2.04 MONITORING AND METERING DEVICES

A. Advanced Power Quality Monitor (CM4250): Provide at the main breakers of the substation low voltage switchgear, and where otherwise indicated on Drawings. Identify power system anomalies and measure, display, and record trends and alarms of the following power quality parameters:

1. Advanced power quality monitor shall be accurate to 0.04 percent of reading plus/minus 0.025 percent of full scale for voltage and current metering and 0.08 percent of reading plus 0.025 percent for power.
2. No annual re-calibration by users shall be required to maintain published accuracy.
3. Metering standard instrumentation readings in real time including:
    a. Voltage all appropriate phases.
    b. Current all phases.
    c. Power Factor: Displacement and true.
    d. THD Percent: Voltage and current per phase.
    e. Energy and Power: Real, apparent, and reactive.
4. Voltage regulation and unbalance.
5. Periodic maximum, minimum, and average samples.

6. Current and voltage signals shall be digitally sampled at a rate high enough to provide true rms accuracy to the 255th harmonic (based on fundamental of 60-Hz).
7. Monitor shall provide continuous sampling at a minimum of up to 512 samples/cycle, simultaneously on all voltage and current channels in the meter.
8. Advanced harmonic information shall be available via the circuit monitor. This shall include the calculation of the harmonic magnitudes and angles for each phase voltage and current through the 255th harmonic.
9. Harmonics – voltage and current – waveform capture with spectrum graph view.
10. Voltage and current for all phases shall be sampled simultaneously to assure high accuracy in conditions of low power factor or large waveform distortions (harmonics).
11. Harmonic power flows will be provided up to the 41st harmonic for real, reactive and apparent power.
12. Three types of waveform capture shall be available for response to an alarm condition:
    a. Steady state shall be manually initiated and provide a resolution of 512 samples/cycle.
    b. Disturbance shall be initiated manually or by an alarm condition and allow the user to select a resolution of 16 to 512 samples/ cycle and a duration of 715 cycles to 1 cycle.
    c. Adaptive shall be initiated manually or by an alarm condition and allow the user to select a resolution of 16 to 512 samples/cycle and a duration of 88 seconds to 2 seconds.
13. Capture and store steady-state waveforms of voltage and current channels; initiated manually. Each capture shall be for 3 cycles, 512 data points for each cycle, allowing resolution of harmonics to 255th harmonic of basic 60-Hz.
14. Capture and store disturbance waveform captures of voltage and current channels, initiated automatically based on an alarm event. Each capture shall be fully configurable for duration with resolution of at least 512 data points per cycle, for all channels simultaneously. Waveform shall be configurable to capture 4 pre-event cycles for analysis.
15. Store captured waveforms in internal nonvolatile memory; available for PC display, archiving, and analysis.
16. Monitor shall have a minimum of 16MB of on board memory to log harmonic magnitudes and angles.
17. Monitor (CM4250) shall include anti-aliasing filters on both voltage and current metering inputs. These anti-aliasing filters are capable of having the corner frequency adjusted between 60-Hz, or “off” modes.
18. Alarms shall be user definable with each over/under metered value alarm, the user shall be able to define a pick-up, drop-out and delay.

19. Alarms shall be configurable from the following events:
    a. Over/Under voltage and/or current, frequency.
    b. Imbalance voltage and/or current.
    c. Phase loss voltage and/or current.
    d. Phase reversal and/or reverse power.
    e. Over kVA, kW, or kVAR.
    f. Under power factor.
    g. Sag/swell voltage and/or current.
20. Power quality monitor shall communicate via RS-485 or Ethernet Modbus RTU protocol with provisions for both 2-wire or 4-wire or UTP Cat 6 Ethernet cable with connection at speeds up to 38.4 k Baud.
21. Advanced power quality monitor shall operate properly over a wide range of control power including 100 to 264V ac or 100 to 300V dc. Connections to 18 to 60V dc shall also be available.
22. A stable control power source must be provided for proper monitoring or Ride-through capability shall be available for backup control power for up to 2 seconds or with parallel units up to 10 seconds.

B. Digital Power Meter (DPM): Power metering with advanced capability for THD alarming; equal to SQD PM820.

1. Permanently installed instrument for power monitoring.
    a. Integral to the equipment.
    b. Install on each of the service entrance switchgear feeder breakers, substation low voltage switchgear feeder breakers, generator paralleling switchgear breakers, and on other devices shown on Drawings. Do not install on motor control center main breakers located in Substation 2 and Substation 3 rooms.
2. rms Real-Time Measurements:
    a. Current: Each phase, neutral, average of three phases, percent unbalance.
    b. Voltage: Line-to-line each phase, line-to-line average of three phases, line-to-neutral each phase, line-to-neutral average of three phases, line-to-neutral percent unbalance.
    c. Power: Per phase and three-phase total.
    d. Reactive Power: Per phase and three-phase total.
    e. Apparent Power: Per phase and three-phase total.
    f. Power Factor: Per phase and three-phase total.
    g. Displacement Power Factor: Per phase and three-phase total.
    h. Frequency.
    i. THD: Current and voltage.
3. Sampling:
    a. Current and voltage shall be digitally sampled at a rate high enough to provide accuracy to 63rd harmonic of 60-Hz fundamental.

b. Power monitor shall provide continuous sampling at a rate of 128 samples per cycle on all voltage and current channels in the meter.

4. Minimum and Maximum Values: Records monthly minimum and maximum values, including date and time of record. For three-phase measurements, identify phase of recorded value. Record the following parameters:
   a. Line-to-line voltage.
   b. Line-to-neutral voltage.
   c. Current per phase.
   d. Line-to-line voltage unbalance.
   e. Line-to-neutral voltage unbalance.
   f. Power factor.
   g. Total power.
   h. Total reactive power.
   i. Total apparent power.
   j. THD current.
   k. Frequency.
5. Current and Voltage Ratings:
   a. Designed for use with current inputs from standard instrument current transformers with 5 amp secondary and shall have a metering range of 0 to 10 amp.
   b. Withstand ratings shall be not less than 15 amp, continuous; 50 amp, lasting over 10 seconds, no more frequently than once per hour; 500 A, lasting 1 second, no more frequently than once per hour.
   c. Designed for use with voltage inputs from standard instrument potential transformers with a 120 volt secondary.
6. Accuracy:
   a. Comply with ANSI C12.20, Class 0.5; and IEC 60687, Class 0.5 for revenue meters.
   b. Accuracy from Light to Full Rating:
      1) Power: Accurate to 0.25 percent of reading, plus 0.025 percent of full scale.
      2) Voltage and Current: Accurate to 0.075 percent of reading, plus 0.025 percent of full scale.
      3) Power Factor: Plus or minus 0.002, from 0.5 leading to 0.5 lagging.
      4) Frequency: Plus or minus 0.01 Hz at 45-Hz to 67-Hz.
7. Alarms:
   a. User Options: Define pickup, dropout, and delay.
   b. Alarm Events:
      1) Over/under current and voltage.
      2) Current and voltage imbalance.
      3) Phase loss, current and/or voltage.
      4) Over kW demand.

5) Phase reversal.

8. Provide a stable control power source integral to devices where power meters are installed for proper monitoring or ride-through capability for backup control power for up to 8 seconds.
9. Communications: Power monitor shall be permanently connected to communicate via RS-485 or Ethernet Modbus RTU.
10. Display Monitor:
    a. Backlighted LCD display metered data with touch-screen selecting device.
    b. Reset: Allow reset of the following parameters at the display:
        1) Peak demand current.
        2) Peak demand power (kW) and peak demand apparent power (kVA).
        3) Energy (MWh) and reactive energy (MVARh).

C. Basic Group Power Metering (High-density Metering Group Metering; where shown on Drawings): With the following metered values.

1. Metering standard instrumentation readings in real time including:
    a. Voltage all appropriate phases.
    b. Current all phases.
    c. Power factor – displacement and true.
    d. Energy and Power – Real, apparent and reactive.
2. Power meter shall communicate via RS-485 or Ethernet Modbus RTU protocol with a 2-wire or 4-wire connection at speeds up to 19.2 k Baud.
3. Separate stable control power shall be provided to the data acquisition board such as from a UPS source.

2.05 ETHERNET COMMUNICATIONS GATEWAY

A. Ethernet Gateway (EGX-100SD)

1. The Ethernet Gateway (EGX-100SD) shall feature one 10/100 MB UTP port.
2. The Ethernet Gateway shall have one serial RS-485 port that is used to connect serial field devices to the LAN. The RS-485 serial port shall support up to 32 serial devices without a repeater. Supports both 2-wire or 4-wire daisy chain devices.
3. Ethernet Gateway shall feature one configurable RS-485 or RS-232 port.
4. The Ethernet Gateway shall be a stand-alone product that offers various mounting configuration and includes at a minimum the following mounting options: DIN-rail mounting, desk top or Enclosed as noted on Drawings.
5. Ethernet Gateway shall UL, CUL, CE, NOM and FCC Class A compliant.

6. Ethernet Gateway shall be compatible with Ethernet TCP/IP networks and allows users to access power monitoring information from any location on a local area network (LAN) or a wide area network (WAN).
7. Ethernet Gateway shall use Modbus/TCP protocol as its high-speed backbone network protocol.
8. Ethernet Gateway shall be configured remotely using a standard internet browser.
9. Separate stable 24V dc control power source equal to IDEC-IZUMI PS5R-A24 shall be provided to the data acquisition board.

2.06 COMMUNICATION CABLES

A. Provide communication cabling as required to complete or establish an RS485 communication daisy chain following metering device installations instructions using the following cables.

1. PVC, CPE or Teflon-jacketed, RS-485 4-wire Cable: Paired, 2 pairs, twisted, No. 24 AWG, stranded (7x30) tinned copper conductors, 12.8 pf/ft nominal capacitance, 120 ohms nominal impedance, shielded, jacketed, and NFPA 70, Type CMG.

2.07 LAN CABLES

A. Unshielded Twisted Pair Cables: Category 6e as specified for horizontal cable for data service.

2.08 SOFTWARE AND POWER MONITORING

A. Provide, from manufacturer of display devices for power distribution system equipment, Microsoft Windows-based software suitable for number of devices monitored.

B. Capable of the following:

1. Interval logging of metering data every 15 minutes.
2. Error detection and diagnostics for metering device status.
3. Automatic retrieval of data from display device memory.
4. Reporting of all measured data.
5. Assignment of individual information, such as names, to display devices.
6. Production of Reports:
   a. Load profile by day, week, and month.
   b. Annual summary of data.
   c. Export of up to 1 year of data to Microsoft Excel.

C. Each power monitoring device shall have two (redundant) Ethernet 10/100/1000 base t compatible connection points and shall include Interface

Adapters to convert the data protocol to be compatible with the Owner's Ethernet based digital control system. The supplier shall also include software package(s) that will allow all available status points to be programmed, read, and recorded.

2.09 ANALOG METERS AND INSTRUMENTS

A. General:

1. Semi-flush mounted, switchboard type.
2. Suitable for mounting on hinged steel panels.
3. Case: Dust-tight, enclosed, with dull black finish.
4. Shape: Square or rectangular.
5. Complete with resistors, reactors, and necessary auxiliaries.
6. 1 percent accuracy.
7. Antiparallax scales with convex clear glass shadow-proof covers for indicating meters and relays.
8. White dials with black points and markings.
9. Indicating Scale: 250-degree circular, nominal.
10. Zero Adjustment: External zero capability.

B. Instrument and Control Switches:

1. Type: Rotary, cam-operated, with two contacts per stage.
2. Silver contacts and maintained positive contact position.
3. Wiping action closing contacts.
4. Adjacent contacts separated by barriers.
5. Contact assembly enclosed in removable cover.
6. Rating: Minimum 20 amperes with 600-volt insulation.
7. Marked escutcheon plates.
8. Operating Handles:
   a. Power Circuit Breaker Control: Pistol grip.
   b. Instrument Switches: Round knurled handles.
   c. Voltmeter Switches: Four-position, phase-to-phase voltage, and OFF.
   d. Ammeter Switches: Four-position, three-phase currents, and OFF.
   e. Transfer and Auxiliary Switches: Oval type with arrow.
9. Circuit Breaker Switches:
   a. Momentary contact, spring-return type.
   b. Operation indicator to show last operation.
   c. Indicating Lights:
      1) Red to indicate closing.
      2) Green to indicate open.
      3) White to indicate tripped.
      4) Switchboard type with series resistors.
   d. Mechanical key interlock for locking in OFF position.

10. Test Switches for Instrument and Current Sources:
    a. Back connected with clear plastic covers.
    b. Test jacks in phases for current test switches.
    c. Four-pole units for both current and voltage.

C. Indicating Instruments and Meters:

1. Register Size: 6.9-inch scale length, 250-degree arc.
2. ac Voltmeters:
    a. Full-scale rating 150-volt movement calibrated for 15,000 volts, 60-Hz.
    b. Taut-suspension type.
3. ac Ammeters:
    a. Full-scale rating 5-ampere movement.
    b. Taut-suspension type.
4. Wattmeters and Varmeters:
    a. Rated 5 amperes at 120 volts.
    b. Taut-suspension type with built-in watt and var transducer.
    c. Register: Clock.
    d. Elements: Two.

D. Metering Transducers:

1. In accordance with IEC 60688.
2. Inputs: 115 volts nominal, 5 amperes, 60-Hz.
3. Output: 4 mA to 20 mA dc into variable loads as established by manufacturer.
4. Withstand:
    a. IEEE C37.90.1 surge capability tests.
    b. Minimum of 1,500-volt rms between input, output, and case.
5. Maximum Ripple: 1 percent dc peak-to-peak output.
6. Step Change Input Response: Within 400 milliseconds.
7. Operating Temperature Range: Minus 20 to plus 60 degrees C.
8. Circuitry: Solid state, with calibration and zero adjustment.
9. Enclosure: Steel, suitable for back mounting.
10. Screw type barrier terminal blocks plus enclosure grounding terminal.
11. Transducers: Voltage current watt var and frequency.

2.10 INSTRUMENT TRANSFORMERS

A. Current Transformer (CT), 600V and Below:

1. Type: Molded bar or donut.
2. Accuracy: 0.3 at burden imposed by meters and instruments.
3. Shorting type terminal boards for current transformer leads.

B. Potential Transformer (PT), 600V and Below:

1. Type: Molded.
2. Accuracy Classification: 0.3 at burden imposed by meters and instruments, including future.
3. Primary Fuses: Two, current-limiting.
4. Secondary Fuses: One, current-limiting.

2.11 SOFTWARE

A. Provide, from manufacturer of display devices for power distribution and generation systems equipment, Microsoft Windows-based software suitable for number of devices monitored.

B. Capable of the following:

1. Interval logging of metering data every 15 minutes.
2. Error detection and diagnostics for metering device status.
3. Automatic retrieval of data from display device memory.
4. Reporting of all measured data.
5. Assignment of individual information, such as names, to display devices.
6. Production of Reports:
   a. Load profile by day, week, and month.
   b. Annual summary of data.
   c. Export of up to 1 year of data to Microsoft Excel.

PART 3 EXECUTION

3.01 INSTALLATION

A. PMCS components, including circuit monitors, electronic trip units, transformer temperature monitors, motor protection devices, and digital relays, included within the power equipment lineups shall be factory-installed, wired and tested prior to shipment to the job site.

B. All control power, CT, PT and data communications wire shall be factory-wired and harnessed within the equipment enclosure.

C. Where external circuit connections are required, terminal blocks shall be provided and the manufacturer's drawings must clearly identify the interconnection requirements including wire type to be used.

D. All wiring required to externally connect equipment lineups shall be installed by the electrical contractor.

E. Contractor interconnection wiring requirements shall be clearly identified on the PMCS system drawings.

3.02 SYSTEM START-UP AND TRAINING

A. Onsite startup and training of the new devices added to the EPMS by a factory-trained service representative shall be included in the project bid.

B. Startup services shall include:

1. Configuration of the building and devices in the EPMS system for communications.
2. Configuration of the devices for historical data logging, alarming and verification/upgrade the device has the latest firmware. Where applicable, all metering devices will be configured for periodic time synch to master device.
3. Creation of a one-line graphic of the building and the metering locations on the one-line activated to show some meter readings (i.e., average current, average voltage L-L, 3 phase kW power reading, if trip units involved also include breaker status).
4. Archiving of historical data will be configured.
5. Reports will be configured to run monthly, unless otherwise specified, then stored and/or printed. Reports will be configured to run automatically on the first day of each month, reporting the prior month information.
    a. Energy usage report.
    b. Basic load profile report.

C. Training shall include any documentation and hands-on exercises necessary to enable electrical operations personnel to assume full operating responsibility for the EPMS after completion of the training period.

D. The project bid shall include a minimum of two separate days startup assistance and two separate days orientation/training on the EPMS system. The bid shall quote rates for additional days.

E. Development and/or adjustment of the EPMS system diagram shall be provided upon completion of the building to include the new devices in the system communications diagram. The diagram shall be provided in AutoCAD format for future use and adjustment.

F. Prior to leaving the jobsite, electronic backups of all system files will be made, one copy shall be left on site and second copy shall be kept offsite.

G. Documentation/Installation Reports shall include:

1. EPMS system diagram with additional devices added.
2. Communication test report showing communications of all devices.
3. System report showing the historical data logging and alarming for all devices.
4. Screen captures of all graphic screens activated.

H. The power monitoring vendor shall offer regularly scheduled factory training for customers on all aspects of power monitoring and control, including:

1. Comprehensive software and hardware setup, configuration, and operation.
2. Advanced monitoring and data reporting.
3. Advanced power quality and disturbance monitoring.

END OF SECTION

SECTION 26 12 02
LIQUID-FILLED PAD MOUNTED TRANSFORMERS

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Descriptive information.
2. Dimensional drawings.
3. Transformer nameplate data.
4. Schematic and connection diagrams.
5. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
2. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
3. Factory test reports certified.
4. Transformer submittal shall include loss data at no load, 25 percent, 50 percent, 75 percent and 100 percent of rated loads and shall state primary and secondary connection and ratings for current and voltage and percentage impedance guaranteed.

1.02 QUALITY ASSURANCE

A. Design, test, and assemble in accordance with applicable standards of NEMA TR 1, IEEE C57.12.00, IEEE C57.12.22, IEEE C57.12.26, and IEEE C57.12.90.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Eaton.

B. Schneider.

C. Elsco.

D. Cooper Power System.

E. “Or-equal.”

2.02 GENERAL

A. Integral Unit: Compartmental type unit consisting of transformer, liquid-filled tank, and high- and low-voltage terminating compartments, assembled on a common structural base.

B. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, 1/2-inch minimum diameter, and as specified in Section 05 50 00, Metal Fabrications.

2.03 TRANSFORMER

A. Transformers shall be liquid-immersed 3-phase pad-mounted transformer of low-silhouette design with ratings noted below and as shown on Drawings. Equipment to be furnished shall be designed, built, and tested in accordance with the latest revision of all applicable standards of IEEE, NEMA, and ANSI. Transformer shall be designed for outdoor application at altitudes not to exceed 3,300 feet, in an ambient not exceeding 40 degrees C maximum and average ambient for any 24-hour period not exceeding 30 degrees C.

1. Transformer shall comply with energy efficient standards in accordance with DOE 2010.
2. Transformer shall be arranged for radial feed, as indicated on Drawings.

B. Transformer Ratings:

Transformer Label	kVA	Primary Voltage	Secondary Voltage
TL4	2500	13.8 kV Delta	480/277 V WYE
TR4	2500	13.8 kV Delta	480/277 V WYE
TL2	1000	13.8 kV Delta	480/277 V WYE
TR2	1000	13.8 kV Delta	480/277 V WYE

C. BIL Rating:

1. 95 BIL for 15 kV insulation class transformers.
2. 30 BIL for secondary.

D. Temperature Rise: 55/65 degrees C above 30 degrees average ambient with maximum ambient not to exceed 40 degrees C.

E. Impedance:

1. 5.0 percent minimum for transformers rated 225, 300, and 500 kVA.
2. 5.75 percent for transformers rated 750 kVA and above.

F. Dielectric Coolant: Fully biodegradable, nontoxic, and nonbio-accumulating fluid, qualifying as “less flammable” in accordance with NEC 450.23. The fluid shall be bio-based biodegradable electrical insulating and cooling liquid. Base fluid shall be 100 percent derived from edible seed oils. Performance-enhancing additives shall be food grade. The fluid shall be FM Global approved, UL classified, Envirotemp FR3 fluid, “or-equal.” Fluid compatibility with transformer components shall be verified. The fluid shall be certified to comply with the US EPA environmental technology verification (ETV) requirements.

G. Primary Taps:

1. Full capacity, two 2-1/2 percent below and two 2-1/2 percent above, rated voltage.
2. Externally operated no-load tap changer.
3. Provisions for locking handle in any position.

H. Coil Conductors: Copper windings.

I. Wye-wye transformers wound on 5-legged cores.

J. Sound Level: In accordance with manufacturer’s standards.

2.04 ENCLOSURE

A. In accordance with IEEE C57.12.28 requirements.

B. Welded carbon steel transformer tank, with cooling panels when required, and lifting eyes.

C. 12-gauge sheet steel terminal compartment enclosure having no exposed screws, bolts, or other fasteners that are externally removable.

D. Color: Provide green finish as approved by Engineer.

E. The paint finish total film thickness applied shall be 3.0 millimeter thickness as determined by testing in accordance with V.P.A. Technology MINIDERM S-100A standard. Certified test data shall be supplied upon request demonstrating compliance with the following parameters:

1. Paint finish shall be capable of passing a 1,500 hours salt spray test per ASTM B117 and Federal Specification TT-P-141 with NO blistering and passing method 6061 with less than 1/16 inch underfilm present.

2. Paint finish shall be capable of passing an 850-hour humidity test with 98 percent relative humidity at 45 to 50 degrees C with no blistering.
3. Paint finish shall be capable of passing a cross-hatch tape adhesion test.
4. Paint finish shall be capable of passing oil resistance tests of 3 days immersion at room temperature and three days immersion at 100 degrees C with no apparent effect.

2.05 TERMINAL COMPARTMENTS

A. General: IEEE C57.12.28, enclosed high- and low-voltage compartments side by side, separated by steel barrier, bolted to transformer tank.

1. Doors:
   a. Individual, full-height, air-filled.
   b. Low-voltage door with three-point latching mechanism, vault type handle, and single padlocking provision.
   c. High-voltage door fastenings inaccessible until low-voltage door has been opened.
   d. Door Bolts: Pentahead type.
   e. Lift-off, stainless steel hinges and door stops.
   f. Removable front sill to facilitate rolling or skidding over conduit stubs.
   g. Recessed lock pocket, with steel door release bolt adjacent to secondary compartment door handle.

B. High-voltage Compartment:

1. Deadfront in accordance with IEEE C57.12.26 type construction.
2. Protective fuses.
3. High-voltage bushings. Total of six arranged in a feed-through configuration.
4. Transformer grounding pad.
5. Surge arrestors. Dead front, elbow type, metal-oxide-varistor units that plug into three of the primary side bushings.
6. Radial feed, two position ON-OFF load-break switch.

C. Low-voltage Compartment:

1. Livefront in accordance with IEEE C57.12.26 type construction.
2. Low-voltage bushings.
3. Grounding pad.
4. Stainless steel equipment nameplate.
5. Liquid level gauge.
6. 1-inch upper filter press and filling plug.
7. Drain valve with sampling device.
8. Dial type thermometer.
9. Pressure relief valve.

10. Pressure-vacuum gauge.
11. Nameplate.

2.06 BUSHINGS

A. High-voltage:

1. Deadfront Termination:
   a. Universal bushing well rated at 15 kV in accordance with IEEE 386.
   b. Bushings externally clamped and front removable.
   c. Rated for 600 amperes non load-break continuous, 95 kV BIL.
   d. Standoff brackets located adjacent to bushings.

B. Low-voltage:

1. Molded epoxy bushing clamped to tank with rotatable 4-hole (75 kVA to 500 kVA and 8-hole (750 kVA and above) spade type terminals.
2. Rated 150 percent of continuous full-load current, 30 BIL, 600 volts.
3. Internally connected neutral extending to neutral bushing.

2.07 HIGH VOLTAGE SWITCHING

A. Internal, oil-immersed, gang-operated load-break, manually operated switches.

B. Hot stick operated handle located in high-voltage compartment.

C. Capable of operating at full-load current.

D. Feed Switch: Two-position, ON/OFF radial.

2.08 HIGH VOLTAGE PROTECTION

A. Combination Oil-immersed Bayonet Expulsion and Current-limiting Fuses:

1. Accessibility:
   a. Bayonet expulsion fuse accessible through primary compartment.
   b. Current-limiting fuse accessible through tank handhole.
2. Expulsion Fuse for Low Current Faults: Interrupting capacity of 1,800 amperes rms asymmetrical.
3. Current Limiting for High Current Faults: Interrupting capacity of 50,000 amperes rms symmetrical.
4. Bayonet fuse externally replaceable with hot stick.

2.09 SURGE ARRESTORS

A. Elbow Valve Type: Uninsulated body, 10 kV with barriers in accordance with IEEE C62.11.

2.10 TANK GROUNDING PADS

A. High- and Low-voltage Compartments:

1. Connected together with bare No. 2/0 stranded copper conductors.
2. Wye-wye high- and low-voltage neutrals internally connected with link and brought out to insulated low-voltage bushing externally grounded to tank.
3. Low-voltage neutral connected to externally mounted insulating bushing in low-voltage compartment and grounded to tank with removable strap.

2.11 TAP CHANGER WARNING SIGN

A. Red laminated plastic, engraved to white core.

B. Engrave to read: DO NOT OPERATE WHEN TRANSFORMER ENERGIZED.

C. Mount above tap changer handle.

2.12 FACTORY TESTS

A. Production tests in accordance with IEEE C57.12.90 and IEEE C57.12.00, Section 8 and Table 16.

B. Dielectric test in accordance with IEEE C57.12.26.

PART 3 EXECUTION

3.01 GENERAL

A. Secure to mounting pads with anchor bolts.

B. Install plumb and longitudinally in alignment with pad or adjacent building wall.

C. Ground neutrals and enclosures in accordance with applicable codes.

3.02 ADJUSTMENTS

A. Adjust voltage taps to obtain rated output voltage under normal operating load conditions.

3.03 FIELD TESTS

A. Perform field testing in accordance with Section 26 08 00, Commissioning of Electrical Systems, for new transformers and for existing Substation 2 and Substation 4 transformers that will be retained.

END OF SECTION

SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Descriptive information.
2. Dimensions and weight.
3. Transformer nameplate data.
4. Schematic and connection diagrams.

B. Informational Submittals:

1. Test Report: Sound test certification for dry type power transformers (0-volt to 600-volt, primary).

PART 2 PRODUCTS

2.01 GENERAL

A. UL 1561, NEMA ST 20, unless otherwise indicated.

B. Dry-type, self-cooled, two-winding, with copper windings.

C. Units larger than 5 kVA suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

D. Efficiency: Meet or exceed values in Table 4.2 of NEMA TP 1.

E. Maximum Sound Level in accordance with NEMA ST 20:

1. 40 decibels for 0 kVA to 9 kVA.
2. 45 decibels for 10 kVA to 50 kVA.
3. 50 decibels for 51 kVA to 150 kVA.
4. 55 decibels for 151 kVA to 300 kVA.
5. 60 decibels for 301 kVA to 500 kVA.

F. Overload capability: Short-term overload in accordance with IEEE C57.96.

G. Wall Bracket: For single-phase units, 15 kVA to 37-1/2 kVA, and for three-phase units, 15 kVA to 30 kVA.

H. Vibration Isolators:

1. Rated for transformer's weight.
2. Isolation Efficiency: 99 percent, at fundamental frequency of sound emitted by transformer.
3. Less Than 30 kVA: Isolate entire unit from structure with external vibration isolators.
4. 30 kVA and Above: Isolate core and coil assembly from transformer enclosure with integral vibration isolator.

I. Manufacturers:

1. Eaton/Cutler-Hammer.
2. Square D Co.
3. General Electric Co.
4. "Or-equal."

2.02 GENERAL PURPOSE TRANSFORMER

A. Insulation Class and Temperature Rise: Manufacturer's standard.

B. Core and Coil:

1. Encapsulated for single-phase units 1/2 kVA to 25 kVA and for three-phase units 3 kVA to 15 kVA.
2. Thermosetting varnish impregnated for single-phase units 37.5 kVA and above, and for three-phase units 30 kVA and above.

C. Enclosure:

1. Single-phase, 3 kVA to 25 kVA: NEMA 250, Type 3R, nonventilated.
2. Single-phase, 37-1/2 kVA and Above: NEMA 250, Type 2, ventilated.
3. Three-phase, 3 kVA to 15 kVA: NEMA 250, Type 3R, nonventilated.
4. Three-phase, 30 kVA and Above: NEMA 250, Type 2, ventilated.
5. Outdoor Locations: NEMA 250, Type 3R.
6. Corrosive Locations: NEMA 250, Type 3R stainless steel.

D. Voltage Taps:

1. Single-phase, 3 kVA to 10 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
2. Single-phase, 15 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
3. Three-phase, 3 kVA to 15 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
4. Three-phase, 30 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.

E. Impedance: 4.5 percent minimum on units 75 kVA and larger.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with NECA and manufacturer's instructions.

B. Load external vibration isolator such that no direct transformer unit metal is in direct contact with mounting surface.

C. Provide moisture-proof, flexible conduit for electrical connections.

D. Connect voltage taps to achieve (approximately) rated output voltage under normal plant load conditions.

E. Provide wall brackets for single-phase units, 15 kVA to 167-1/2 kVA, and three-phase units, 15 kVA to 112 kVA.

F. Grounding: Ground and bond transformer in accordance with NEC.

END OF SECTION

SECTION 26 23 00
LOW-VOLTAGE SWITCHGEAR

PART 1 GENERAL

1.01 SUMMARY

A. This section includes metal-enclosed, low-voltage power circuit-breaker switchgear rated 1,000V and less for use in ac systems and includes the following switchgear lineups:

Switchgear Label	Location
Substation 4	Process Air Facility Electrical Room

B. Related sections include Section 26 09 13, Power Measurement and Control, for interfacing communication and metering requirements.

C. Special Note: The existing plant-wide power measurement and control system and associated switchgears are based on GE Industrial Solutions. Any additions shall be compatible with that system. GE Requisition No. 302EW210-PM. See Section 26 09 13, Power Measurement and Control for additional requirement. Note that these systems are now recently provided by ABB.

1.02 SUBMITTALS

A. Action Submittals:

1. Descriptive product information.
2. Itemized bill of material.
3. Dimensional drawings.
4. Operational description.
5. Anchoring instructions and details.
6. One-line, three-line, and control schematic drawings.
7. Connection and interconnection drawings.
8. Circuit breakers.
9. Ground fault protection.
10. Bus data.
11. Incoming line section equipment data.
12. Transformer section equipment data.
13. Conduit entrance locations.
14. Arc protection system data.
15. Automatic load transfer system data.

B. Informational Submittals:

1. Manufacturer's installation instructions.
2. Certified factory test report.
3. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
4. Manufacturer's Certificate of Proper Installation as specified in Section 01 43 33, Manufacturer's Field Services.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by UL shall conform to those standards and shall have an applied UL listing mark.

B. Deliver in sections of lengths that can be moved past obstructions in delivery path as indicated.

C. Store switchgear indoors in clean dry space with uniform temperature to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1. Remove loose packing and flammable materials from inside switchgear; install electric heating (250 W per section) to prevent condensation.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. GE Industrial Systems.
2. ABB.

2.02 GENERAL REQUIREMENTS

A. Service: 480Y/277 volts, three-phase, four-wire solid grounded wye having an available short circuit current at line terminals of 100,000 amperes rms symmetrical.

B. Designed and assembled in accordance with IEEE C37.20.3, IEEE C37.100, ANSI C37.50, and UL 1558.

C. Switchgear and its major components shall be end products of one manufacturer in order to achieve standardization for appearance, operation and maintenance, spare parts replacement, and manufacturer's services.

D. Operating Conditions:

1. Ambient Temperature: Maximum 40 degrees C.
2. Equipment shall be fully rated without derating for operating conditions.

E. Lifting lugs on equipment and devices weighing over 100 pounds.

F. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, 1/2-inch minimum diameter, and as specified in Section 05 50 00, Metal Fabrications. Coat in accordance with Section 09 90 00, Painting and Coating.

2.03 STATIONARY STRUCTURE

A. Type: ANSI C37.50 switchgear construction, consisting of pull section with cable terminations, metering, breaker, transition, and auxiliary sections assembled to form a rigid, self-supporting, metal enclosed structure.

B. Material: 11-gauge minimum cold-rolled steel, formed with reinforced steel members.

C. Grounded metal barriers between each breaker, main bus, branch cabling, and instrumentation/control.

D. Modular-designed steel frame with removable plates and individual, bolted, steel-framed vertical sections.

E. Individual, hinged doors over each breaker, metering, and auxiliary compartments.

F. Cable Installation and Termination Compartments:

1. Rear hinged doors, capable of being bolted closed.
2. Cable bending space in accordance with NFPA 70.
3. Cable supports in each vertical section.

G. Breaker Compartments:

1. Individual, grounded compartments, with:
   a. Sheet steel, top, bottom, sides, and ventilated compartment door with padlocking features.
   b. Flame-retardant, arc track-resistant nonmetallic rear barrier.

c. Drawout rails, stationary breaker contacts, interlocks, and necessary control and indicating devices.
d. Shutters over stationary contacts when breaker is in TEST or DISCONNECT position.
e. Padlocking provision on rackout rails for locking breaker in TEST or DISCONNECT position.

2. Drawout Mechanism:
a. Shall retain removable element in connected position.
b. Mechanical interlocks to ensure breaker is open before moved from a position, or when between positions.
c. Four Distinct Breaker Positions: CONNECTED, TEST, DISCONNECTED, and WITHDRAW.
d. Indicators to display breaker position.
e. Capable of being operated without opening breaker door.

3. Breaker frame grounded to steel frame throughout travel of drawout mechanism.
4. Each compartment designed for specific breaker frame size.
5. Future breaker compartments fully equipped with electrical connections, bolted metal barrier across compartment face, and compartment door.

H. Slide-out Instrument Tray:

1. Mount above associated breaker.
2. Accessible from front of switchgear.
3. For control circuitry, breaker close and trip fuses, indicating lights, and feeder metering.

2.04 ENCLOSURE

A. Finish: Baked enamel applied over rust-inhibiting phosphated base coating.

1. Color:
a. Exterior: Provide gray finish as approved by Engineer.
b. Interior: White.
c. Unpainted Parts: Plated for corrosion resistance.

B. Indoor Enclosure:

1. NEMA 250, Type 1, with formed edges on hinged and nonhinged panels.
2. Rear, full-height, bolt-on panels for each enclosure section.
3. Cable Termination Access: Padlock provision.

2.05 BUSWORK

A. Material: Phase isolated and insulated tin-plated copper throughout entire length of sufficient cross section to limit temperature rise at rated current to 55 degrees C.

B. Bus Arrangement: A-B-C, left-to-right, top-to-bottom, and front-to-rear, as viewed from front.

C. Brace for short circuit currents 100,000 amperes rms symmetrical.

D. Main Horizontal Bus: Nontapered, continuous current rating as shown.

E. Neutral Bus: Continuous current rating as shown; 50 percent of main horizontal bus rating unless noted otherwise.

F. Ground Bus:

1. Material: Tin-plate copper.
2. Rating: 800 amperes.
3. Bolted to each vertical section.
4. Ground lug for 3/0 to 750 kcMIL copper conductor on each end of bus.
5. Bus Connections and Joints: Bolted with Belleville washers.

G. Extend each bus entire length of switchgear with provision for extension to future units.

2.06 PROTECTIVE DEVICES

A. Power Air Circuit Breakers:

1. Main, tie, and feeder breakers in accordance with IEEE C37.13 and IEEE C37.16.
2. Arrangement: Fully rated main, tie, and branch feeder zone-selective and fully rated branch feeder circuit breakers.
3. Three-pole electrically and mechanically trip-free with:
   a. Self-aligning primary and secondary contacts.
   b. Integral, solid state, over-current trip programmer.
   c. Arc quenchers.
   d. Closing Mechanism: Electric.
   e. Stored energy mechanism with maximum five-cycle closing.
   f. Solid state trip device.
4. Individually mounted, drawout breaker listed for 100 percent continuous ampere rating.
5. Frame Size: As shown.
6. Interrupting Rating: 100,000 amperes rms symmetrical at 480 volts.

B. Mechanical Operation:

1. Front-mounted, spring charging handle.
2. Mechanical closing breaker handle, escutcheon mounted, pushbutton.
3. Mechanical trip, escutcheon mounted, trip pushbutton handle.

C. Electrical Operation:

1. Motor or solenoid automatic charging, plus manual charging.
2. Electrically closing, escutcheon mounted pushbutton with mechanical closing upon loss of control power.
3. Electrical trip, escutcheon mounted, trip pushbutton.
4. Control Power Voltage: 120 ac.

D. Color-Coded Visual Indicators: Contacts OPEN and CLOSED, plus mechanism CHARGED and DISCHARGED.

E. Accessories:

1. Slow breaker closing handle for contact adjustments.
2. Breaker lifting hoist and travel rail on top of switchgear.
3. Auxiliary a/b contacts on main, tie, and feeder breakers.
4. Shunt trip for main, tie, and feeder breakers.

F. Test Facilities:

1. Breakers with integral external test points for portable test kit.
2. Handheld test kit for functional testing of trip circuitry of each breaker.
3. Separately mounted panel to test ground fault by not tripping breaker.

G. Solid State Trip Units: Flux-shift trip and current sensors.

1. Trip units shall be compatible with the power monitoring system without the addition of separate power meters for individual breakers.
2. Protective Programmers:
    a. Self-powered, automatic rms sensing micro-electronic processor.
    b. No external relays or accessories.
    c. Printed circuit cards with gold-plated contacts.
    d. Programmable Controls:
        1) Fixed-point, with repetitive accuracy and precise unit settings.
        2) Trip adjustments made by nonremovable, discrete step switching.
    e. Field-Installable Rating Plugs:
        1) Long-time pickup LED indicator and test receptacle.
        2) Matching load and cable requirements.
        3) Interlocked with tripping mechanism.
        4) Breaker to remain trip-free with plug removed.

5) Keyed rating plugs to prevent incorrect application.

f. Long-time pickup light.

g. Selective coordination time/current curve shaping adjustable functions:

1) Current setting.
2) Long-time pickup.
3) Long-time delay.
4) Instantaneous pickup with short-time for main, tie, and feeders. Main instantaneous must have ability to be turned OFF.
5) Short-time pickup for main, tie, and feeders.
6) Short-time delay for main, tie, and feeders with I2T function, and IN-OUT switch.
7) Ground fault pickup.
8) Ground fault delay with I2T function.
9) Zone selective interlock.

h. Fault Trip Indicators: Mechanical push-to-reset type for overload and short circuit overload plus ground fault trip.

i. Rejection Pins: For each programmer frame size.

3. Phase Current Sensors:
   a. Multi-ratio type.
   b. Fixed, mounted on breaker frame.
   c. Molded epoxy construction.
   d. One toroidal type for each phase.
4. Ground Fault Sensor:
   a. Neutral bar single-ratio CT mounted in cable compartment.
   b. Molded epoxy construction.
   c. Shorting bar.
5. Portable Test Set: ac/dc static, full function unit for checking programmer's time-current characteristics of programmer.

2.07 AUTOMATIC LOAD TRANSFER SYSTEM

A. Provide an automatic load transfer system for a main-tie-main arrangement. The system shall automatically control electrically operated circuit breakers to provide transfer to alternate circuit upon loss of voltage of one of the normal source(s). Potential transformers feeding phase balance, synchronization and undervoltage relays shall be provided to continuously monitor all three phases on both sources. The system shall allow either both main CBs closed, tie CB open operation or preferred source main CB closed, alternate source main CB open, tie CB closed or alternate main CB closed, tie CB closed, preferred source main open operation.

1. The system shall consist of a programmable logic controller or a relay system, potential transformers, control power transfer contactor, control selector switches, two 3-phase, phase-balance/undervoltage (47/27) relays, and status indicating lights.

2. The potential transformers shall also provide 120V ac control power for the motor operators and the logic control. Other accessories for the system include:
    a. One auto/manual selector switch with indicating lights. Manual position disables the load transfer system except the electrical interlocks remain enabled to permit manual switching and prevent both main CBs and the tie CB to be all closed simultaneously (closed transition).
    b. One hold retransfer/auto retransfer selector switch with indicating lights.
    c. Two undervoltage test push buttons.
    d. Two close pushbuttons with indicating lights.
    e. Two open pushbutton with indicating lights.
    f. Preferred source selector switch.
    g. Electrical interlocks to prevent closed transition switching even when in manual switching mode.
3. Sequence of Operation:
    a. The normal conditions shall be with both sources designated as preferred, both main breakers closed and the tiebreaker open. A transfer is initiated after an adjustable time delay initially set at 15 seconds upon detection of a phase unbalance and/or undervoltage condition on either source and determination that the other source is available. If neither source is available (complete outage), the transfer will not proceed and the main and tie breakers will remain as they are. The affected source circuit breaker will open within three cycles after the time delay. The tie circuit breaker will close with an adjustable time delay initially set at 15 seconds. Re-transfer will occur after voltage on the affected source is restored and stabilizes for a 5-minute time delay and will occur by manual or automatic as selected operation in an open transition mode. The electrical interlocks along with non-reclosure onto a fault and voltage protection interlocks will permit the automatic switching operation to occur and prevent closed transition switching whether in manual or automatic mode. The time registers are adjustable by the use of a handheld programmer.
    b. If system is operating with a single source supplying power and the other source CB open but available, transfer back to the active source will be initiated automatically after a 15-second time delay if the single source is lost even if the retransfer switch is in manual.
    c. If both sources had been out, upon return of both sources, the mains and tie shall remain as is. Upon return of one of the sources, all loads shall be connected to that source after the selected time delays.

4. Provide a UPS system integral to the secondary unit substation to provide a stable source of control power to operate the automatic load transfer system.
5. Provide portable testing and calibration device.

2.08 ARC PROTECTION SYSTEM

A. Provide arc protection system to protect equipment and operating personnel.

B. The arc protection system shall be suitable for installing in new low voltage metal-enclosed air-insulated indoor switchgear, for protection of the switchgear against the effects of internal arcs and to ensure personnel safety and to minimize damage and outage to the switchgear.

C. Arc protection system shall be designed and constructed for indoor installation and operated under the following conditions:

1. Altitude: up to 1,000 m above sea level.
2. Ambient Air Temperature: Minus 10 degrees C to 55 degrees C.
3. Relative Humidity: Up to 90 percent.
4. Climatic Condition: Tropical climate.

D. Arc protection system shall consist of the arc protection relay, required extension units, along with sensor fibers and/or lens sensors and shall include the following features:

1. Loop-type sensor fiber, radial sensor fiber or lens-type sensor for arc detection.
2. Two high-speed semiconductor outputs for tripping.
3. Tripping from light only or secured with fast, adjustable three-phase or two-phase and neutral overcurrent condition.
4. Total Operate Time: less than 2.5ms.
5. Wide area automatic or manual backlight compensation.
6. Two RJ45 ports for chaining the extension units.
7. Two opto-connectors for fast ON/OFF signal transfer between central units.
8. Circuit-breaker failure protection, i.e., delayed output for higher-level circuit breaker.
9. Self-supervision unit for monitoring the sensor fiber, operating voltages and cabling between central units and extension units.

E. Arc detectors/sensors shall be light detecting sensor and shall be installed in each compartment of the switchgear panels including busbar compartment, switching device compartment of the switchgear like circuit breaker, etc., cable connection compartment, voltage transformer compartment.

1. The detectors/sensors shall be arranged so that every internal arc is detected.

2. Both fiber sensor and lens type sensors shall be available.
3. Signal from detectors/sensors shall be transmitted to the arc monitor unit(s) by suitable RJ-45 communication cables.
4. Continuous self supervision of sensor-fiber loops, operating voltages and cabling between central units and extension units shall be provided.
5. Two opto-connection link for fast signal transfer of light/current/trip signals between main units shall be provided.

F. Arc protection system shall include two high-speed, galvanically isolated solid state relays for fast fault clearing. An additional dry-contact relay output shall be provided for circuit breaker protection or for alarming.

G. Arc flash relays shall be mounted on the switchgear door of an instrumentation compartment that is not directly susceptible to incident arc flash energy.

H. Fiber sensor installer shall be certified by arc flash relay vendor on the installation of the fiber sensor. Proper routing of the optical sensor is important for the correct operation of the REA arc flash system. The fiber shall be routed with the following guidelines in mind:

1. Each optical sensor fiber should be routed with the appropriate protection zone in mind.
2. Minimize exposure to moving parts to avoid snagging the fiber.
3. Avoid high temperature surfaces.
4. Avoid obstructions that would shield the fiber from the light of an arc flash.
5. Secure the fiber using non-conductive wire ties.
6. Use protective tubing when routing the optical fiber through metal walls.
7. Avoid sharp bends.

2.09 CONTROL WIRING

A. NFPA 70, Type SIS, single-conductor, Class B, stranded copper, rated 600 volts for control, instrumentation, and power/current circuits.

B. Shielded cable rated 600 volts for transducer output and analog circuits.

C. Enclosed in top and vertical steel wiring troughs, and front-to-rear in nonmetallic wiring troughs.

D. Conductor Lugs: Preinsulated, self-locking, spade type, with reinforced sleeves.

E. Identification: Individually, with permanent wire markers at each end.

F. Splices: Not permitted in switchgear wiring.

2.10 TERMINAL BLOCKS

A. Enclosed in steel wiring troughs.

B. Rated 600 volts, 30 amperes minimum, one-piece barrier type with strap screws.

C. Shorting type for current transformer leads.

D. Provide terminal blocks for:

1. Conductors connecting to circuits external to switchgear.
2. Internal circuits crossing shipping splits.
3. Equipment parts requiring replacement and maintenance.

E. Spare Terminals: Not less than 20 percent.

F. Group terminal blocks for external circuit wiring leads.

G. Maintain 6-inch minimum space between columns of terminal blocks.

H. Identification: Permanent, for each terminal and columns of terminals blocks.

I. Manufacturer: General Electric; Type EB-5; or equal.

2.11 TEST FACILITIES

A. Breakers with integral external test points for portable test kit.

B. Handheld test kit for functional testing of trip circuitry of each breaker.

C. Separately mounted panel to test ground fault by not tripping breaker.

2.12 INSTRUMENTATION AND METERING

A. As specified in Section 26 09 13, Power Measurement and Control.

2.13 POWER METER

A. As specified in Section 26 09 13, Power Measurement and Control.

2.14 EQUIPMENT IDENTIFICATION

A. Master Nameplate:

1. Deep-etched aluminum with manufacturer’s name and model number.
2. Riveted to main vertical section.

B. Section Identification:

1. Stamped metallic, riveted to each vertical section.
2. Serial number, bus rating, and section reference number.
3. Size: Manufacturer's standard.

C. Nameplate:

1. Engraved, acrylic for each circuit breaker cubicle and door-mounted device.
2. Black with white block type characters.
3. Character Height: 1/4-inch.
4. Size: Manufacturer's standard with 15 characters per each line.
5. Inscriptions: As shown on one-line diagram.
6. Blank plates for future spaces.
7. Attachment Screws: Stainless steel panhead.

D. Cubicle Labels:

1. Nonmetallic, applied inside each cubicle compartment.
2. Device serial number, rating, and description.
3. Size: As required.

E. Metering Instruments: Meter type identified on meter face below pointer or dial.

F. Control Switches: Deep-etched, aluminum escutcheon plate.

G. Relays and Devices:

1. Stamped metallic, riveted to instrument case.
2. Manufacturer's name, model number, relay type, and rating data.

H. Switchgear Signs:

1. Two signs each on front and back of switchgear.
2. Size: Manufacturer's standard, as required.
3. Engraved, acrylic.
4. Color: Red with white.
5. Inscription: DANGER/HIGH VOLTAGE/KEEP OUT.
6. Characters: Gothic type, 2 inches high.
7. Attachment: Four rivets each sign.
8. Tie circuit breaker stating the following: "WARNING CLOSING THIS BREAKER MAY PARALLEL TWO SOURCES."

2.15 FACTORY TESTING

A. In accordance with IEEE C37.20.1.

B. Owner may desire to attend witness test. Advise 3 weeks prior to scheduled testing.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install equipment in accordance with manufacturer's instructions and recommendations.

B. Secure equipment to mounting pads with anchor bolts.

C. Install equipment plumb and in longitudinal alignment with pad or wall.

D. Coordinate terminal connections with installation of secondary feeders.

3.02 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative in accordance with Section 01 43 33, Manufacturers' Field Services, for the following services at Site or classroom as designated by Owner, for minimum person-days listed below, travel time excluded:

1. 1 person-day for installation assistance and inspection.
2. 2 person-days for functional and performance testing.
3. 1 person-day for prestartup classroom or site training.
4. 2 person-days for plant startup.
5. 1 person-day for post-startup training.

B. Arc Protection System Field Certification: Engage manufacturer's representative to inspect and certify the installation and operation of the fiber optical sensor after the new switchgear is fully assembled in the field. Technician shall certify that the optical sensor is properly routed to ensure proper operation of the ABB arc flash protection system.

C. Provide Manufacturer's Certificate of Proper Installation in accordance with Section 01 43 33, Manufacturers' Field Services.

END OF SECTION

SECTION 26 24 16
PANELBOARDS

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Manufacturer's data sheets for each type of panelboard, protective device, accessory item, and component.
2. Manufacturer's Shop Drawings including dimensioned plan, section, and elevation for each panelboard type, enclosure, and general arrangement.
3. Tabulation of features for each panelboard to include the following:
   a. Protective devices with factory settings.
   b. Provisions for future protective devices.
   c. Space for future protective devices.
   d. Voltage, frequency, and phase ratings.
   e. Enclosure type.
   f. Bus and terminal bar configurations and current ratings.
   g. Provisions for circuit terminations with wire range.
   h. Short circuit current rating of assembled panelboard at system voltage.
   i. Features, characteristics, ratings, and factory settings of auxiliary components.
   j. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's recommended installation instructions.
3. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.

1.02 QUALITY ASSURANCE

A. Listing and Labeling: Provide products specified in this Section that are listed and labeled as defined in NEC Article 100.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. General Electric Co.
2. ABB.
3. "Or-equal."

B. Panelboards shall be of the same manufacturer as equipment furnished under Section 26 23 00, Low-Voltage Switchgear.

2.02 GENERAL

A. Provide low voltage panelboards for application at 600V or less in accordance with this section.

B. Provide equipment in accordance with NEMA PB 1, NFPA 70, and UL 67.

C. Wire Terminations:

1. Panelboard assemblies, including protective devices, shall be suitable for use with 75 degrees C or greater wire insulation systems at NEC 75 degrees C conductor ampacity.
2. In accordance with UL 486E.

D. Load Current Ratings:

1. Unless otherwise indicated, load current ratings for panelboard assemblies, including bus and circuit breakers, are noncontinuous as defined by NEC. Continuous ratings shall be 80 percent of noncontinuous rating.
2. Where indicated "continuous," "100 percent," etc., selected components and protective devices shall be rated for continuous load current at value shown.

E. Short Circuit Current Rating (SCCR): Integrated equipment short circuit rating for each panelboard assembly shall be as shown on Drawings.

F. Overcurrent Protective Devices:

1. In accordance with NEMA AB 1, NEMA KS 1, UL 98, and UL 489.
2. Protective devices shall be adapted to panelboard installation.
   a. Capable of device replacement without disturbing adjacent devices and without removing main bus.
   b. Spaces: Cover openings with easily removable cover.

3. Series-connected Short Circuit Ratings: Devices shall be fully rated; series-connected ratings unacceptable.

G. Circuit Breakers:

1. For breakers under 200A, thermal-magnetic unless otherwise indicated, quick-make, quick-break, molded case, of indicating type showing ON/OFF and TRIPPED positions of operating handle.
2. Noninterchangeable: In accordance with NEC.
3. Bus Connection: Bolt-on circuit breakers in 480Y/277-volt, and plug-in circuit breakers in 208Y/120 and 240/120-volt branch circuit panelboards.
4. Trip Mechanism:
    a. Individual permanent thermal and magnetic trip elements in each pole.
    b. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
    c. Two and three pole, common trip.
    d. Automatically opens all poles when overcurrent occurs on one pole.
    e. Test button on cover.
    f. Calibrated for 40 degrees C ambient, unless shown otherwise.
5. Unacceptable Substitution:
    a. Do not substitute single-pole circuit breakers with handle ties for multi-pole breakers.
    b. Do not use tandem or dual circuit breakers in normal single-pole spaces.
6. Ground Fault Circuit Interrupter (GFCI): Where indicated, equip breaker as specified above with ground fault sensor and rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel).
    a. Ground fault sensor shall be rated same as circuit breaker.
    b. Push-to-test button.
    c. Reset button.
7. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker specified above with ground fault sensor and rated to trip on 30-mA ground fault (UL listed for equipment ground fault protection).

H. Enclosures:

1. Material: Type 1 shall be code-gauge, hot-dip galvanized sheet steel with reinforced steel frame. “Door in door” construction.
2. Finish: Rust inhibitor prime followed by manufacturer’s standard gray baked enamel or lacquer.

I. Bus:

1. Material: Copper, full sized throughout length.
2. Provide for mounting of future protective devices along full length of bus regardless of number of units and spaces shown. Machine, drill, and tap as required for current and future positions.

J. Feeder Lugs: Main, feed-through, and neutral shall be replaceable, bolted mechanical or crimp compression type.

K. Equipment Ground Terminal Bus: Copper with suitably sized provisions for termination of ground conductors, and bonded to box.

1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
2. Provide individual termination points for all other grounding conductors such as feeder, grounding electrode, etc.
3. Termination points shall be bolted crimp compression lugs for conductors 6 AWG and larger.

L. Neutral Terminal Bus: Copper with suitably sized provisions for termination of neutral conductors, and isolated from box.

1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
2. Provide individual termination points for all other neutral conductors.
3. Termination points shall be bolted crimp compression lugs for conductors 6 AWG and larger.
4. Oversize Neutral: Provide oversized neutral terminal bus as indicated.

M. Provision for Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances for future protective device ampere ratings indicated.

2.03 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

A. Protective Device Locking: Furnish provisions for handle padlocking for main and subfeed devices; also provide for branch devices where indicated.

B. NEMA 250 Type 1 Branch Panelboard Enclosure:

1. Front trim shall be secured to box with concealed hinges and screw release. Panelboards shall be “door in door” construction.
2. Surface-mount panelboard front trim shall have same dimensions as box.
3. Door in panelboard front trim, with concealed hinges, shall provide access to protective device operating handles.
4. Doors over 30 inches in height shall have multi-point latching.

5. Door lock shall be secure with flush catch and tumbler lock; all panelboards keyed alike, with two milled keys each lock.
6. Circuit Directory: Metal frame with transparent plastic face and enclosed card, mounted inside each panel door.

PART 3 EXECUTION

3.01 GENERAL

A. Install in accordance with NECA 407, NEMA PB 1.1 and manufacturers' written installation instructions.

B. Install securely, plumb, in-line and square with walls.

C. Install top of cabinet trim78 inches above floor, unless otherwise shown. Install cabinet so tops of protective device operating handles are no more than 78 inches above the floor.

D. Ground Fault Protection: Install panelboard ground fault circuit interrupter devices in accordance with installation guidelines of NEMA 289.

E. Install filler plates in unused spaces.

F. Wiring in Panel Gutters: Train conductors neatly in groups; bundle, and wrap with nylon wire ties.

3.02 BRANCH CIRCUIT PANELBOARD

A. Mount flush panels uniformly flush with wall finish.

B. Provide typewritten circuit directory for each panelboard.

C. In addition to conduit or nipples otherwise required for feeder and branch circuit wiring between multi-section panelboard sections, provide nipples for branch circuits two trade sizes larger than required for installed branch circuit wires or an empty 2-inch nipple, or a 1-1/4-inch trade size conduit if tubs are more than 24 inches apart.

END OF SECTION

SECTION 26 27 26
WIRING DEVICES

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals: Manufacturer's product data for wiring devices.

PART 2 PRODUCTS

2.01 SWITCHES

A. Switch, General-purpose:

1. NEMA WD 1 and FS W-S-896F.
2. Totally enclosed, ac type, with quiet tumbler switch and screw terminal.
3. Rivetless one-piece brass or copper alloy contact arm with silver alloy contact.
4. Capable of controlling 100 percent tungsten filament and fluorescent lamp loads.
5. Rating 20 amps, 120/277 volts.
6. Automatic grounding clip and integral grounding terminal on mounting strap.
7. Special Features: Provide the following features in comparable devices where indicated:
   a. Three-way and four-way.
   b. Tamper resistant.
   c. Locator, illuminated operator.
   d. Pilot, red illuminated operator.
   e. Three-position, maintained contact, center off.
8. Manufacturers and Products, Industrial Grade:
   a. Cooper Arrow Hart; AH1220 Series.
   b. Bryant; 4901 Series.
   c. Hubbell; 1221 Series.
   d. Leviton; 1221 Series.
   e. "Or-equal."

B. Switch, Motor Rated:

1. Type: Two-pole or three-pole, manual motor starting/disconnect switch without overload protection.
2. UL 508 listed.
3. Totally enclosed snap-action switch. Quick-make, slow-break design with silver alloy contacts.
4. Minimum General-purpose Rating: 30 amperes, 600V ac.

5. Minimum Motor Ratings:
    a. 2 horsepower for 120V ac, single-phase, two-pole.
    b. 3 horsepower for 240V ac, single-phase, two-pole.
    c. 15 horsepower for 480V ac, three-phase, three-pole.
6. Screw-type terminal.
7. Manufacturers and Products:
    a. Cooper Arrow Hart.
    b. Hubbell Bryant: HBL78 Series.
    c. Leviton.
    d. “Or-equal.”

2.02 RECEPTACLES

A. Receptacle, General-purpose:

1. NEMA WD 1 and FS W-C-596G.
2. Duplex, two-pole, three-wire grounding type with screw type wire terminals.
3. Impact resistant nylon cover and body, with finder grooves in face, unless otherwise indicated.
4. One-piece mounting strap with integral ground contact (rivetless construction).
5. Contact Arrangement: Contact to be made on two sides of each inserted blade without detent.
6. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps, unless otherwise indicated.
7. Size: For 2-inch by 4-inch outlet box.
8. Special Features: Provide the following features in comparable devices where indicated:
    a. Listed weather-resistant per NEC 406.8.
9. Industrial Grade Manufacturers and Products:
    a. Cooper Arrow Hart; 5362 Series.
    b. Hubbell Bryant; HBL5362 Series.
    c. Leviton; 5362 Series.
    d. “Or-equal.”

B. Receptacle, Ground Fault Circuit Interrupter:

1. Meet requirements of general-purpose receptacle.
2. Listed Class A to UL 943, tripping at 5 mA.
3. Rectangular smooth face with push-to-test and reset buttons.
4. Listed weather-resistant in accordance with NEC 406.8.
5. Feed-through Capability: 20 amps.
6. Manufacturers and Products:
    a. Hubbell Bryant; GFTR20 Series.
    b. Cooper Arrow Hart WRVGF20 Series.

c. Leviton; 7899 Series.
d. “Or-equal.”

C. Receptacle, Corrosion-resistant:

1. Meet requirements of general-purpose receptacle.
2. Nickel coated metal parts.
3. Manufacturers and Products:
   a. Hubbell Bryant; HBL53CM62 Series.
   b. Leviton; 53CM-62 Series.
   c. Cooper Arrow Hart; 5362CR Series.
   d. “Or-equal.”

2.03 DEVICE PLATES

A. Sectional type plate not permitted.

B. Plastic:

1. Material: Specification grade, 0.10-inch minimum thickness, noncombustible, thermosetting.
2. Color: To match associated wiring device.
3. Mounting Screw: Oval-head metal, color matched to plate.

C. Metal:

1. Material: Specification grade, one-piece, 0.040-inch nominal thickness stainless steel.
2. Finish: ASTM A167, Type 302/304, satin.
3. Mounting Screw: Oval-head, finish matched to plate.

D. Cast Metal:

1. Material: Malleable ferrous metal or copper-free aluminum, with gaskets.
2. Screw: Oval-head stainless steel.

E. Sheet Steel:

1. Finish: Zinc electroplate.
2. Screws: Oval-head stainless steel.

F. Engraved:

1. Character Height: 1/8-inch.
2. Filler: Black.

G. Weatherproof:

1. Receptacle, Weatherproof Type 1:
   a. Gasketed, cast-aluminum, with individual cap over each receptacle opening.
   b. Mounting Screw and Cap Spring: Stainless steel.
   c. Manufacturers and Products:
      1) Crouse-Hinds; Type WLRD-1.
      2) Appleton; Type FSK-WRD.
      3) "Or-equal."
2. Receptacle, Weatherproof Type 2:
   a. UL listed for wet location while in use.
   b. Die cast metal cover.
   c. Manufacturer and Product:
      1) TayMac; Type Multi-Mac.
      2) Thomas & Betts, Type RED DOT.
      3) "Or-equal."
3. Switch:
   a. Gasketed, cast-metal or cast-aluminum, incorporating external operator for internal switch.
   b. Mounting Screw: Stainless steel.
   c. Manufacturers and Products:
      1) Crouse-Hinds; DS-181 or DS-185.
      2) Appleton; FSK-1VTS or FSK-1VS.
      3) "Or-equal."

H. Raised Sheet Metal: 1/2-inch high zinc- or cadmium-plated steel designed for one-piece drawn type sheet steel box.

I. Sheet Steel: Formed sheet steel or Feraloy designed for installation on cast-metal box.

2.04 FINISHES

A. Wiring device catalog numbers specified in this section do not designate device color. Unless otherwise indicated, or required by code, provide colors as specified below.

B. Wiring Device Connected to Normal Power System:

1. Office Areas: White.
2. Other Areas: Gray.

C. Special-purpose and hazardous location devices may be manufacturer's standard color (black).

PART 3 EXECUTION

3.01 INSTALLATION, GENERAL

A. Comply with NECA 1.

B. Coordination with Other Trades:

1. Ensure device and its box are protected. Do not place wall finish materials over device box and do not cut holes for box with router that is guided by riding against outside of box.
2. Keep outlet box free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate raceway system, conductors, and cables.
3. Install device box in brick or block wall such that cover plate does not cross a joint, unless otherwise indicated. Where indicated or directed to cross joint, trowel joint flush with face of wall.
4. Install wiring device after wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
2. Strip insulation evenly around conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. Length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
   a. Cut back and pigtail, or replace damaged conductors.
   b. Straighten conductors that remain and remove corrosion and foreign matter.
   c. Pigtailing existing conductors is permitted provided outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction or that show signs they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (150 mm) in length.

5. Use torque screwdriver when a torque is recommended or required by manufacturer.
6. When conductors larger than 12 AWG are installed on 15-amp or 20-amp circuits, splice 12 AWG pigtails for device connections.
7. Tighten unused terminal screws on device.
8. Device Plates:
    a. Do not use oversized or extra deep plate.
    b. Repair wall finishes and remount outlet box when standard device plate does not fit flush or does not cover rough wall opening.

3.02 SWITCH INSTALLATION

A. Switch, General-purpose:

1. Mounting Height: See Section 26 05 33, Raceway and Boxes.
2. Install with switch operation in vertical position.
3. Install single-pole, two-way switch such that toggle is in up position when switch is on.

B. Switch, Motor Rated:

1. Mounting Height: See Section 26 05 33, Raceway and Boxes.
2. Install with switch operation in vertical position such that toggle is in up position when ON.
3. Install within sight of motor when used as disconnect switch.

C. Occupancy Sensor, Wall Switch: Install in accordance with manufacturer's instructions.

3.03 RECEPTACLE INSTALLATION

A. Duplex Receptacle:

1. Install with grounding slot up except where horizontal mounting is shown, in which case install with neutral slot up down.
2. Ground receptacle to box with grounding wire only.
3. Weatherproof Receptacle:
    a. Install in cast metal box.
    b. Install such that hinge for protective cover is above receptacle opening.
4. Ground Fault Interrupter: Install feed-through model at locations where ground fault protection is specified for "downstream" conventional receptacles.

3.04 DEVICE PLATE INSTALLATION

A. Securely fasten to wiring device; ensure tight fit to box.

B. Flush Mounted: Install with all four edges in continuous contact with finished wall surface without use of mat or similar material. Plaster fillings will not be acceptable.

C. Surface Mounted: Plate shall not extend beyond sides of box, unless plate has no sharp corners or edges.

D. Install with alignment tolerance to box of 1/16 inch.

E. Engrave with designated title.

F. Type (Unless Otherwise Shown):

1. Office Areas: Plastic.
2. Other Areas: Metal.
3. Exterior:
    a. Switch: Weatherproof.
    b. Receptacle in Wet Location: Weatherproof Type 2.

G. Interior:

1. Flush-mounted Box: Plastic.
2. Surface-mounted, Metal Box:
    a. General-purpose Areas: Sheet Steel.
    b. Other Areas: Cast.
3. Surface-mounted, Aluminum Box:
    a. General-purpose Areas: Stamped.
    b. Other Areas: Cast.
4. Surface-mounted, Sheet Steel Box: Raised sheet steel.
5. Surface-mounted, Nonmetallic Box: Manufacturer’s standard.
6. Receptacle Shown as Weatherproof on Drawings: Weatherproof Type 2.

3.05 IDENTIFICATION

A. Use tape labels for identification of individual receptacles in dry indoor locations.

1. Degrease and clean device plate surface to receive tape labels.
2. Use 3/16-inch Kroy black letters on white background, unless otherwise indicated.
3. Identify panelboard and circuit number from which item is served on face of plate.

B. Identify conductors with durable wire markers or tags inside outlet boxes.

3.06 FIELD QUALITY CONTROL

A. Perform tests and inspections, and prepare test reports.

B. Test Instrument for 125-Volt 20-Amp Receptacle: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

C. Using test plug, verify device and its outlet box are securely mounted.

D. Line Voltage Range: 105 volts to 132 volts.

E. Percent Voltage Drop under 15-Amp Load: Less than 6 percent; 6 percent or higher is not acceptable.

F. Ground Impedance: 2 ohms, maximum.

G. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.

H. Tests shall be diagnostic, indicating damaged conductors, high resistance at circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

END OF SECTION

SECTION 26 36 23
AUTOMATIC TRANSFER SWITCHES

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Descriptive product information.
2. Dimensional drawings.
3. Control diagrams.
4. Conduit entrance locations.
5. Equipment ratings.
6. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Seismic Anchorage and Bracing.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services.
3. Factory certified test reports.
4. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
5. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.

1.02 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

PART 2 PRODUCTS

2.01 MANUFACTURER

A. ABB Zenith.

B. Eaton.

C. ASCO.

D. “Or-equal.”

2.02 GENERAL

A. Transfer switch to be product of a single manufacturer in order to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer’s service.

B. In accordance with applicable standards of NFPA 70, NEMA ICS 1, NEMA ICS 2, NEMA ICS 6, IEEE C37.90.1, and UL 1008.

C. Transfer switch consisting of inherently double-throw power switch unit with interconnected control module.

D. Rated 100 percent, in amperes, for total system transfer of motor, electric heating, discharge lamp loads, and tungsten-filament lamp loads.

1. Switches rated 400 amperes and below suitable for 100 percent tungsten-filament lamp loads.
2. Switches rated above 400 amperes suitable for 30 percent tungsten-filament lamp loads.

E. Main and arcing contacts visible for inspection with cabinet door and barrier covers removed.

F. Neutral transfer contacts for switched neutral conductors.

G. Suitable for 480-volt three-phase, three-wire or four-wire as shown on Drawings. Switch shall be suitable for service having an available short circuit current at line terminals of 65,000 amperes rms symmetrical.

H. Switch Rating: continuous amperes as shown on Drawings and in nonventilated enclosure.

I. Current carrying capacity of arcing contacts shall not be used to determine the transfer switch rating.

J. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

K. Operating Conditions:

1. Ambient Temperature: Maximum 40 degrees C.
2. Equipment to be fully rated without any derating for operating conditions listed above.

2.03 ENCLOSURE

A. Type: Nonventilated NEMA 250, Type 1 with enclosure grounding terminal.

B. Dead front, front accessible wall or floor mounted cabinet with 14-gauge welded steel construction.

C. Continuously hinged single door, with handle and lock cylinder.

D. Finish: Baked enamel applied over rust-inhibiting, phosphated base coating.

1. Exterior and Interior Color: Provide gray finish as approved by Engineer.
2. Unpainted Metal Parts: Plated for corrosion resistance.

2.04 TRANSFER SWITCH

A. Type: Electrically operated, mechanically held, double-throw.

B. Momentarily energized, single-electrically operated mechanism energized from source to which load is to be transferred.

C. Locking mechanism to maintain constant contact pressure.

D. Mechanical interlock switch to ensure only one of two possible switch positions or time delay in neutral position.

E. Silver alloy contacts protected by arcing contacts.

F. Main and arcing contacts visible when door is open and barrier covers removed.

G. Manual operating handle for transfer in either direction under either loaded or unloaded conditions.

H. Internal control wire connections made with ring or spade type terminals, lock washers, and sleeve type marking labels.

2.05 CONTROL MODULE

A. Completely enclosed and mounted separately from the transfer switch unit.

B. Microprocessor for sensing and logic control with inherent digital communications capability.

C. Plug-in, industrial grade interfacing relays with dust covers.

D. Connected to transfer switch by wiring harness having keyed disconnect plug.

E. Plug-in printed circuit boards for sensing and control logic.

F. Adjustable solid state undervoltage sensors for all three phases of preferred and for standby source:

1. Pickup 85 to 100 percent nominal.
2. Dropout 75 to 98 percent of pickup setting.

G. Adjustable frequency sensors for standby source:

1. Pickup 90 to 100 percent nominal.
2. Dropout 87 to 89 percent of pickup setting.

H. Control module with adjustable time delays:

1. 0.5- to 6-second engine start delay.
2. 0- to 5-minute load transfer to emergency delay.
3. 0- to 30-minute retransfer to normal delay.
4. 0- to 30-minute unload running time delay.
5. Switch to bypass any of the above time delays during testing.

2.06 INDICATORS

A. Type: Manufacturer’s standard.

B. Green lens to indicate switch position for preferred power source.

C. Red lens to indicate switch position for standby power source.

D. White lens to indicate preferred power source is available within parameters established by pickup and dropout settings.

E. Amber lens to indicate standby power source is available within parameters established by pickup and dropout settings.

F. Provide one normally open and one normally closed, 5 amperes, 120-volt contact for remote indication when transfer switch is in either position.

2.07 FACTORY TESTS

A. Test to Ensure Correct:

1. Operation of individual components.
2. Sequence of operation.
3. Transfer time, voltage, frequency, and time delay settings.

B. Dielectric strength test in accordance with NEMA ICS 1.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Secure enclosure to floor using anchor bolts for floor mounted units and structural steel channels attached to wall surface for wall mounted units, Provide anchor bolts or steel channel of sufficient size and number adequate for specified seismic conditions.

END OF SECTION

SECTION 26 43 00
TRANSIENT VOLTAGE SUPPRESSION

PART 1 GENERAL

1.01 SUBMITTALS

A. Submit product data on each suppressor type, indicating component values, part numbers, and conductor sizes. Include dimensional drawing for each, showing mounting arrangements.

B. Submit manufacturer's UL certified test data and nameplate data for each TVSS.

C. Submit electrical single-line diagram showing location of each TVSS.

1.02 QUALITY ASSURANCE

A. UL Compliance and Labeling:

1. For power and signal circuits, TVSS devices shall comply with UL 1449 and complimentary listed to UL 1283 as an electromagnetic interference filter. Provide units that are listed and labeled by UL.
2. For telephone circuit protection, TVSS devices shall comply with UL 497A.

B. ANSI Compliance: Use TVSS devices in compliance with the recommendations of IEEE C62.41.1, IEEE C62.41.2, and IEEE C62.45.

PART 2 PRODUCTS

2.01 GENERAL

A. All TVSS devices for power circuits, provided under this section, shall be the product of a single manufacturer.

B. TVSS devices shall be capable of performance at ambient temperatures between minus 40 degrees C and 60 degrees C, at relative humidity ranging from 0 percent to 95 percent, and at altitudes ranging from sea level to 12,000 feet.

C. TVSS devices shall be fused to disconnect the suppressor from the electrical source should the suppressor fail. The fusing shall allow full surge handling capabilities and to afford safety protection from thermal overloads and short circuits.

D. Design TVSS devices for the specific type and voltage of the electrical service. Single-phase and three-phase wye-configured systems shall have L-N,

L-G, and N-G protection. Grounded delta-configured systems shall have L-L and L-G protection.

E. Power Filter: The TVSS shall include a high frequency extended range power filter complimentary listed to UL 1283 as an electromagnetic interference filter.

2.02 MANUFACTURERS

A. Innovative Technology, VanGuard Series.

B. Advanced Protection Technologies, Inc.

C. Current Technology.

D. "Or-equal."

2.03 SWITCHGEAR AND MOTOR CONTROL CENTERS TVSS

A. Provide TVSS meeting IEEE C62.41.1 and IEEE C62.41.2 Location in accordance with Category C.

B. Surge current capacity shall be not less than the following:

1. L-N Capacity: 200 kA.
2. L-G Capacity: 200 kA.
3. N-G Capacity: 120 kA.

C. Suppressor housing shall be in an enclosure that has the same NEMA rating as the equipment it protects and painted to match.

D. UL 1449 maximum suppression voltage shall not be more than:

System Voltage	Phase	L-L or L-N Suppression Voltage
120	1	400
208Y/120	3	400
240	3	800
480Y/277	3	800

2.04 PANELBOARD TVSS

A. Provide TVSS meeting IEEE C62.41.1 and IEEE C62.41.2 Location Category B.

B. Surge current capacity shall be not less than the following:

1. L-L Capacity: 80 kA.
2. L-N Capacity: 80 kA.
3. L-G Capacity: 80 kA.
4. N-G Capacity: 80 kA.

C. Suppressor shall be in an enclosure that has the same NEMA rating as the panel it protects or the TVSS may be integral to a panelboard.

D. UL 1449 maximum clamp voltage shall not be more than:

System Voltage	Phase	L-L or L-N Clamp Voltage
120	1	400
208Y/120	3	400
240	3	800
480Y/277	3	800

2.05 ANNUNCIATION

A. Provide unit or separately mounted LED-type indication lights to show the normal and failed status of each module. Provide one normally open and one normally closed contacts which operate when the unit fails.

2.06 SURGE COUNTER

A. Provide each TVSS rated above 100 kA with a counter displaying the number of voltage transients that have occurred on the unit input. The counter shall be battery backed and retain the count through system power outages.

2.07 PAIRED CABLE DATA LINE INTERIOR SUPPRESSORS

A. Provide units meeting IEEE C62.41, Location Category A.

B. Use bi-polar 1,500-watt silicon avalanche diodes between the protected conductor and earth ground.

C. Provide units with a maximum single impulse current rating of 80 amperes (10 by 1,000 microsecond-waveform).

D. Breakdown voltage shall not exceed 36 volts.

2.08 PAIRED CABLE DATA LINE EXTERIOR SUPPRESSORS

A. Provide units meeting IEEE C62.41, Location Category A.

B. Suppressors shall be a hybrid design with a minimum of three stages, utilizing solid-state components and operating bi-directionally.

C. Suppressors shall meet or exceed the following criteria:

1. Maximum single impulse current rating of 10,000 amperes (8 by 20 microsecond-waveform).
2. Pulse Life Rating: 3,000 amperes (8 by 20 microsecond-waveform): 2,000 occurrences.
3. Maximum clamping voltage at 10,000 amperes (8 by 20 microsecond current waveform), shall not exceed the peak of the normal applied signal voltage by 200 percent.

PART 3 EXECUTION

3.01 APPLICATION REQUIREMENTS

A. Install TVSS when indicated on Drawings and:

1. TVSS in or near each low-voltage switchgear (load center).
2. TVSS in or near each motor control center.
3. Panelboard TVSS In or near each distribution panelboard unless otherwise indicated.

B. Electronic Equipment Paired Cable Conductors: Install data line suppressors at the low voltage input and output of each piece of equipment, including telephone cable entrance.

1. Use secondary protectors on lines that do not exit the structure.
2. Use primary protectors on lines that exit and enter the structure.

3.02 GENERAL INSTALLATION REQUIREMENTS

A. Install suppressors according to manufacturer’s recommendations.

B. Install suppressors directly to the cabinet which houses the circuit to be protected so that the suppressor leads are straight and short, with all conductors laced, running directly to the point of connection within the panel, without loops or bends. If bends are unavoidable, no bend may exceed 90 degrees and bending radius may not be less than 6 inches.

C. Connecting wires shall be as short as possible with gently twisted conductors, tied together, to prevent separation. Connecting wires shall not exceed 24 inches in length at any point.

D. Field installed conductors shall be the same as specified for building wire, not smaller than No. 8 AWG and not larger than No. 4 AWG. Device leads shall not be longer than the length recommended by the manufacturer, unless specifically reviewed and approved by the manufacturer.

E. Provide dedicated disconnecting means for TVSS devices installed at switchgear, motor control centers. Provide dedicated 30-60-ampere circuit breakers (size dependent upon wire size used) with number of poles as required, as disconnecting means for TVSS devices installed at panelboards. The interrupting capacity of the circuit breakers shall be that specified for the other breakers at that location.

END OF SECTION

SECTION 26 50 00
LIGHTING

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Interior Luminaires:
      1) Catalog data sheets and pictures.
      2) Luminaire finish and metal gauge.
      3) Lens material, pattern, and thickness.
      4) Candle power distribution curves in two or more planes.
      5) Candle power chart 0 degree to 90 degrees.
      6) Lumen output chart.
      7) Average maximum brightness data in foot lamberts.
      8) Coefficients of utilization for zonal cavity calculations.
      9) Mounting or suspension details.
      10) Heat exchange and air handling data.
   b. Exterior Luminaires:
      1) Catalog data sheets and pictures.
      2) Luminaire finish and metal gauge.
      3) Lens material, pattern, and thickness.
      4) IESNA lighting classification and isolux diagram.
      5) Fastening details to wall or pole.
      6) Ballast type, location, and method of fastening.
      7) For light poles, submit wind loading, complete dimensions, and finish.
   c. Lamps:
      1) Voltages.
      2) Colors.
      3) Approximate life (in hours).
      4) Approximate initial lumens.
      5) Lumen maintenance curve.
      6) Lamp type and base.
      7) Copy of lamp order, including individual quantities, for Project.
   d. Ballasts:
      1) Type.
      2) Wiring diagram.
      3) Nominal watts and input watts.
      4) Input voltage and power factor.
      5) Starting current, line current, and restrike current values.
      6) Sound rating.

7) Temperature rating.
8) Efficiency ratings.
9) Low temperature characteristics.
10) Emergency ballasts rating and capacity data.

e. Photo-Time Control:
1) Wiring diagram.
2) Contact ratings.

f. Photocells:
1) Voltage, and power consumption.
2) Capacity.
3) Contacts and time delay.
4) Operating levels.
5) Enclosure type and dimensions.
6) Temperature range.

g. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

1.02 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

PART 2 PRODUCTS

2.01 LUMINAIRES

A. Specific requirements relative to execution of the Work of this section are located in Luminaire Schedule on Drawings.

B. Feed-through type, or separate junction box.

C. Ballasts: Two-lamp when possible.

D. Wire Leads: Minimum 18 AWG.

E. Component Access: Accessible and replaceable without removing luminaire from ceiling.

F. Soffit Installations:

1. UL Labeled: SUITABLE FOR DAMP LOCATIONS.
2. Ballast: Removable, prewired.

G. Exterior Installations:

1. UL Labeled: SUITABLE FOR WET LOCATIONS.
2. Ballast: Removable, prewired.

3. When factory-installed photocells are provided, entire assembly shall have UL label.

2.02 LAMPS

A. Fluorescent:

1. Type Efficiency: As shown on Drawings.
2. Color: As shown on Drawings.

B. LED:

1. Type: As shown on Drawings.
2. Color: As shown on Drawings.

Manufacturers: As noted on the Drawings.

2.03 BALLASTS

A. General:

1. Meet requirements for fixture light output, reliable starting, radio interference, total harmonic distortion, electromagnetic interference, and dielectric rating.
2. Certified by electrical testing laboratory to conform to CBM specifications.

2.04 LIGHTING CONTROL

A. Photocell:

1. Automatic ON/OFF switching photo control.
2. Housing: Self-contained, die-cast aluminum, unaffected by moisture, vibration, or temperature changes.
3. Setting: ON at dusk and OFF at dawn.
4. Time delay feature to prevent false switching.
5. Field adjustable to control operating levels.

6. Manufacturers:
    a. Tork.
    b. Paragon Electric Company.
    c. “Or-equal.”

2.05 EMERGENCY BALLAST

A. In accordance with UL 924.

B. Nickel cadmium battery, charger, and electronic circuitry in metal case.

C. Solid state charging indicator monitoring light and double-pole test switch.

D. Capable of operating two fluorescent lamps for a period of 90 minutes with output of 1,100 to 1,200 lumens.

E. Manufacturers:

1. MagneTek Lighting Products.
2. The Bodine Co., Inc.; B50.
3. Lithonia.
4. “Or-equal.”

PART 3 EXECUTION

3.01 LUMINAIRES

A. General:

1. Install in accordance with manufacturer’s recommendations.
2. Provide proper hangers, pendants, and canopies as necessary for complete installation and meeting specified anchorage and bracing requirements.
3. Provide additional ceiling bracing, hanger supports, and other structural reinforcements to building required to safely mount.
4. Install plumb and level.
5. Install each luminaire outlet box with galvanized stud.

B. Mounting:

1. General:
    a. Mounting, fastening, and environmental conditions shall be coordinated with Section 26 05 02, Basic Electrical Requirements.
    b. Refer to Fastener Schedule in Section 05 50 00, Metal Fabrications.
2. Wall-mounted: Measure mounting heights from center of mounting plate to finished floor or finished grade, whichever is applicable.

3. Pendant-mounted:
    a. Provide swivel type hangers and canopies to match luminaires, unless otherwise noted.
    b. Space single-stem hangers on continuous-row fluorescent luminaires nominally 48 inches apart.
    c. Provide twin-stem hangers on single luminaires.
    d. Measure mounting heights from bottom of luminaire to finished floor or finished grade, whichever is applicable.

C. Finished Areas:

1. Install symmetrically with tile pattern.
2. Locate with centerlines either on centerline of tile or on joint between adjacent tile runs.
3. Install recessed luminaires tight to finished surface such that no spill light will show between ceilings and sealing rings.
4. Combustible Low-density Cellulose Fiberboard: Provide spacers and mount luminaires 1-1/2 inches from ceiling surface, or use fixtures suitable for mounting on low density ceilings.
5. Junction Boxes:
    a. Flush and Recessed Luminaires: Locate minimum 1-foot from luminaire.
    b. In concealed locations, install junction boxes to be accessible by removing luminaire.
6. Wiring and Conduit:
    a. Provide wiring of temperature rating required by luminaire.
    b. Provide flexible steel conduit.
7. Provide plaster frames when required by ceiling construction.
8. Independent Supports:
    a. Provide each recessed fluorescent luminaire with two safety chains or two No. 12 soft-annealed galvanized steel wires of length needed to secure luminaire to building structure independent of ceiling structure.
    b. Tensile strength of chain or wire, and method of fastening to structure shall be adequate to support weight of luminaire.
    c. Fasten chain or wire to each end of luminaire.

D. Building Exterior: Flush-mounted back box and concealed conduit, unless otherwise indicated.

3.02 LAMPS

A. Provide in each fixture, number and type for which fixture is designed, unless otherwise noted.

3.03 BALLASTS

A. Install in accordance with manufacturer's recommendations.

B. Utilize all ballast mounting holes to fasten securely within luminaire.

C. Replace noisy or defective ballasts.

3.04 EMERGENCY BALLAST

A. Install battery, charger, and electronic circuitry metal case inside fluorescent fixture housing adjacent to ac ballast.

B. Install monitoring light and double-pole switch adjacent to light fixture.

C. Wire in accordance with manufacturer's wiring diagrams.

3.05 EMERGENCY LIGHTING UNIT

A. Install in accordance with manufacturer's recommendations.

B. Provide permanent circuit connections with conduit and wire.

C. Connect to branch circuit feeding normal lighting in area ahead of all local switches.

D. Provide separate circuit wiring to luminaire.

3.06 CLEANING

A. Remove labels and markings, except UL listing mark.

B. Wipe luminaires inside and out to remove construction dust.

C. Clean luminaire plastic lenses with antistatic cleaners only.

D. Touch up painted surfaces of luminaires and poles with matching paint ordered from manufacturer.

E. Replace defective lamps at time of Substantial Completion.

END OF SECTION

SECTION 31 23 13
SUBGRADE PREPARATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft^3 (600 kN-m/m^3)).
   b. D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).

1.02 DEFINITIONS

A. Optimum Moisture Content: As defined in Section 31 23 23, Fill and Backfill.

B. Prepared Ground Surface: Ground surface after completion of clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and scarification and compaction of subgrade.

C. Relative Compaction: As defined in Section 31 23 23, Fill and Backfill.

D. Relative Density: As defined in Section 31 23 23, Fill and Backfill.

E. Subgrade: Layer of existing soil after completion of clearing, grubbing, scalping of topsoil prior to placement of fill, roadway structure or base for floor slab.

F. Proof-Rolling: Testing of subgrade by compactive effort to identify areas that will not support the future loading without excessive settlement.

1.03 SEQUENCING AND SCHEDULING

A. Complete applicable Work specified in Sections 02 41 00, Demolition and 31 23 16, Excavation, prior to subgrade preparation.

1.04 QUALITY ASSURANCE

A. Notify Engineer when subgrade is ready for compaction or proof-rolling or whenever compaction or proof-rolling is resumed after a period of extended inactivity.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Prepare subgrade when unfrozen and free of ice and snow.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Keep subgrade free of water, debris, and foreign matter during compaction or proof-rolling.

B. Bring subgrade to proper grade and cross-section and uniformly compact surface.

C. Do not use sections of prepared ground surface as haul roads. Protect prepared subgrade from traffic.

D. Maintain prepared ground surface in finished condition until next course is placed.

3.02 COMPACTION

A. Under Pavement Structure: Compact upper 12 inches to minimum of 95 percent relative compaction as determined in accordance with ASTM D698 Method, or three passes with a loaded dump truck or similar heavy-wheeled vehicle.

3.03 MOISTURE CONDITIONING

A. Dry Subgrade: Add water, then mix to make moisture content uniform throughout.

B. Wet Subgrade: Aerate material by blading, discing, harrowing, or other methods, to hasten drying process.

3.04 TESTING

A. Prepare trench bottom as per Section 31 23 23.15, Trench Backfill.

B. Proof-roll subgrade prior to final surface restoration and finish (such as pavement) with equipment specified in Article Compaction to detect soft or loose subgrade, as determined by Engineer.

3.05 CORRECTION

A. Soft or Loose Subgrade:

1. Adjust moisture content and recompact.
2. Over excavate in accordance with the Engineer's direction, and replace with suitable material from the excavation, as specified in Section 31 23 23, Fill and Backfill.

END OF SECTION

SECTION 31 23 16
EXCAVATION

PART 1 GENERAL

1.01 DEFINITIONS

A. Common Excavation: Excavation is unclassified. Complete all excavation regardless of the type, nature, or condition of the materials encountered.

1.02 SUBMITTALS

A. Action Submittals:

1. Excavation Plan, Detailing:
   a. Methods and sequencing of excavation in accordance with Section 02 61 00, Removal and Disposal of Contaminated Soil.
   b. Proposed offsite landfill disposal site, and proposed locations of temporary storage or stockpiling in accordance with Section 02 61 00, Removal and Disposal of Contaminated Soil.
   c. Numbers, types, and sizes of equipment proposed to perform excavations.
2. Qualification documents of the independent testing laboratory complying requirements specified in Article Quality Assurance.
3. Excavation Sampling, Testing, Analysis, and Classification Plan:
   a. Sampling plan identifying sample locations, number and type of samples, and sampling techniques.
   b. Analytical methods that will be used to test material (solids and liquids) and the laboratory's QA/QC procedures.
   c. Classification of material in accordance with CT DEEP requirements, by excavation area and by elevation within each excavation area.
4. Shoring and Trench Excavation Plan:
   a. Details of shoring, bracing, sloping or other provisions for worker protection from hazards of caving ground.
   b. Design assumptions and calculations.
   c. Methods and sequencing of installing excavation support.
   d. If a prefabricated support system is used, submit manufacture's certification of support depth rating based on OSHA Soil Type.
5. Test Pit Excavation Plan and Duct Banks Survey Results:
   a. Plan view of test pit locations and approximate size of test pit.
   b. Description of excavation method.
   c. Duct banks survey results.

1.03 QUALITY ASSURANCE

A. Provide adequate survey control to avoid unauthorized overexcavation.

B. Independent Testing Laboratory: Shall be approved by Owner or Owner's Representative and shall be accredited by the State of Connecticut and have minimum 5-years' experience performing required tests.

1.04 WEATHER LIMITATIONS

A. Material excavated when frozen or when air temperature is less than 32 degrees F shall not be used as fill or backfill until material completely thaws.

B. Material excavated during inclement weather shall not be used as fill or backfill until after material drains and dries sufficiently for proper compaction.

1.05 SEQUENCING AND SCHEDULING

A. The soil sampling and characterization report must be complete and submitted to the Engineer a minimum of 60 days prior to any scheduled excavation.

B. Demolition: Complete applicable Work specified in Section 02 41 00, Demolition, prior to excavating.

C. Dewatering: Conform to applicable requirements of Section 31 23 19.01, Dewatering, prior to initiating excavation.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Excavate to lines, grades, and dimensions shown and as necessary to accomplish Work. Excavate to within tolerance of plus or minus 0.1 foot, except where dimensions or grades are shown or specified as maximum or minimum. Allow for forms, working space, granular base, topsoil, and similar items, wherever applicable. Trim to neat lines where concrete is to be deposited against earth.

B. Do not overexcavate without written authorization of Engineer.

C. Remove or protect obstructions as shown and as specified in Section 01 50 00, Temporary Facilities and Controls, Article Protection of Work and Property.

D. Securely support existing facilities vulnerable to settlement due to excavation operations. Support shall include, but not be limited to, bracing and underpinning.

E. Use of explosives is not permitted.

3.02 CHARACTERIZATION OF SOIL

A. All excavated material is considered contaminated unless the results of the material sampling and testing indicate otherwise. Excavated material must be transported and disposed of in accordance with Section 02 61 00, Removal and Disposal of Contaminated Soil.

B. Prior to any excavation, sampling for the purposes of material (solids and liquids) characterization must be completed.

C. In general, sampling for the purpose of material characterization shall be conducted at 50-foot spacing along proposed trench excavations. A composite sample taken at 3-foot increments from existing grade for the anticipated depth of excavation shall be collected for analysis.

D. For proposed building excavations, sampling for the purpose of waste characterization shall be conducted on a 25-foot grid pattern covering the entire limits of excavation. A composite sample taken at 3-foot increments from existing grade for the anticipated depth of excavation shall be collected for analysis.

3.03 TRENCH WIDTH

A. Minimum Width of Trenches:

1. Single Pipes, Conduits, Direct-Buried Cables, and Duct Banks:
   a. Less than 4-inch Outside Diameter or Width: 18 inches.
   b. Greater than 4-inch Outside Diameter or Width: 18 inches greater than outside diameter or width of pipe, conduit, direct-buried cable, or duct bank.
2. Multiple Pipes, Conduits, Cables, or Duct Banks in Single Trench: 18 inches greater than aggregate width of pipes, conduits, cables, duct banks, plus space between.
3. Increase trench widths by thicknesses of sheeting.

B. Multiple pipes in the same trench: comply with minimum trench width and clearance between pipes as per Contract Drawings.

C. Maximum Trench Width: Unlimited, unless otherwise shown or specified, or unless excess width will cause damage to existing facilities, adjacent property, or completed Work.

3.04 TRENCH SHORING

A. All ground support system elements including sheeting, shoring, and bracing of excavations shall conform to the requirements of Subpart P, Excavations (1926.650 of 29 CFR) of the Occupational Safety and Health Administration (OSHA).

B. The contractor shall assume OSHA Type C soil for selecting and designing trench excavation support system.

C. For trench excavation exceeding 4 feet in depth, provide adequate safety system meeting requirements of applicable state and local construction safety orders, and federal requirements.

D. All shoring elements shall be removed upon completion of Work.

3.05 TEST PITS

A. The purpose of the test pits is to expose the top and the top edges of the 2 duct banks to identify the actual elevation and horizontal limits of these.

B. Excavate 1 test pit at each location of duct bank penetrating the proposed building foundation wall. A total of 4 test pits (2 per duct bank) are anticipated.

C. Test pits excavation shall be conducted using vacuumed or hand digging to prevent damage of the duct bank.

D. At each test pit location, survey one point on top of the duct bank and one point at each top edge of the duct bank. Total three points shall be surveyed at each test pit location. Do not proceed to micropile installation until the duct bank survey results are approved and the final micropile locations are issued by the Engineer.

E. Test pits and the survey shall be conducted prior to the excavation for the building construction.

3.06 STOCKPILING EXCAVATED MATERIAL

A. Only allowed per soil characterization results and requirements in Section 02 61 00, Removal and Disposal of Contaminated Soil.

3.07 DISPOSAL OF SPOIL

A. Dispose excavated material in accordance with Section 02 61 00, Removal and Disposal of Contaminated Soil.

END OF SECTION

SECTION 31 23 19.01
DEWATERING

PART 1 GENERAL

1.01 WORK OF THIS SECTION

A. Work included in this section consists of controlling groundwater and surface water within all construction excavations. Ground water and surface water shall be controlled, intercepted, and maintained 2 feet below the lowest point of the excavation.

B. The Contractor shall assume that dewatering well(s) are needed for the excavation required for the repair of the existing expansion joints outside of the aeration basin. The Contractor is responsible for the design, installation, and operation of the dewatering well(s). The design of the dewatering well(s) shall be based on available geotechnical information.

1.02 SUBMITTALS

A. Action Submittals:

1. Water control plan.
2. Dewatering well permits.
3. Discharge permits.

1.03 WATER CONTROL PLAN

A. As a minimum, include:

1. Descriptions of proposed groundwater and surface water control facilities including, but not limited to, equipment; methods; standby equipment and power supply, pollution control facilities, discharge locations to be utilized, and provisions for immediate temporary water supply as required by this section.
2. Drawings showing locations, dimensions, and relationships of elements of each system.
3. Design calculations demonstrating adequacy of proposed dewatering systems and components.

B. If system is modified during installation or operation revise or amend and resubmit Water Control Plan.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Continuously control water during course of construction, including weekends and holidays and during periods of work stoppages, and provide adequate backup systems to maintain control of water.

3.02 SURFACE WATER CONTROL

A. See Section 01 50 00, Temporary Facilities and Controls.

B. Remove surface runoff controls when no longer needed.

3.03 DEWATERING SYSTEMS

A. Provide, operate, and maintain dewatering systems of sufficient size and capacity to permit excavation and subsequent construction in dry and to lower and maintain groundwater level a minimum of 2 feet below the lowest point of excavation. Continuously maintain excavations free of water, regardless of source, and until backfilled to final grade.

B. Design and Operate Dewatering Systems:

1. In accordance with the approved Water Control Plan.
2. To prevent loss of ground as water is removed.
3. To avoid inducing settlement or damage to existing facilities, completed Work, or adjacent property.
4. To relieve artesian pressures and resultant uplift of excavation bottom.

C. Provide means to measure water discharge from any dewatering well. Monitor the rate of discharge from each well on a daily basis with an accuracy of at least 2 percent of the flow and make records available to the Engineer on a weekly basis or as requested.

D. Provide sufficient redundancy in each system to keep excavation free of water in event of component failure.

E. Provide 100 percent emergency power backup with automatic startup and switchover in event of electrical power failure.

F. Provide supplemental ditches and sumps as necessary to collect water from local seeps.

3.04 DISPOSAL OF WATER

A. Obtain discharge permit for water disposal from authorities having jurisdiction.

B. Treat water collected by dewatering operations, as required by regulatory agencies, prior to discharge.

C. Discharge water as required by discharge permit and in manner that will not cause erosion or flooding, or otherwise damage existing facilities, completed Work, or adjacent property.

D. Remove solids from treatment facilities and perform other maintenance of treatment facilities as necessary to maintain their efficiency.

E. Comply with Section 02 61 00, Removal and Disposal of Contaminated Soil.

3.05 PROTECTION OF PROPERTY

A. Make assessment of potential for dewatering induced settlement. Provide and operate devices or systems including, but not limited to, infiltration trenches and cutoff walls necessary to prevent damage to existing facilities, completed Work, and adjacent property.

B. Securely support existing facilities, completed Work, and adjacent property vulnerable to settlement due to dewatering operations. Support shall include, but not be limited to, bracing, underpinning, or compaction grouting.

C. Upon completion of construction, abandon and grout (using cement grout) all dewatering wells and observation wells in accordance with requirements of local and state authorities.

END OF SECTION

SECTION 31 23 23
FILL AND BACKFILL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C117, Standard Test Method for Materials Finer Than 75-Micrometers (No. 200) Sieve in Mineral Aggregates by Washing.
   b. C136, Standard Method for Sieve Analysis of Fine and Coarse Aggregates.
   c. D75, Standard Practice for Sampling Aggregates.
   d. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)).
   e. D1556, Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
   f. D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).
   g. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
   h. D4254, Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
   i. D6938, Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.02 DEFINITIONS

A. Relative Compaction:

1. Ratio, in percent, of as-compacted field dry density to laboratory maximum dry density as determined in accordance with ASTM D698.
2. Apply corrections for oversize material to either as-compacted field dry density or maximum dry density, as determined by Engineer.

B. Optimum Moisture Content:

1. Determined in accordance with ASTM Standard specified to determine maximum dry density for relative compaction.
2. Determine field moisture content on basis of fraction passing 3/4-inch sieve.

C. Relative Density: Calculated in accordance with ASTM D4254 based on maximum index density determined in accordance with ASTM D4253 and minimum index density determined in accordance with ASTM D4254.

D. Prepared Ground Surface: Ground surface after completion of required demolition, clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and subgrade preparation.

E. Completed Course: A course or layer that is ready for next layer or next phase of Work.

F. Lift: Loose (uncompacted) layer of material.

G. Geosynthetics: Geotextiles, geogrids, or geomembranes.

H. Well-Graded:

1. A mixture of particle sizes with no specific concentration or lack thereof of one or more sizes.
2. Does not define numerical value that must be placed on coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters.
3. Used to define material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.

I. Influence Area: Area within planes sloped downward and outward at 60-degree angle from horizontal measured from:

1. 1 foot outside outermost edge at base of foundations or slabs.
2. 1 foot outside outermost edge at surface of roadways or shoulder.
3. 0.5 foot outside exterior at spring line of pipes or culverts.

J. Borrow Material: Material from required excavations or from designated borrow areas on or near Site.

K. Selected Backfill Material: Materials available onsite that Engineer determines to be suitable for specific use.

L. Imported Material: Materials obtained from sources offsite, suitable for specified use.

M. Granular Fill: Fill materials as required under structures, pavements, and other facilities.

N. Embankment Material: Fill materials required to raise existing grade in areas other than under structures.

1.03 SUBMITTALS

A. Action Submittals:

1. Samples: Imported material taken at each source.
2. Submit compaction curve per ASTM D698 if earthfill is used.
3. Certified test results from independent testing agency.
4. Lightweight cellular concrete mix design and certified test results.
5. Placement plan of lightweight cellular concrete: as the minimum, include description of on-site mixing equipment (if used) and placement stages.

1.04 QUALITY ASSURANCE

A. Notify Engineer when:

1. Structure is ready for backfilling, and whenever backfilling operations are resumed after a period of inactivity.
2. Soft or loose subgrade materials are encountered wherever embankment or site fill is to be placed.
3. Fill material appears to be deviating from Specifications.

1.05 SEQUENCING AND SCHEDULING

A. Complete applicable Work specified in Section 02 41 00, Demolition, Section 31 23 16, Excavation, Section 31 23 19.01, Dewatering, and Section 31 23 13, Subgrade Preparation, prior to placing fill or backfill.

B. Do not place granular base, subbase, or surfacing until after subgrade has been prepared as specified in Section 31 23 13, Subgrade Preparation.

PART 2 PRODUCTS

2.01 SOURCE QUALITY CONTROL

A. Gradation Tests: in accordance with ASTM C136.

1. As necessary to locate acceptable sources of imported material.
2. During production of imported material, test as follows:
   a. Granular Fill: one per each source.

B. Samples: Collected in accordance with ASTM D75:

1. During production of imported material, provide Samples as follows:
   a. Granular Fill: one per each source**.**
2. Clearly mark to show source of material and intended use.

2.02 EARTHFILL

A. Material free from rocks larger than 3 inches, from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials.

2.03 GRANULAR FILL

A. Comply with No. 6, or No. 67 coarse aggregate as specified in Connecticut Department of Transportation, Form 818, M.01.02.

2.04 LIGHTWEIGHT CELLULAR CONCRETE

A. The lightweight cellular concrete shall have the properties as specified below:

Property	Requirements	Test Method
Maximum / Minimum Dry Density	48.0 / 40.0 pounds per cubic foot	ASTM C796
Minimum Unconfined Compressive Strength @ 28 days curing	120 pounds per square inch	ASTM C495
Internal Friction Angle	35 degrees (min.)	AASHTO T236 (ASTM D3080-72)
Frost Heave. Sample @ 250-hour exposure, 4.5-inch high x 4-inch dia.	< 0.5 in	British Road Research Laboratory, Lab Report LR 90, 1967, by Croney, Jacobs.
Freezing and Thawing Resistance	Relative Dynamic Modulus, RDM ≥ 80% at 300 cycles.	ASTM C666 Procedure B (Rapid freezing in air and thawing in water) modified per Bidwell Report dated April, 1975
Coefficient of permeability @ 2.0 pounds per square inch	$1x10^{-4}$ centimeter per second (min.)	

B. Portland cement shall be Type I/II Portland cement, conform to ASTM C150.

C. Water quality shall meet the requirements of ASTM C1602.

D. Commercially available foaming agents shall meet the requirements of ASTM C869.

E. Admixtures shall only be used if designed and approved by the supplier.

2.05 WATER FOR MOISTURE CONDITIONING

A. Free of hazardous or toxic contaminates, or contaminants deleterious to proper compaction.

PART 3 EXECUTION

3.01 GENERAL

A. Keep placement surfaces free of water, debris, and foreign material during placement and compaction of fill and backfill materials.

B. Place and spread fill and backfill materials in horizontal lifts of uniform thickness, in a manner that avoids segregation, and compact each lift to specified densities prior to placing succeeding lifts. Slope lifts only where necessary to conform to final grades or as necessary to keep placement surfaces drained of water.

C. During filling and backfilling, keep level of fill and backfill around each structure and buried tank even.

D. Do not place fill or backfill, if fill or backfill material is frozen, or if surface upon which fill or backfill is to be placed is frozen.

E. Tolerances:

1. Final Lines and Grades: Within a tolerance of 0.1 foot unless dimensions or grades are shown or specified otherwise.
2. Grade to establish and maintain slopes and drainage as shown. Reverse slopes are not permitted.

F. Settlement: Correct and repair any subsequent damage to structures, pavements, curbs, slabs, piping, and other facilities, caused by settlement of fill or backfill material.

3.02 BACKFILL

A. Provide a minimum 4-inch layer of granular fill under structural concrete of building foundation slab and foundation wall.

B. Use granular fill to backfill the gap between the duct bank and the building foundation wall/slab. Place material in lifts of 6-inch maximum thickness. Thoroughly tamp each lift, including area under haunches, with handheld tamping bars supplemented by “walking in” and slicing material under haunches with a shovel to ensure voids are completely filled before placing each succeeding lift.

C. Under pavement:

1. Backfill with granular fill to lines and grades shown, with proper allowance for pavement structure. Place in lifts of 6-inch maximum thickness. Each lift shall be compacted with a minimum of two passes by either a vibratory plate compactor or a power-driven impact

compactor. Final subgrade preparation under pavement shall conform to Section 31 23 23 Subgrade Preparation.

D. Trench: Comply with Section 31 23 23.15, Trench Backfill.

E. Other Areas:

1. Granular Fill Option: Backfill with granular fill to lines and grades shown, with proper allowance for topsoil thickness or other surfacing details where shown. Place in lifts of 6-inch maximum thickness. Each lift shall be compacted with a minimum of two passes by either a vibratory plate compactor or a power-driven impact compactor.
2. Earthfill Option: Use earthfill conforming to the requirements in this Section. Place in lifts of 6-inch maximum thickness and compact each lift to minimum 93 percent relative compaction as determined in accordance with ASTM D698. Excavated material in accordance with Section 31 23 16, Excavation, is contaminated and shall not be used for backfill.

3.03 SITE TESTING

A. Gradation:

1. One sample from each type of finished product from each source or more often as determined by Engineer, if variation in gradation is occurring, or if material appears to depart from Specifications.
2. If test results indicate material does not meet Specification requirements, terminate material placement until corrective measures are taken.
3. Remove material placed in Work that does not meet Specification requirements.

B. In-Place Density Tests: In accordance with ASTM D6938. During placement of materials, test as follows:

1. Earthfill: Three tests per every 2 vertical foot of backfill and at every 300 square foot area of backfill.

C. Lightweight Cellular Concrete: Test the following for every 3 mixing trucks or every 30 cubic yard of in-place mixed material.

1. One wet density test per ASTM C796.
2. One compressive strength test per ASTM C495.

END OF SECTION

SECTION 31 23 23.15
TRENCH BACKFILL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Public Works Association (APWA): Uniform Color Code.
2. ASTM International (ASTM):
   a. C33/C33M, Standard Specification for Concrete Aggregates.
   b. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   c. C117, Standard Test Method for Materials Finer than 75 Micrometer (No. 200) Sieve in Mineral Aggregates by Washing.
   d. C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   e. C150/C150M, Standard Specification for Portland Cement.
   f. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
   g. C1012/C1012M, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
   h. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)).
   i. D1140, Standard Test Methods for Amount of Material in Soils Finer than No. 200 (75 micrometer) Sieve.
   j. D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).
   k. D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
   l. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
   m. D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
   n. D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
   o. D4832, Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
3. National Electrical Manufacturers Association (NEMA): Z535.1, Safety Colors.

1.02 DEFINITIONS

A. Base Rock: Granular material upon which manhole bases and other structures are placed.

B. Bedding Material: Granular material upon which pipes, conduits, cables, or duct banks are placed.

C. Imported Material: Material obtained by Contractor from source(s) offsite.

D. Lift: Loose (uncompacted) layer of material.

E. Pipe Zone: Backfill zone that includes full trench width and extends from prepared trench bottom to 12 inches above top outside surface of pipe, conduit, cable or duct bank.

F. Prepared Trench Bottom: Graded trench bottom after excavation and installation of stabilization material, if required, but before installation of bedding material.

G. Relative Compaction: The ratio, in percent, of the as-compacted field dry density to the laboratory maximum dry density as determined by ASTM D698. Corrections for oversize material may be applied to either as-compacted field dry density or maximum dry density, as determined by Engineer.

H. Relative Density: As defined by ASTM D4253 and ASTM D4254.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Manufacturer’s descriptive literature for marking tapes.

B. Informational Submittals:

1. Catalog and manufacturer’s data sheets for compaction equipment.
2. Certified Gradation Analysis: comply with Section 31 23 23, Fill and Backfill.
3. Controlled Low Strength Material: Certified mix design and test results. Include material types and weight per cubic yard for each component of mix.

PART 2 PRODUCTS

2.01 MARKING TAPE

A. Nondetectable:

1. Inert polyethylene, impervious to known alkalis, acids, chemical reagents, and solvents likely to be encountered in soil.
2. Thickness: Minimum 5 mils.
3. Width: 3 inches.
4. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.
5. Manufacturers and Products:
   a. Reef Industries; Terra Tape.
   b. Mutual Industries; Non-detectable Tape.
   c. Presco; Non-detectable Tape.

B. Detectable:

1. Solid aluminum foil, visible on unprinted side, encased in protective high visibility, inert polyethylene plastic jacket.
2. Foil Thickness: Minimum 0.35 mils.
3. Laminate Thickness: Minimum 5 mils.
4. Width: 3 inches.
5. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.
6. Joining Clips: Tin or nickel-coated furnished by tape manufacturer.
7. Manufacturers and Products:
   a. Reef Industries; Terra Tape, Sentry Line Detectable.
   b. Mutual Industries; Detectable Tape.
   c. Presco; Detectable Tape.

C. Color: In accordance with APWA Uniform Color Code.

Color*	Facility
Red	Electric power lines, cables, conduit, and lightning cables
Orange	Communicating alarm or signal lines, cables, or conduit
Yellow	Gas, oil, steam, petroleum, or gaseous materials
Green	Sewers and drain lines
Blue	Potable water
Purple	Reclaimed water, irrigation, and slurry lines
*As specified in NEMA Z535.1, Safety Color Code.	

2.02 GRANULAR FILL

A. Conform to Section 31 23 23, Fill and Backfill.

2.03 EARTHFILL

A. Conform to Section 31 23 23, Fill and Backfill.

2.04 CONTROLLED LOW STRENGTH MATERIAL (CLSM)

A. Select and proportion ingredients to obtain compressive strength between 50 psi and 150 psi at 28 days in accordance with ASTM D4832.

B. Materials:

1. Cement: ASTM C150/C150M, Type I or Type II.
2. Aggregate: ASTM C33/C33M, Size 7.
3. Fly Ash (Pozzolan): Class F fly ash in accordance with ASTM C618, except as modified herein:
    a. ASTM C618, Table 1, Loss on Ignition: Unless permitted otherwise, maximum 3 percent.
    b. Test in accordance with ASTM C1012/C1012M to verify sulfate resistance is acceptable.
4. Water: Clean, potable, containing less than 500 ppm of chlorides.

2.05 SOURCE QUALITY CONTROL

A. Certify Laboratory Performance of Mix Designs: Controlled low strength material.

PART 3 EXECUTION

3.01 TRENCH PREPARATION

A. Water Control:

1. Promptly remove and dispose of water entering trench as necessary to grade trench bottom and to compact backfill and install manholes, pipe, conduit, direct-buried cable, or duct bank. Do not place concrete, lay pipe, conduit, direct-buried cable, or duct bank in water. Perform dewatering as specified in Section 31 23 19.01, Dewatering.
2. Remove water in a manner that minimizes soil erosion from trench sides and bottom.
3. Provide continuous water control until trench backfill is complete.

B. Remove foreign material and backfill contaminated with foreign material that falls into trench.

3.02 TRENCH BOTTOM

A. Firm Subgrade: Grade with hand tools, remove loose and disturbed material, and trim off high areas and ridges left by excavating bucket teeth. Allow space for bedding material if shown or specified.

B. Soft Subgrade: If subgrade is encountered that may require removal to prevent pipe settlement, notify Engineer. Engineer will determine depth of overexcavation, if any required.

3.03 TRENCH STABILIZATION MATERIAL INSTALLATION

A. Rebuild trench bottom with granular fill.

B. Place material over full width of trench in 6-inch lifts to required grade.

C. Compact each lift so as to provide a firm, unyielding support for the bedding material prior to placing succeeding lifts.

3.04 BACKFILL PIPE ZONE AND BEDDING

A. Use CLSM to backfill bedding and pipe zone (from trench bottom to at least 12 inches above the pipe).

B. Provide temporary support for pipes during placement of CLSM.

C. Use temporary tie-down straps, fill pipes with water, placing CLSM in stages or other means to prevent uplift (flotation) of pipes.

D. Discharge from truck mounted drum type mixer into trench.

3.05 MARKING TAPE INSTALLATION

A. Continuously install marking tape along centerline of buried piping a minimum of 12 inches above buried utility. Coordinate with piping installation drawings.

1. Detectable Marking Tape: Install with nonmetallic piping and waterlines.
2. Nondetectable Marking Tape: Install with metallic piping.

3.06 BACKFILL ABOVE PIPE ZONE

A. Granular Fill Option: backfill with granular fill to lines and grades shown, with proper allowance for topsoil thickness or other surfacing details where shown. Place in lifts of 6-inch maximum thickness. Each lift shall be compacted with a minimum of 2 passes by either a vibratory plate compactor or a power-driven impact compactor.

B. Earthfill Option: Use earthfill conforming to the requirements in this Section. Place in lifts of 6-inch maximum thickness and compact each lift to minimum 93 percent relative compaction as determined in accordance with ASTM D698. Excavated material in accordance with Section 31 23 16, Excavation, is contaminated and shall not be used for backfill.

3.07 REPLACEMENT OF TOPSOIL

A. Replace topsoil in top 6 inches of backfilled trench in areas specified in Contract Drawings.

B. Maintain finished grade of topsoil even with adjacent area and grade as necessary to restore drainage.

3.08 MAINTENANCE OF TRENCH BACKFILL

A. After each section of trench is backfilled, maintain surface of backfilled trench even with adjacent ground surface until final surface restoration is completed.

B. Topsoil: Add topsoil where applicable and as necessary to maintain surface of backfilled trench level with adjacent ground surface.

C. Concrete Pavement: Replace settled slabs as specified in Section 32 12 16, Asphalt Paving.

D. Asphaltic Pavement: Replace settled areas or fill with asphalt as specified in Section 32 12 16, Asphalt Paving.

E. Other Areas: Add material of backfilling above pipe zone where applicable and keep surface of backfilled trench level with adjacent ground surface.

3.09 SETTLEMENT OF BACKFILL

A. Settlement of trench backfill, or of fill, or facilities constructed over trench backfill will be considered a result of defective compaction of trench backfill.

END OF SECTION

SECTION 31 32 00
SOIL STABILIZATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. Official Seed Analysts of North America.

1.02 DEFINITIONS

A. Maintenance Period: Begin maintenance immediately after each area is planted and continue for a period of 8 weeks after planting under this section is completed.

B. Satisfactory Stand: Grass or section of grass of 1,000 square feet or larger that has:

1. No bare spots larger than 3 square feet.
2. Not more than 10 percent of total area with bare spots larger than 1 square foot.
3. Not more than 15 percent of total area with bare spots larger than 6 square inches.

1.03 SUBMITTALS

A. Action Submittals: Product data for commercial products; seed, fertilizer, and lime.

B. Informational Submittals:

1. Seed certifications.
2. Copies of delivery invoices or other proof of quantities of mulch, lime, and fertilizer.
3. Manufacturer’s Installation Instructions: Commercial products.

1.04 DELIVERY, STORAGE, AND PROTECTION

A. Seed:

1. Furnish in standard containers with seed name, lot number, net weight, percentages of purity, germination, and hard seed and maximum weed seed content, clearly marked for each container of seed.
2. Keep dry during storage.

B. Hydroseeding Mulch: Mark package of wood fiber mulch to show air dry weight.

1.05 SEQUENCING AND SCHEDULING

A. Complete soil preparation, seeding, liming, fertilizing, and mulching within 10 days after final grades have been reached.

B. Notify Engineer at least 5 days in advance of:

1. Materials delivery.
2. Start of planting/seeding activity.

C. Seeding: Perform between March 15 and September 15.

1.06 MAINTENANCE

A. Operations:

1. Perform during maintenance period to include:
   a. Watering: Keep seeded surface moist.
   b. Washouts: Repair by filling with topsoil, fertilizing, seeding, and mulching.
   c. Mulch: Replace wherever and whenever washed or blown away.
   d. Reseed unsatisfactory areas or portions thereof immediately at end of maintenance period if a satisfactory stand has not been produced.
   e. Reseed during next planting season if scheduled end of maintenance period falls after September 15.
   f. Reseed entire area if satisfactory stand does not develop by July 1 of the following year.
   g. Mowing: Mow to 2 inches after grass height reaches 3 inches, and mow to maintain grass height from exceeding 3-1/2 inches.

B. Maintenance Service Agreement: Provide for period of 1 year from Substantial Completion.

PART 2 PRODUCTS

2.01 FERTILIZER

A. Commercial, uniform in composition, free-flowing, suitable for application with equipment designed for that purpose.

B. Fertilizer shall have the following minimum percentage of plant food by weight:

1. Summer Mix:
   a. Nitrogen: 20 percent.
   b. Phosphoric Acid: 10 percent.
   c. Potash: 10 percent.
2. Winter Mix:
   a. Nitrogen: 16 percent.
   b. Phosphoric Acid: 8 percent.
   c. Potash: 0 percent.

2.02 SEED

A. Seeds of Legumes: Inoculated with pure culture of nitrogen-fixing bacteria prepared specifically for legume species in accordance with inoculant manufacturer's instructions.

B. Winter Protective Mix:

1. Winter Barley: 100 percent.
2. Annual Ryegrass: 100 percent.

2.03 MULCH

A. Wood Cellulose Fiber Mulch:

1. Specially processed wood fiber containing no growth or germination inhibiting factors.
2. Dyed suitable color to facilitate inspection of material placement.
3. Manufactured such that after addition and agitation in slurry tanks with water, material fibers become uniformly suspended to form homogenous slurry.
4. When hydraulically sprayed on ground, material will allow absorption and percolation of moisture.

B. Straw:

1. Clean salt hay or threshed straw of oats, wheat, barley, or rye, free from seed of noxious weeds. Suitable for spreading with mulch blower equipment.
2. Average Stalk Length: 6 inches.
3. Seasoned before baling or loading.

2.04 EROSION CONTROL MATTING

A. Excelsior mat or straw blanket; staples as recommended by matting manufacturer.

B. Manufacturers and Products:

1. Akzo Industries, Asheville, NC; Curlex Mat.
2. North American Green, Evansville, IN; S150 blanket.
3. Or equal approved by the Engineer.

2.05 S150 BLANKET TACKIFIER

A. Derived from natural organic plant sources containing no growth or germination-inhibiting materials.

B. Capable of hydrating in water, and to readily blend with other slurry materials.

C. Wood Cellulose Fiber: Add as tracer, at rate of 150 pounds per acre.

2.06 REINFORCED PLASTIC COVERING

A. Co-extruded, copolymer laminate reinforced with nonwoven grid of high strength nylon cord submersed in a permanently flexible adhesive media allowing for equal tear resistance in all directions.

B. Black in color and ultraviolet stabilized.

C. Physical Requirement (Minimum Average Roll Values):

1. Tear Strength: 130 pounds.
2. Elongation: 620 percent.

D. Manufacturers:

1. Reef Industries, Inc., Houston, TX.
2. Griffolyn Co., Houston, TX.

PART 3 EXECUTION

3.01 SOIL PREPARATION

A. Before start of hydroseeding or broad cast seeding, and after surface has been shaped and graded, and lightly compacted to uniform grade, scarify soil surface to minimum depth of 1 inch.

3.02 SEEDING

A. Prepare 1-inch-deep seed bed; obtain Engineer’s acceptance prior to proceeding.

B. Apply by hydroseeding or broad cast seeding method on moist soil, but only after free surface water has drained away. Prevent drift and displacement of mixture into other areas.

C. Summer Application:

1. Prepare and apply mix as follows:
   a. Seed Mix: 50 pounds per acre.
   b. Fertilizer, 20-10-10: 650 pounds per acre.
   c. Lime: 50 pounds per 1,000 square feet.
   d. Wood Cellulose Fiber Mulch (Pounds per acre): As recommended by Manufacturer.
   e. Water: As necessary.

2. Irrigation: 1 inch per week to seeded areas from June 1 through August 15.

D. Winter Application: Prepare and apply mix as follows:

1. Winter Seed Mix: 50 pounds per acre.
2. Fertilizer, 16-8-0 700: pounds per acre.
3. Wood Cellulose Fiber Mulch (Pounds per acre): As recommended by Manufacturer.
4. Water: As necessary.

3.03 MULCHING

A. Apply uniformly on seeded areas. Do not apply mulch on seeded areas that will be immediately covered with erosion control matting.

B. Application: Sufficiently loose to permit penetration of sunlight and air circulation, and sufficiently dense to shade ground, reduce evaporation rate, and prevent or materially reduce erosion of underlying soil.

1. Straw: Apply by hand or mechanical means to minimum depth of 2 inches.
2. Wood Cellulose Fiber: 1,000 to 1,500 pounds per acre.

3.04 EROSION CONTROL MATTING

A. Place on seeded slopes 3H:1V and steeper, staple/stake in place and with the appropriate overlap in accordance with manufacturer’s instruction.

3.05 TACKIFIER

A. Apply on areas mulched with straw.

B. Spray on after mulch is in place.

3.06 REINFORCED PLASTIC COVERING

A. Place on areas where hydroseeding and erosion control matting have not controlled erosion.

B. Install in single thickness, strips parallel to direction of drainage.

C. Maintain tightly in place by using sandbags on ropes with a maximum 10-foot grid spacing in all directions.

D. Tape or weight down full length, overlap seams at least 12 inches.

E. Remove at final acceptance, unless notified otherwise by Engineer.

3.07 FIELD QUALITY CONTROL

A. Upon completion of maintenance period and on written notice from Contractor, Engineer will within 15 days of receipt, determine if a satisfactory stand has been established.

B. If a satisfactory stand has not been established, Engineer will make another determination upon written notice from Contractor following the next growing season.

END OF SECTION

SECTION 31 32 19.16
GEOTEXTILES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including General and Supplemental Conditions and Division 01 Specification Sections, apply to this Section.

B. Extent of the Work under this Section is shown on the Drawings.

1.02 DESCRIPTION OF WORK

A. Provide woven geotextile fabric for filter fabric as indicated or specified.

B. Related Sections include the following Section 31 37 00, Riprap.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM) Publications:

1. D4355: Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-ARC Type Apparatus).
2. D4491: Test Methods for Water Permeability of Geotextile by Permittivity.
3. D4533: Test Method for Trapezoid Tearing Strength of Geotextiles.
4. D4632: Test Method for Grab Breaking Load and Elongation of Geotextiles.
5. D475 1: Test Method for Determining Apparent Opening Size of a Geotextile.
6. D4833: Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.

B. The Standard Specifications referenced herein shall be State of Connecticut, Department of Transportation Standard Specifications for Roads, Bridges, Facilities, and Incidental Construction – Form 818, including all supplemental specifications.

1.04 SUBMITTALS

A. Shop Drawings: Submit the following in accordance with Section 01 33 00, Submittal Procedures:

1. At least two weeks prior to shipment, submit manufacturer’s certificate of compliance and physical property data sheet, indicating that requirements for materials and manufacture are in conformance as specified.

B. General:

1. Producer of geotextile fabric to maintain competent laboratory at point of manufacture to ensure quality control in accordance with ASTM testing procedures. Laboratory to maintain records of quality control results.
2. Take all precautions to protect geotextile fabric from damage resulting from any cause. Either repair or replace geotextile fabric to Engineer's satisfaction at no additional cost to the Owner.

PART 2 PRODUCTS

2.01 MATERIALS

A. Filter fabric shall conform to Section M.08.01-19 of the Standard Specifications. The fabric shall conform to the High Survivability column of a Separator material as described on the CT DOT Qualified Product List.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install filter fabric as detailed in the Drawings.

END OF SECTION

SECTION 31 37 00
RIPRAP

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   b. C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   c. C150, Standard Specification for Portland Cement.
   d. C535, Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

1.02 DEFINITIONS

A. Refer to applicable definitions in Section 31 23 23, Fill and Backfill.

B. Standard Specifications, as used in this section, refer to State of Connecticut Department of Transportation Standard Specifications for Roads, Bridges, Facilities and Incidental Construction Form 818 with supplemental specifications dated January 2022.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Description and location of proposed sources of riprap bedding and riprap.
   b. Description and location of 3 projects where proposed riprap has been successfully used for minimum 3 years' duration under similar service conditions.
2. Samples:
   a. General:
      1) Deliver to Site at location designated by Engineer.
      2) Incorporate Samples into Work after material placement is nearly complete.
   b. Riprap: Provide minimum:
      1) 20 tons of Type I Class I.
      2) 10 tons of Type II Class II.
      3) Each Sample shall meet gradation requirements specified for corresponding riprap type, include at least one piece of

maximum size, and be representative of material to be furnished for incorporation into Work. Weigh individual pieces of riprap with scales that are certified accurate to within plus or minus 1 percent of actual weight.

c. Riprap Bedding: Provide minimum 1,100 pounds.

B. Informational Submittals:

1. Quarry Certificate of Conformance and supporting documentation showing proposed riprap bedding or riprap meet Standard Specification gradation and materials requirements for the Class or Type specified.
2. Certified Test Results:
   a. Riprap Bedding:
      1) Gradation.
      2) Abrasion resistance.
   b. Riprap:
      1) Gradation.
      2) Abrasion resistance.
      3) Bulk density.
3. Trip tickets showing source, type, and weight of each load of material delivered to Site.

1.04 QUALITY ASSURANCE

A. Riprap Source: Quarry that has produced riprap and has performed satisfactorily on other projects for at least 5 years.

B. Site Visit: Make arrangements for Engineer to visit quarry site to observe materials proposed for riprap and riprap bedding.

1.05 SCHEDULING AND SEQUENCING

A. Complete subgrade preparation as specified in Section 31 23 13, Subgrade Preparation, and geotextile installation as specified in Section 31 32 19.16, Geotextile, prior to placing riprap bedding or riprap.

PART 2 PRODUCTS

2.01 AGGREGATE RIPRAP BEDDING

A. Gravel with Cobbles or Crushed Rock with Cobble-Sized Pieces:

1. Gradation, as determined in accordance with ASTM C136:
   a. Well-graded from coarse to fine.
   b. All pieces pass a 6-inch square opening.
   c. Minimum 85 percent by weight passes 4-inch square opening.
   d. Minimum 10 percent by weight passes No. 4 U.S. standard sieve.

2. Abrasion Resistance: Maximum 35 percent wear when tested in accordance with ASTM C535.

B. Free of roots and other organic or deleterious matter.

C. Onsite material from excavations or designated borrow sources that meets or is processed to meet requirements specified above may be used as riprap bedding in lieu of importing material.

2.02 GEOTEXTILE RIPRAP BEDDING

A. Bedding geotextile as specified in Section 31 32 19.16, Geotextile.

2.03 RIPRAP

A. Hard and durable quarry stone free from fractures, bedding planes, pronounced weathering, and earth or other adherent coatings.

B. Minimum Dimension of Individual Pieces: Not less than 1/3 maximum dimension.

C. Abrasion Resistance: Maximum 35 percent wear as determined in accordance with ASTM C535.

D. Bulk Density: Minimum 160 pounds per dry cubic foot.

E. Gradation: Smaller pieces shall generally fill voids between larger pieces without either excess or deficiency of one or more sizes of stone.

Class	Thickness (Inches)	Weight (Pounds)	% Greater Than
I	12	150 100 50 25	0 to 5 30 75 90
II	18	250 150 50 25	0 to 5 30 75 90
III	24	800 400 200 25	0 to 5 30 75 90

Class	Thickness (Inches)	Weight (Pounds)	% Greater Than
		1,600	0 to 5
		800	30
		400	75
IV	30	50	90
		2,700	0 to 5
		1,600	30
		800	75
V	36	100	90

PART 3 EXECUTION

3.01 PLACING RIPRAP BEDDING

A. Place riprap bedding over prepared subgrade geotextile to uniform depth thickness lines and grades shown.

B. No mechanical compaction of riprap bedding is required; however, work riprap bedding as necessary to distribute it and to eliminate detrimental voids. Avoid overworking or long pushes that result in segregation of particle sizes.

C. Grade surface of riprap bedding free from irregularities and to tolerances of 0.2 feet from established grade.

D. Place and grade riprap bedding in a manner that avoids subgrade disturbance and displacement or damage to geotextile. Do not push riprap bedding down slope. If wrinkles form in geotextile as riprap bedding is placed, correct them as specified in Section 31 32 19.16, Geotextile.

E. Place riprap bedding on geotextile without puncturing or damaging geotextile. If accidentally damaged, repair geotextile prior to proceeding.

3.02 PLACING RIPRAP ON RIPRAP BEDDING

A. Place riprap over prepared subgrade riprap bedding to uniform depth thickness shown. minimum -inch depth thickness. If riprap bedding is underlain with geotextile, place riprap from bottom to top of slope.

B. Intermix different sizes of pieces to eliminate segregation and to fill voids between larger pieces with smaller pieces and work surface free from irregularities.

C. Use placement and intermixing methods that avoid disturbing prepared subgrade riprap bedding and underlying geotextile or damaging existing facilities, completed Work, or adjacent property.

END OF SECTION

SECTION 31 43 00
MICROPILES

PART 1 GENERAL

1.01 PURPOSE OF SPECIFICATION

A. This Specification, along with the Drawings, encompasses furnishing all necessary ancillary design, materials, products, accessories, tools, equipment, services, transportation, labor, supervision, and installation techniques required for testing and installing micropiles.

1.02 SCOPE OF WORK

A. The Work consists of furnishing all necessary ancillary design, supervision, labor, materials, and equipment to perform all work necessary to install and test the micropiles required for the construction of the proposed structure, in accordance with the Specifications described herein, and as shown on the Drawings.

B. The Contractor shall install the micropiles in accordance with FHWA NHI-05-039 Micropile Design and Construction Reference Manual, dated 2005, Table 2-1, using Micropile Type and Grouting Method sub-type A3.

C. The Contractor shall select the micropile installation means and methods and design the grout mix that are compatible and appropriate for the project ground conditions described in the Specifications. In accordance with Paragraph Submittals, the Contractor shall submit a Work Plan. The approval of the Work Plan will be provisional until the test pile is successfully installed and load-tested.

D. One pre-production (sacrificial) test micropile shall be installed at least 5 feet away from production micropile locations and with the tip elevation and bond length determined by the Engineer in the field. For quantity estimate purpose, the Contractor shall assume the pre-production test micropile having the same estimated tip elevation and bond length of the production micropiles, plus 10 feet additional casing and center bar. Pre-production test micropile location shall be selected by the Contractor and approved by the Engineer.

E. The sacrificial micropile shall be load-tested as specified in Paragraph Micropile Load Tests. The pre-production test micropile shall be installed under full time inspection by the Engineer.

F. Production micropiles shall not be installed until the test micropile is successfully installed and load-tested to required capacity. If the Contractor failed to install or meet the required capacity due to poor construction quality, the Contractor shall identify the cause of problems, provide solutions, and

reinstall test micropile at the Contractor's own expense and with no adjustment of Contract Time. If pre-production test micropile with good construction quality as approved by Engineer did not meet specified capacity, the Engineer will evaluate required quantity and length of micropile for the production micropiles based on pre-production load-test results.

G. Micropile lengths shown on the Drawings are for quantity estimate purposes only. Final length will be determined by the Engineer within 1 week after finishing the pre-production load test(s) and submitting test results to the Engineer.

1.03 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. M31, Standard Specification for deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   b. M85, Standard Specification for Portland Cement.
   c. M183, Standard Specification for Structural Steel.
   d. M194, Standard Specification for Chemical Admixtures for Concrete.
   e. M223, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
   f. M275, Standard Specification for Uncoated High-Strength Steel Bar for Prestressing Concrete.
   g. T26, Standard Method of Test for Quality of Water to Be Used in Concrete.
2. American Petroleum Institute (API): 5CT (N80), Specification for Casing and Tubing.
3. American Welding Society (AWS):
   a. D 1.1, Structural Welding Code – Steel.
   b. D 1.2, Structural Welding Code – Reinforcing Steel.
4. ASTM International (ASTM):
   a. A36, Standard Specification for Carbon Structural Steel.
   b. A252, Standard Specification for Welded and Seamless Steel Pipe Piles.
   c. A572, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
   d. A615, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   e. A722, Standard Specification for High-Strength Steel Bars for Prestressed Concrete.
   f. C150, Standard Specification for Portland Cement.
   g. C494, Standard Specification for Chemical Admixtures for Concrete.

h. D1143, Standard Test Methods for Deep Foundations Under Static Axial Compressive Load.

5. Post-Tensioning Institute (PTI): Recommendations for Prestressed Rock and Soil Anchors.

1.04 DEFINITIONS

A. Admixture: Substance added to the grout to either control bleed and/or shrinkage, improve flowability, reduce water content, retard setting time, or resist washout.

B. Alignment Load (AL): A nominal load applied to a micropile during testing to keep the testing equipment correctly positioned.

C. Apparent Free Micropile Length: The length of pile, which is apparently not bonded to the surrounding ground, as calculated from the elastic load extension data during testing.

D. Bond Breaker: A sleeve or coating placed over the steel reinforcement to prevent load transfer.

E. Bond Length: The length of micropile that is bonded to the ground, and which is conceptually used to transfer applied axial loads to surrounding soil or rock.

F. Casing: Steel pipe introduced during the drilling process to temporarily stabilize the drill hole. Depending on details of micropile construction and composition, this casing may be fully extracted during or after grouting, or may remain partially or completely in-place, as part of the final pile configuration.

G. Centralizer: A device to centrally locate reinforcing element(s) within the borehole.

H. Contractor: Person/firm responsible for performing micropile Work.

I. Core Steel: Reinforcing bars or pipes used to strengthen or stiffen the pile, excluding any left-in drill casing.

J. Corrosion-inhibiting Compound: Material used to protect against corrosion (and/or lubricate the reinforcing steel inside a bond breaker).

K. Coupler: The means by which load can be transmitted from one partial length of reinforcement to another.

L. Creep Movement: Movement that occurs during the creep test of a micropile under a constant load.

M. Design Load (DL): Anticipated final maximum service load in the micropile, as specified in load test schedule in this section.

N. Duplex Drilling: A drilling system involving the simultaneous advancement of (inner) drill rod and (outer) drill casing. Flush from the inner drill rod is permitted to exit the borehole via the annulus between rod and casing.

O. Elastic Movement: Recoverable movement measured during a micropile test.

P. Encapsulation: A corrugated tube protecting the reinforcing steel against corrosion.

Q. Free (Unbonded) Length: Designed length of micropile that is not bonded to the surrounding ground or grout during testing.

R. Micropile: A small diameter, bored, cast-in-place pile, in which most of the applied load is resisted by the steel reinforcement.

S. Overburden: Non-lithified material, natural or placed, which normally requires cased drilling methods to provide an open borehole to underlying strata.

T. Post-grouting: Injection of additional grout into the bond length of a micropile after primary grout has set. Also known as re-grouting or secondary grouting.

U. Preloading: The principle whereby load is applied to the micropile, prior to the micropile's connection to the structure, to minimize any structural movement in service.

V. Primary Grout: Portland cement-based grout that is injected into the micropile hole prior to or after installation of reinforcement to provide load transfer to surrounding ground along the micropile and affords a degree of corrosion protection in compression.

W. Reinforcement: Steel component of micropile which accepts and/or resists applied loadings.

X. Residual Movement: Non-elastic (non-recoverable) movement of a micropile measured during load testing.

Y. Safety Factor: Ratio of ultimate capacity to the working load used for the design of any component or interface.

Z. Single-tube Drilling: Advancement of a steel casing through overburden usually aided by water flushing through the casing. Also known as “external flush.” Fluid may or may not return to the surface around the casing, depending largely on permeability of the overburden.

AA. Test Load (TL): Maximum load to which the micropile is subjected during testing.

BB. Tremie Grouting: Placing of grout in a borehole via a grout pipe introduced to the bottom of the hole. During grouting, the exit of the pipe is kept at least 10 feet below the level of grout in the hole.

CC. Working Load: Equivalent term for DL.

1.05 QUALIFICATIONS OF THE CONTRACTOR

A. The micropile contractor shall be fully experienced in all aspects of micropile design and construction, and shall furnish all necessary equipment, materials, skilled labor, and supervision to carry out the contract. The Contractor shall have successfully completed at least 5 projects in the previous 5 years of similar scope and size. Contractor shall have successfully installed micropiles in sites with obstructions, including boulders, and minimum 100 micropiles of similar capacity to those required in the plans and specifications. Contractor must also provide resumés of key personnel who will be present on-site (and will be materially involved) and who will each have at least 3 years of relevant experience. These personnel shall include superintendent, driller, and project engineer/manager. Work shall not be started, nor materials ordered, until the Engineer's written approval of Contractor experience qualifications is given. The Engineer may suspend Work if the Contractor uses non-approved personnel. If Work is suspended, the Contractor shall be fully liable for all resulting costs and no adjustment in Contract Time will result from the suspension.

B. Prequalified micropile contractors are listed below:

Nicholson Construction Company 12 McClane Street Cuddy, PA 15031 Contact: Thomas Richards Phone: 412-221-4500	Rembco Geotechnical Contractors PO Box 23009 Knoxville, TN 37933 Contact: Clay Griffin Phone: 865-671-2925
Schnabel Foundation Company 5210 River Road Bethesda, MD 20816 Contact: Harald P. Ludwig Phone: 301-657-3060	Berkel & Co. Contractors, Inc. 2341 Linden Lane Silver Spring, MD 20910 Contact: Fabian Lehmann Phone: 301-587-5111

C. The micropile contractor shall not sublet the whole or any part of the contract without the express permission, in writing, of the Owner.

1.06 ALLOWABLE TOLERANCES

A. Centerline of piling shall not be more than 3 inches from indicated plan location.

B. Pile-hole alignment shall be within 1 percent of design alignment.

C. Top elevation of pile shall be within plus 1 inch to minus 1 inch of the design vertical elevation.

D. Centerline of core reinforcement shall not be more than 3/4 inch from centerline of piling.

1.07 GROUND CONDITIONS

A. Installation advancement shall expect drilling into soil, boulders, and weathered/competent bedrock. The micropile contractor is responsible to assess the impact of obstructions on micropile installation and take measures to overcome obstructions without causing additional cost to Owner or delays in construction.

B. If an obstruction encountered during micropile installation prevents practical advancement of drilling, the hole shall be abandoned and filled with grout. A new micropile shall be drilled at a location determined by the Owner and Engineer. The Contractor must acknowledge that relocation options may be limited by piping, utilities, etc. in some instances, and further attempts at the original location with different drilling methods may be required.

1.08 SUBMITTALS

A. Action Submittals:

1. Work shall not begin until required submittals have been received, reviewed, and approved by Engineer. Additional time required to resubmit an incomplete or unacceptable submission shall not be cause for delay or impact claims.
2. Conduct test pits and submit the duct bank survey results per 31 23 16, Excavation. The Engineer will issue to the final micropile locations within 14 calendar days upon receiving the duct bank survey results.
3. Shop Drawings:
   a. The Contractor shall prepare and submit to the Engineer for review and approval, working drawings and relevant calculations for micropile installation at least 15 calendar days prior to planned start of construction.
   b. Working drawings shall include micropile installation details, giving:
      1) Micropile number, location, and installation (drilling and grouting) pattern.
      2) Micropile design load.
      3) Type and size of reinforcing steel.
      4) Minimum total bond length.
      5) Total micropile length.
      6) Grouting volumes and maximum pressures.
      7) Micropile top attachment.
      8) Micropile cut-off elevation.

4. Work Plan: The Contractor shall submit a detailed description of the construction procedures. This shall include a schedule of major equipment resources.
5. Grout Mix: The Contractor shall submit the grout mix designs, including details of all materials to be incorporated, and the procedure for mixing and placing the grout. This submittal shall include certified test results verifying acceptability of proposed mix designs.
6. Load Test Plan: The Contractor shall submit detailed plans for the proposed micropile testing method prior to beginning load tests. This shall include all necessary drawings and details to clearly describe the test method and equipment proposed. The plan shall also include:
    a. Pre-production test micropile location and details.
    b. Type and accuracy of apparatus for measuring load.
    c. Type and accuracy of apparatus for applying load.
    d. Type and accuracy of apparatus for measuring pile deformation.
    e. Type and capacity of reaction load system, including sealed design drawings.
    f. Hydraulic jack calibration report.
7. Load-test Results: The Contractor shall submit load-test results for Engineer review and approval. The Contractor shall allow the Engineer 7 calendar days to review load-test results.
8. The Contractor shall submit calibration reports for each test jack, pressure gauge, and master pressure gauge to be used. The calibration tests shall have been performed by an independent testing laboratory and tests shall have been performed within 1 year of the date submitted. Testing shall not commence until the Engineer has approved the jack, pressure gauge, and master pressure gauge calculations.
9. The Contractor shall submit certified mill test reports, properly marked, for the reinforcing steel, as the materials are delivered, to the Engineer for record purposes. Ultimate strength, yield strength, elongation, and composition shall be included. For steel pipe used as permanent casing, or core steel, the Contractor shall submit a minimum of two representative coupon tests or mill certifications (if available) on each load delivered to the Project.
10. Installation Records: The records shall be completed within 24 hours after each micropile installation is completed. Records shall include the following minimum information:
    a. Micropile drilling duration and observations (e.g., flush return).
    b. Information on soil and rock encountered, including description of strata, water, etc.
    c. Approximate final tip elevation.
    d. Cut-off elevation.
    e. Design loads (DLs).
    f. Description of unusual installation behavior, conditions.
    g. Any deviations from the intended parameters.
    h. Grout pressures attained, where applicable.
    i. Grout quantities pumped.

j. Micropile materials and dimensions.
k. Micropile test records, analysis, and details.
l. In addition, as-built drawings showing the location of the micropiles, their depth and inclination, and details of their composition shall be submitted within 15 calendar days of Project completion.

11. Approval of Shop Drawings, Work Plan, and Grout Mix: Approval of these items shall be contingent upon successful installation of pre-production (sacrificial) micropile and successful load tests. The Engineer reserves the right to make additional comments and request modification to shop drawings, work plan, and grout mix based on the sacrificial pile installation.

PART 2 PRODUCTS

2.01 WATER

A. Water for mixing grout shall be potable, clean and free from substances which may be in any way deleterious to grout or steel. If water is not potable, it shall be tested in accordance with AASHTO T26 for acceptability.

2.02 ADMIXTURES

A. Admixtures shall conform to the requirements of ASTM C494 (AASHTO M194). Admixtures that control bleed, improve flowability, reduce water content, and retard set may be used in the grout, subject to review and acceptance of the Engineer. Expansive admixtures shall only be added to the grout used for filling sealed encapsulations. Admixtures shall be compatible with the grout and mixed in accordance with manufacturer recommendations. Their use will only be permitted after appropriate field tests on fluid and set grout properties. Admixtures with chlorides shall not be permitted.

2.03 CEMENT

A. All cement shall be portland cement conforming to ASTM C150 (AASHTO M85) Type II and shall be the product of one manufacturer. If the brand or type of cement is changed during a project, additional grout mix tests shall be conducted to ensure consistency of quality and performance in situ.

2.04 FILLERS

A. Fillers such as sand may be used in the grout in special situations (e.g., presence of large voids in the ground, when grout take and travel are to be limited) as approved by the Engineer.

2.05 BAR REINFORCEMENT

A. Reinforcing steel shall be deformed bars in accordance with ASTM A722 Grade 150. Reinforcing steel shall be threaded bars.

B. For compressive loading, the coupler shall be compatible with efficient load transfer and overall reinforcement performance requirements.

2.06 PIPE/CASING

A. Permanent Steel Casing/Pipe:

1. Shall meet tensile requirements of API-N80 or ASTM A252 with minimum yield strength of 80 ksi and minimum elongation of 15 percent.
2. Casing shall have minimum length as shown on the Drawings without field welding.
3. Casing sections shall be joined by manufactured thread joints constructed to develop at least the required compressive, tensile, and/or bending structural strength used in the micropile design.

2.07 PLATES AND SHAPES

A. Structural steel plates and shapes for pile top attachments shall conform to ASTM A572 Grade 50.

2.08 CENTRALIZERS

A. Centralizers shall be fabricated from plastic, steel, or material that is non-detrimental to the reinforcing steel. Wood shall not be used.

PART 3 EXECUTION

3.01 INSTALLATION

A. All production micropile installation shall be performed under full time inspection by the Engineer. The Engineer will determine the top of bond zone elevation based on observation of drilling condition at each production micropile.

B. The Contractor is responsible to plan the drilling and grouting sequence in such way that the communication between two micropiles can be minimized. Drilling of a micropile shall be at least 20 feet away from the micropile drill hole which is to be grouted or which is freshly grouted within 2 days.

C. The micropile installation technique shall be consistent with the geotechnical, logistical, environmental, and load carrying conditions of the Project. The micropile contractor shall select the drilling method and grouting procedures used for micropile installation, subject to the approval of the Engineer.

D. Drilling equipment and methods shall be suitable for drilling through the conditions to be encountered, with minimal disturbance to these conditions or any overlying or adjacent structure or service. The borehole must be open to defined nominal diameter, full-length, prior to placing grout and reinforcement.

E. The micropile casing shall be advanced simultaneously with the drill bit all the way down to the estimated top of rock in accordance with the Drawings.

F. The Contractor shall take any preventive measures to ensure successful micropile installation through the proposed working platform at no additional cost to the Owner.

G. All installation techniques shall be determined and scheduled such that there will be no interconnection or damage to micropiles in which grout has not achieved final set.

H. Centralizers shall be provided at 10-foot maximum vertical spacing on central reinforcement. The uppermost centralizer shall be located a maximum of 5 feet from the top of the micropile. Centralizers shall permit the free flow of grout without misalignment of reinforcement.

I. Central reinforcement steel with centralizers shall be lowered into the stabilized drill holes to the desired depth without difficulty. Partially inserted reinforcing bars shall not be driven or forced into the hole.

J. The Contractor shall check micropile top elevations and adjust all installed micropiles to planned elevations.

3.02 GROUTING

A. The Contractor shall be responsible for the grout mix design that is suitable for the ground condition and effective to control the grout loss. The pro-production test micropile installation will be used to observe the suitability of the Contractor's grout mix design. If the grout mix result in excessive amount of grout loss or result in other grout issues, the Contractor shall change the grout mix design at no additional cost to the Owner. The Contractor shall be responsible for all grout quantity, including the grout loss amount.

B. The Contractor shall provide systems and equipment to measure the grout quality, quantity, and pumping pressure during the grouting operations. The grouting information is to be measured and recorded by the Contractor.

C. After drilling, the hole shall be flushed with water and/or air to remove drill cuttings and/or other loose debris.

D. The Contractor shall provide a stable, homogenous neat cement grout or a sand cement grout with a minimum 28-day unconfined compressive strength

of 4000 psi. The grout shall not contain lumps or any other evidence of poor or incomplete mixing. Admixtures, if used, shall be mixed in accordance with manufacturer's recommendations. The pump shall be equipped with a pressure gauge to monitor grout pressures. The pressure gauge shall be capable of measuring pressures of at least 150 psi or twice the actual grout pressures used by the Contractor, whichever is greater. The grouting equipment shall be sized to enable the grout to be pumped in one continuous operation. The grout should be kept in constant agitation prior to pumping.

E. The grout shall be injected from the lowest point of the drill hole (by tremie methods) until clean, pure grout flows from the top of the micropile. The tremie grout may be pumped through grout tubes, hollow stem augers, or drill rods. Subsequent to tremie grouting, all grouting operations associated with, for example, extraction of drill casing and pressure grouting, must ensure complete continuity of the grout column. The use of compressed air to directly pressurize the fluid grout is not permissible. The grout pressures and grout takes shall be controlled to prevent excessive heave in cohesive soils or fracturing of soil or rock formations. The entire pile shall be grouted to the design cut-off level.

F. Upon completion of grouting, the grout tube may remain in the hole, but it shall be filled with grout. Grout tubes shall be installed prior to the tremie grouting.

G. Grouting shall be performed within 24 hours upon completion of each micropile drill hole, unless otherwise approved by the Engineer.

H. Grout within the micropiles shall be allowed to attain the minimum design strength prior to being loaded.

I. If the Contractor uses a post-grouting system, all relevant details including grouting pressure, volume, location, and mix design, shall be submitted as part of Article Submittals.

J. Precautions shall be taken to prevent freezing of the grout when the temperature is 35 degrees or below.

3.03 MICROPILE SPLICES

A. Micropile splices shall be constructed to develop required design strength of the micropile section.

B. Lengths of casing and reinforcing steel to be spliced shall be secured in proper alignments and in such a manner that no eccentricity between the axes of the two lengths spliced or angle between them results.

3.04 MICROPILE LOAD TESTS

A. Pre-production Micropile Load Tests:

1. The purpose of the preproduction micropile load test is to: 1) verify the ultimate bond strength, 2) validate the Contractor's proposed drilling method and tooling, and 3) validate the Contractor's grout mix design and assess grout loss condition.
2. The Contractor shall perform load tests in the Engineer's presence. Notify the Engineer 7 days prior to performing each load test. Perform compression load testing in accord with ASTM D1143, except as modified herein.
3. One pre-production micropile load test on a sacrificial micropile shall be performed to verify adequacy of the micropile system design and proposed construction procedures prior to installation of production micropiles. The sacrificial micropile with dead weight, reaction micropiles, or ground anchors shall be constructed immediately prior to commencement of production micropile installation.
4. Installation of sacrificial micropiles shall not begin until shop drawings, work plan, grout mix, and load-test plan are approved.
5. The specific sacrificial micropile location shall be selected by the Contractor and approved by the Engineer. Drilling-and-grouting method, casing length and outside diameter, reinforcing bar lengths, and depth of bond zone for the sacrificial micropile shall be identical to production micropiles, except that top of pile may be extended to the existing grade and the tip of casing shall be determined by the Engineer in the field.
6. The Contractor shall confirm that sacrificial micropile structural steel sections are sized to safely resist the maximum test load. Maximum test loads applied to the micropile shall not exceed 80 percent of the structural capacity of micropile structural elements, to include steel yield in tension, steel yield or buckling in compression, or grout crushing in compression. Any required increase in strength of the test pile elements above the strength required for production piles shall be provided for in the Contractor's bid price.
7. Resistance from upper unbonded zone shall be minimized for the test micropile. For test micropile(s), four levels of strain gauges, with two strain gauges at each level, shall be installed at locations selected by the Engineer. Strain gauge reading shall be taken at each test load. The strain gauges shall be installed inside of casing or on the bar and properly protected.
8. Load cell and jack shall be maintained and calibrated with manufacturer-recommended calibration and maintenance. Load test instrumentation shall include four dial gauges at 90 degrees apart, along with two sets of backup scales, mirrors, and piano wires for measuring deflections. Additionally, a set of scale, mirror, and piano wire shall be installed for each reaction micropile.

9. Acceptable load and movement criteria are defined below.
10. The load test shall be performed to verify that the Contractor-installed micropiles will meet required maximum load capacities and load-test acceptance criteria and to verify that the length of micropile bond zone is adequate. Micropile verification load-test results must verify the Contractor's design and installation methods and be reviewed and accepted by the Engineer prior to beginning installation of production micropiles.
11. At the beginning of testing the jack shall be positioned such that unloading and repositioning the jack during the test will not be required. An alignment load (AL), if required, may be applied to the micropile prior to setting movement recording devices. This AL shall be no more than 10 percent of design load (DL). The dial gauges shall be zeroed at the first setting of AL.
12. Measurement of pile movement shall be recorded immediately before and after the following load increments are applied during the micropile load test. Axial micropile load tests shall be made by loading the micropile and recording micropile head movement in the following load increments.

Load	**Hold Time (Minutes)**
AL	-
0.15 DL	2.5
0.30 DL	2.5
0.45 DL	2.5
AL	1
0.15 DL	1
0.45 DL	1
0.60 DL	2.5
0.75 DL	2.5
0.90 DL	2.5
1.00 DL	2.5
AL	1
0.15 DL	1
1.00 DL	1
1.15 DL	2.5
1.30 DL	10 *
1.45 DL	2.5
AL	1
0.15 DL	1
1.45 DL	1
1.75 DL	2.5
1.9 DL	2.5
2.50 DL	10
1.50 DL	5
1.00 DL	5

Load	Hold Time (Minutes)
0.50 DL	5
AL	5
* Hold until meeting acceptance criterion 13.b, below. AL = Alignment load; DL = Maximum design compression load as shown on Drawings	

13. Acceptance criteria for micropile load tests are:
    a. The micropile shall sustain compression DL (1.0 DL) with no more than 0.3 inch total vertical movement at the top of the micropile as measured relative to the top of micropile prior to the start of testing. If an AL is used, then allowable movement will be reduced by multiplying by a factor of (DL-AL)/DL. This conservatively accounts for the movement in reaching AL.
    b. Test micropiles shall have a creep rate at the end of the 130 percent DL increment which is not greater than 0.040 inch per log cycle time from 1 to 10 minutes, or 0.080 inch per log cycle time from 6 to 60 minutes and has a linear or decreasing creep rate.
    c. Failure does not occur at the 2.5 DL maximum compression loads. Failure is defined as exceedance of 0.015 inch of deflection (at the end of a holding period) per kip of total applied load.
14. The Contractor shall provide a written report that includes the as-built micropile geometry and construction details within 7 working days after completion of the pre-production load test. This written report will either confirm adequacy of bond lengths shown on the Drawings or provide proposed modifications based on results of the pre-production load test.
15. When a micropile fails to meet acceptance criteria, the cause(s) shall be established and modifications shall be made to design, construction procedures, or both. The new system shall be retested, as directed by the Engineer. Modifications include, but are not limited to, installing replacement micropiles, modifying installation methods, increasing bond length, re-grouting via pre-placed re-grout tubes, or changing micropile type. Any modification that requires changes to micropile design and micropile structure shall have prior review and acceptance of the Owner or Owner's Engineer.
16. Upon completion of the test, the sacrificial micropile shall <u>not</u> be used as a foundation element of any structure.

3.05 FIELD QUALITY CONTROL

A. Grout Sampling and Testing:

1. During production, micropile grout shall be tested for 28-day compressive strength in accordance with ASTM C109 at a frequency of

no less than one set of 3 grout cubes from each grout plant each day of operation or per every 5 piles, whichever occurs more frequently. Compressive strength shall be the average of the 3 cubes tested.

2. Grout samples shall be representative for material in the pile.
3. Grout cube specimens will be made, cured, and tested by independent testing agency hired by the Owner.

B. Micropile installation logs shall be submitted within 24 hours of installation with all information hereinbefore-listed in this Specification.

C. Any unusual conditions encountered during micropile installation shall be immediately reported to the Engineer.

END OF SECTION

SECTION 32 11 23
AGGREGATE BASE AND SUBBASE COURSE(S)

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C29, Standard Test Method for Bulk Density (Unit Weight) and Voids in Aggregate.
   b. C88, Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
   c. C117, Standard Method of Test for Materials Finer Than 75μm (No. 200) Sieve in Mineral Aggregates by Washing.
   d. C131, Standard Specification for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   e. C183, Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates.
   f. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft^3 (600 kN-m/m^3)).
   g. D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lb/ft^3 (2700 kN-m/m^3)).
   h. D1883, Test Method for CBR (California Bearing Ratio) of Laboratory Compacted Soils.
   i. D2216, Standard Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
   j. D2419, Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
   k. D2844, Standard Specification for Resistance R-Value and Expansion Pressure of Compacted Soils.
   l. D4318, Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils.
   m. D4791, Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.
   n. D5195, Standard Test Methods for Density of Soil and Rock In-Place Below Surface by Nuclear Methods.
   o. D6938, Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.02 DEFINITIONS

A. Completed Course: Compacted, unyielding, free from irregularities, with smooth, tight, even surface, true to grade, line, and cross-section.

B. Completed Lift: Compacted with uniform cross-section thickness.

C. Base Course: Crushed aggregate or similar as specified placed and compacted on prepared subgrade or subbase course.

D. Gravel Surfacing: Aggregate used for construction of low-volume access and staging area that can be easily graded and compacted.

E. Leveling Course: Crushed aggregate placed and compacted on base course to be used for finish grading.

F. Standard Specifications: When referenced in this section, shall mean CT DOT Form 818

G. Subbase Course: Sandy, gravelly material placed and compacted on prepared subgrade.

1.03 SUBMITTALS

A. Informational Submittals:

1. Certified Test Results on Source Materials: Submit copies from commercial testing laboratory 20 days prior to delivery of materials to Project showing materials meeting the physical qualities specified.
2. Certified results of in-place density tests from independent testing agency.

PART 2 PRODUCTS

2.01 SUBBASE COURSE

A. As specified in Section 2.12 and M.02.02 of the Standard Specifications.

2.02 BASE COURSE

A. As specified in Section 3.04 and M.05.01 of the Standard Specifications.

B. Clean, hard durable, pit run gravel or crushed stone graded from coarse to fine containing enough fines to bind material when compacted.

C. Physical Qualities:

1. Abrasion, ASTM C131: 35 percent maximum wear.
2. Fractured Face: 75 percent minimum particles.
3. Liquid Limit, ASTM D4318: Maximum 30 percent.
4. Plasticity Index, ASTM D4318: Maximum 6 percent. Nonplastic.
5. Sand Equivalency, ASTM D2419: 35 percent, minimum.
6. Resistance (R) Value, ASTM D2844: 75 percent, minimum.
7. CBR Value, ASTM D1883: 100 percent, minimum.
8. Soundness, ASTM C88: 12 percent, maximum.
9. Flat and Elongated Particles, ASTM D4791: 8 percent, maximum.

2.03 **LEVELING COURSE AND GRAVEL SURFACING**

A. As specified in Section 3.04 of the Standard Specifications.

2.04 SOURCE QUALITY CONTROL

A. Perform tests necessary to locate acceptable source of materials meeting specified requirements.

B. Final approval of aggregate material will be based on test results of installed materials.

C. Should separation of coarse from fine materials occur during processing or stockpiling, immediately change methods of handling materials to correct uniformity in grading.

PART 3 EXECUTION

3.01 SUBGRADE PREPARATION

A. As specified in Section 2.09 of the Standard Specifications.

B. Obtain Engineer’s acceptance of subgrade before placing base course or surfacing material.

C. Do not place base course or surfacing materials snow or on soft, muddy, or frozen subgrade.

3.02 EQUIPMENT

A. In accordance with Section 2.09.03 of the Standard Specifications.

B. Compaction Equipment: Adequate in design and number to provide compaction and to obtain specified density for each layer.

3.03 HAULING AND SPREADING

A. Hauling Materials:

1. Do not haul over surfacing in process of construction.
2. Loads: Of uniform capacity.
3. Maintain consistent gradation of material delivered; loads of widely varying gradations will be cause for rejection.

B. Spreading Materials:

1. Distribute material to provide required density, depth, grade, and dimensions with allowance for subsequent lifts.
2. Produce even distribution of material upon roadway or prepared surface without segregation.
3. Should segregation of coarse from fine materials occur during placing, immediately change methods of handling materials to correct uniformity in grading.

3.04 CONSTRUCTION OF COURSES

A. Construction of Courses: In accordance with Section 2.12 and 3.04 of the Standard Specifications.

3.05 ROLLING AND COMPACTION

A. In accordance with Section 2.12 and 3.04 of the Standard Specifications.

B. Commence rolling at outer edges and continue toward center; do not roll center of road first.

C. Apply water as needed to obtain specified densities.

D. Place and compact each lift to the required density before succeeding lift is placed.

E. Surface Defects: Remedy by loosening and rerolling. Reroll entire area, including surrounding surface, until thoroughly compacted.

F. Finished surface shall be true to grade and crown before proceeding with surfacing.

3.06 SURFACE TOLERANCES

A. Blade or otherwise work surfacing as necessary to maintain grade and cross-section at all times, and to keep surface smooth and thoroughly compacted.

B. Finished Surface of Untreated Aggregate Base Course: Within plus or minus 0.04 foot of grade shown at any individual point.

C. Gravel Surfacing: Within 0.04 foot from lower edge of 10-foot straightedge placed on finished surface, parallel to centerline.

D. Overall Average: Within plus or minus 0.01 foot from crown and grade specified.

3.07 DRIVEWAY RESURFACING

A. Replace gravel surfacing on driveways that were gravel surfaced prior to construction.

B. Provide compacted gravel surfacing to depth equal to original, but not less than 4 inches.

C. Leave each driveway in as good or better condition as it was before start of construction.

3.08 FIELD QUALITY CONTROL

A. In-Place Density Tests:

1. Provide testing laboratory and Engineer at least 24 hours' advance notification prior to testing.
2. Show proof that areas meet specified requirements before identifying density test locations.
3. Refer to Table 2 for minimum sampling and testing requirements for aggregate base course and surfacing.

Table 2
Minimum Sampling and Testing Requirements

Property	Test Method	Frequency	Sampling Point
Gradation	ASTM C117and ASTM C183	One sample every 500 tons but at least every 4 hours of production	Roadbed after processing
Moisture Density (Maximum Density)	AASHTO T 99, T 180	One test for every aggregate grading produced	Production output or stockpile

Table 2 Minimum Sampling and Testing Requirements			
Property	**Test Method**	**Frequency**	**Sampling Point**
In-Place Density and Moisture Content	ASTM D5195, ASTM D6938, and ASTM D2216 for moisture content	One for each 500 ton but at least every 10,000 sq ft of area	In-place completed, compacted area

3.09 CLEANING

A. Remove excess material from the Work area. Clean stockpile and staging areas of all excess aggregate.

END OF SECTION

SECTION 32 12 16
ASPHALT PAVING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. M17, Standard Specification for Mineral Filler for Bituminous Paving Mixtures.
   b. M81, Standard Specification for Cut-Back Asphalt (Rapid Curing Type).
   c. M82, Standard Specification for Cut-Back Asphalt (Medium Curing Type).
   d. M140, Standard Specification for Emulsified Asphalt.
   e. M156, Standard Specification for Requirements for Mixing Plants for Hot-mixed, Hot-laid Bituminous Paving Mixes.
   f. M208, Standard Specification for Cationic Emulsified Asphalt.
   g. R35, Standard Practice for Superpave Volumetric Design for Hot Mix Asphalt.
   h. T166, Standard Method of Test for Bulk Specific Gravity (Gmb) of Compacted Hot Mix Asphalt (HMA) Mixtures Using Saturated Surface-Dry Specimens.
   i. T176 Standard Method of Test for Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test.
   j. T209, Standard Method of Test for Theoretical Maximum Specific Gravity (Gmm) and Density of Hot Mix Asphalt (HMA).
   k. T245, Standard Method of Test for Resistance to Plastic Flow of Asphalt Mixtures Using Marshall Apparatus.
   l. T246, Standard Method of Test for Resistance to Deformation and Cohesion of Hot Mix Asphalt (HMA) by Means of Hveem Apparatus.
   m. T247, Standard Method of Test for Preparation of Test Specimens of Hot Mix Asphalt (HMA) by Means of California Kneading Compactor.
   n. T283, Standard Method of Test for Resistance of Compacted Hot Mix Asphalt (HMA) to Moisture-Induced Damage.
   o. T304, Standard Method of Test for Uncompacted Void Content of Fine Aggregate.
   p. T312, Standard Method of Test for Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of a Superpave Gyratory Compactor.

2. Asphalt Institute (AI):
    a. Manual Series No. 2 (MS-2), Mix Design Methods for Asphalt Concrete.
    b. Superpave Series No. 2 (SP-2), Superpave Mix Design.
3. ASTM International (ASTM):
    a. D75, Standard Method of Test for Sampling of Aggregates.
    b. D140, Standard Method of Test for Sampling Bituminous Materials.
    c. D979, Standard Method of Test for Sampling Bituminous Paving Mixtures.
    d. D2041, Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures.
    e. D2489, Standard Method of Test for Determining Degree of Particle Coating of Asphalt Mixtures.
    f. D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
    g. D4791, Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.
    h. D5821, Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate.
    i. E329 REV A, Standard Specification for Agencies Engaged in Construction Inspection Testing, or Special Inspection.

1.02 DEFINITIONS

A. Combined Aggregate: All mineral constituents of asphalt concrete mix, including mineral filler and separately sized aggregates.

B. Maximum Aggregate Size: One sieve size larger than the nominal aggregate size.

C. Nominal Aggregate Size: One sieve size larger than the first sieve that retains more than 10 percent aggregate.

D. Prime Coat: Low viscosity cutback or emulsified asphalt applied to granular base in preparation of paving to coat and bond loose materials, harden the surface, plug voids, prevent moisture migration, and provide adhesion.

E. Reclaimed asphalt pavement (RAP): Removed and/or processed pavement materials containing binder and aggregate.

F. Seal Coat: Term used for various applications of emulsified asphalt, with or without sand or aggregate, to protect the asphalt surface from aging due to wear, degradation from the sun, wind, and water. Also used to improve skid resistance and aesthetics. The term seal coat can be used to define fog seal, slurry seal, chip seal or sand seal, depending on application.

G. Standard Specifications: State of Connecticut Department of Transportation Standard Specifications for Roads, Bridges, Facilities, and Incidental Construction Form 818 with Supplemental Specifications dated January 2022

H. Tack Coat: Thin layer of emulsified asphalt applied to hard surfaces, including new pavement lifts, to promote adhesion and bonding.

1.03 DESIGN REQUIREMENTS

A. Prepare asphalt concrete mix design, meeting the following design criteria, tolerances, and other requirements of this specification.

B. Design Criteria: All Bituminous Materials as defined in the Standard Specification Section M.04.

C. Furnished Mix Tolerances: Conform to asphalt concrete mix formula within the following, plus or minus:

1. Aggregate Passing No. 4 (4.76 millimeter) and Larger Sieves: 5 percent.
2. Aggregate Passing the No. 8 (2.38 millimeter) to No. 100 (150 μm) Sieves: 4 percent.
3. Aggregate Passing the No. 200 (75 μm) Sieve: 2 percent.
4. Bitumen Content: 0.3 percent of volume or batch weight of aggregate.
5. Temperature Leaving Mixer: 20 degrees F (11 degrees C).
6. Temperature in Paving Machine Hopper: 20 degrees F (11 degrees C).

1.04 SUBMITTALS

A. Action Submittals:

1. Samples: Sample per ASTM D140 and ASTM D195.

B. Informational Submittals:

1. Asphalt Concrete Mix Formula:
   a. Submit minimum of15 days prior to start of production.
   b. Submittal to include the following information:
      1) Gradation and portion for each aggregate constituent used in mixture to produce a single gradation of aggregate within specified limits.
      2) Bulk specific gravity for each aggregate constituent.
      3) Measured maximum specific gravity of mix at optimum asphalt content determined in accordance with ASTM D2041.
      4) Properties as stated in Section M.04 of the Standard Specifications, for at least four different asphalt contents other than optimum, two below optimum, and two above optimum.

2. Test Report for Asphalt Cement:
    a. Submit minimum 10 days prior to start of production.
    b. Show appropriate test method(s) for each material and the test results.
3. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, for the following materials:
    a. Aggregate: Gradation, source test results as defined in Section M.04 of the Standard Specifications.
    b. Asphalt for Binder: Type, grade, and viscosity-temperature curve.
    c. Prime Coat: Type and grade of asphalt.
    d. Tack Coat: Type and grade of asphalt.
    e. Additives.
    f. Mix: Conforms to job-mix formula.
4. Statement of qualification for independent testing laboratory.
5. Test Results:
    a. Mix design.
    b. Asphalt concrete core.
    c. Gradation and asphalt content of uncompacted mix.
    d. Field density.
    e. Quality control.

1.05 QUALITY ASSURANCE

A. Qualifications:

1. Independent Testing Laboratory: In accordance with ASTM E329 REV A.
2. Asphalt concrete mix formula shall be prepared by approved certified independent laboratory under the supervision of a certified asphalt technician.

B. Compaction Control Strip:

1. General:
    a. Construct to approximately 400 square yards in area and at location that will become a portion of completed paved area.
    b. Thickness: Typical of thickness to be paved on Project.
2. Rollers Used for Compaction:
    a. Steel Wheel Rollers: Minimum static weight 10 tons (9 mg).
    b. Pneumatic Rollers: Capable of exerting pressure of 80 psi (550 kPa) on bituminous surface.
    c. Vibratory Rollers: Static weight minimum 6 tons (5.5 mg), capable of applying a 10-ton (9-mg) impact force equipped with amplitude and frequency control specifically designed for compaction of bituminous mixtures.

3. Compaction:
    a. Compact bituminous mat, using a standard rolling pattern that covers entire control strip. Request that Testing Laboratory performs final density test.
    b. Continue rolling until no further compaction can be obtained as determined by field density testing.
    c. Temperature and condition of bituminous mat shall be considered workable when further compaction can no longer be obtained.
4. Target Density Determination:
    a. Select test point near center of normal roller pass, but no closer than 2 feet (600 millimeters) from edge of mat and 50 feet (15 meters) from either end of control strip. Mat thickness at this point shall be at least depth of finished pavement.
    b. Point at which no further densification can be obtained.
5. Establish new target density if change is made in mix design, nominal depth of mat being placed, aggregate source, or material properties.

1.06 ENVIRONMENTAL REQUIREMENTS

A. Temperature: Do not apply asphalt materials or place asphalt mixes when ground temperature is lower than 50 degrees F (10 degrees C) or air temperature is lower than 40 degrees F (4 degrees C). Measure ground and air temperature in shaded areas away from heat sources or wet surfaces.

B. Moisture: Do not apply asphalt materials or place asphalt mixes when application surface is wet.

PART 2 PRODUCTS

2.01 MATERIALS

A. Prime Coat: Cutback asphalt, conform to Section M.04.01-5(b) of the Standard Specifications.

B. Tack Coat:

1. Emulsified Asphalt for Tack Coat or Seal Coat: conform to Section M.04.01-5(b) of the Standard Specifications.

2.02 ASPHALT CONCRETE MIX

A. General: Mix formula shall not be modified except with written approval of Engineer.

1. Source Changes:
   a. Should material source(s) change, establish new asphalt concrete mix formula before new material(s) is used.
   b. Perform check tests of properties of plant-mix bituminous materials on first day of production and as requested by Engineer to confirm that properties are in compliance with design criteria.
   c. Make adjustments in gradation or asphalt content as necessary to meet design criteria.

B. Asphalt Concrete: as specified in the plans and Section M.04 of the Standard Specifications.

C. Composition: Hot-plant mix of aggregate, mineral filler if required, and paving grade asphalt cement. The several aggregate fractions shall be sized, uniformly graded, and combined in such proportions that resulting mixture meets grading requirements of mix formula.

D. Aggregate:

1. General: As specified in Section M.01 of the Standard Specifications

PART 3 EXECUTION

3.01 GENERAL

A. Traffic Control:

1. In accordance with Section 01 50 00, Temporary Facilities and Controls.
2. Minimize inconvenience to traffic but keep vehicles off freshly treated or paved surfaces to avoid pickup and tracking of asphalt.

B. Driveways: Repave driveways from which pavement was removed. Leave driveways in as good or better condition than before start of construction.

3.02 LINE AND GRADE

A. Provide and maintain intermediate control of line and grade, independent of underlying base, to meet finish surface grades and minimum thickness.

B. Shoulders: Construct to line, grade, and cross-section shown.

3.03 APPLICATION EQUIPMENT

A. In accordance with Section 4.06 of the Standard Specifications.

3.04 PREPARATION

A. Prepare subgrade as specified in Section 2.09 of the Standard Specifications.

B. Existing Roadway:

1. Modify profile by grinding, milling, or overlay methods as approved, to provide meet lines and surfaces and to produce smooth riding connection to existing facility.
2. Remove existing material to a minimum depth of 1 inch (25 millimeters).
3. Paint edges of meet line with tack coat prior to placing new pavement.

C. Thoroughly coat edges of contact surfaces (curbs, manhole frames) with emulsified asphalt or asphalt cement prior to laying new pavement. Prevent staining of adjacent surfaces.

3.05 PAVEMENT APPLICATION

A. General: Place asphalt concrete mixture on approved, prepared base in conformance with Section 3.04 of the Standard Specifications.

B. Prime Coat:

1. Heat cutback asphalt prior to application.
2. Apply uniformly to clean, dry surfaces avoiding overlapping of applications.
3. Do not apply when moisture content of upper 3 inches (75 millimeters) of base exceeds optimum moisture content of base, or if free moisture is present.
4. Application Rate: 0.15 gallon to 0.50 gallon per square yard (70 liters to 2.28 liters per square meter) of surface area.
5. Remove or redistribute excess material.
6. Allow a minimum of 5 full days for curing of primed surface before placing asphalt concrete.

C. Tack Coat:

1. Apply uniformly to clean, dry surfaces avoiding overlapping of applications.
2. Do not apply more tack coat than necessary for the day’s paving operation.
3. Touch up missed or lightly coated surfaces and remove excess material.

4. Application Rate:
    a. 0.05 gallon per square yard to 0.15 gallon per square yard (0.25 liter per square meter to 0.70 liter per square meter) of asphalt (residual if diluted emulsified asphalt).
    b. Apply at rate, within range specified, sufficient to assure good bonding, but not so heavy that surplus asphalt flushes into asphalt concrete being placed.

D. Pavement Mix:

1. Prior to Paving:
    a. Sweep primed surface free of dirt, dust, or other foreign matter.
    b. Patch holes in primed surface with asphalt concrete pavement mix.
    c. Blot excess prime material with sand.
2. Place asphalt concrete pavement mix in accordance with the plans.
3. Compacted Lift Thickness:
    a. Minimum: Twice maximum aggregate size, but in no case less than 1 inch (25 millimeters).
    b. Maximum: 4 inches (100 millimeters).
4. Total Compacted Thickness: as shown in the plans.
5. Sequence placement so that meet lines are straight and edges are vertical.
6. Collect and dispose of segregated aggregate from raking process. Do not scatter material over finished surface.
7. Joints:
    a. Offset edge of each layer a minimum of 6 inches (150 millimeters) so joints are not directly over those in underlying layer.
    b. Offset longitudinal joints in roadway pavements so longitudinal joints in wearing layer coincide with pavement centerlines and lane divider lines.
    c. Form transverse joints by cutting back on previous day's run to expose full vertical depth of layer.
8. Succeeding Lifts: Apply tack coat to pavement surface between each lift.
9. After placement of pavement, seal meet line by painting a minimum of 6 inches (150 millimeters) on each side of joint with cutback or emulsified asphalt. Cover immediately with sand.

E. Compaction: In accordance with Section 4.06 of the Standard Specifications.

F. Tolerances:

1. General: Conduct measurements for conformity with crown and grade immediately after initial compression. Correct variations immediately by removal or addition of materials and by continuous rolling.
2. Completed Surface or Wearing Layer Smoothness:
   a. Uniform texture, smooth, and uniform to crown and grade.
   b. Maximum Deviation: 1/8 inch from lower edge of a 12-foot (3.6-meter) straightedge, measured continuously parallel and at right angle to centerline.
   c. If surface of completed pavement deviates by more than twice specified tolerances, remove and replace wearing surface.
3. Transverse Slope Maximum Deviation: 1/4 inch in 12 feet (3.6 meters) from rate of slope shown.
4. Finished Grade:
   a. Perform field differential level survey on maximum 50-foot grid and along grade breaks.
   b. Maximum Deviation: 0.02 foot (6 millimeters) from grade shown.

G. Seal Coat:

1. General: Apply seal coat of paving grade or emulsified asphalt to finished surface at longitudinal and transverse joints, joints at abutting pavements, areas where asphalt concrete was placed by hand, patched surfaces, and other areas as directed by Engineer.
2. Preparation:
   a. Surfaces that are to be sealed shall be maintained free of holes, dry, and clean of dust and loose material.
   b. Seal in dry weather and when temperature is above 35 degrees F (2 degrees C).
3. Application:
   a. Fill cracks over 1/16 inch (1.5 millimeters) in width with asphalt-sand slurry or approved crack sealer prior to sealing.
   b. When sealing patched surfaces and joints with existing pavements, extend minimum 6 inches (150 millimeters) beyond edges of patches.

3.06 PAVEMENT OVERLAY

A. Preparation:

1. Remove fatty asphalt, grease drippings, dust, and other deleterious matter.
2. Surface Depressions: Fill with asphalt concrete mix, and thoroughly compact.
3. Damaged Areas: Remove broken or deteriorated asphalt concrete and patch as specified in Article Patching.

4. Portland Cement Concrete Joints: Remove joint filler to minimum 1/2 inch (12 millimeters) below surface.

B. Application:

1. Tack Coat: As specified in this section.
2. Place and compact asphalt concrete as specified in Article Pavement Application.
3. Place first layer to include widening of pavement and leveling of irregularities in surface of existing pavement.
4. When leveling irregular surfaces and raising low areas, the actual compacted thickness of any one lift shall not exceed 2 inches (50 millimeters).
5. Actual compacted thickness of intermittent areas of 120 square yards (100 square meters) or less may exceed 2 inches (50 millimeters), but not 4 inches (100 millimeters).
6. Final wearing layer shall be of uniform thickness, and meet grade and cross-section as shown.

3.07 FIELD QUALITY CONTROL

A. General: Provide services of approved certified independent testing laboratory to conduct tests.

B. Field Density Tests:

1. Perform tests from cores or sawed samples in accordance with AASHTO T166.
2. Measure with properly operating and calibrated nuclear density gauge in accordance with ASTM D2950.
3. Maximum Density: In accordance with ASTM D2041, using sample of mix taken prior to compaction from same location as density test sample.

C. Testing Frequency:

1. Quality Control Tests:
   a. Asphalt Content, Aggregate Gradation: Once per every 500 tons (400 mg) of mix or once every 4 hours, whichever is greater.
   b. Mix Design Properties, Measured Maximum (Rice's) Specific Gravity: Once every 1,000 tons (900 mg) or once every 8 hours, whichever is greater.
2. Density Tests: Once every 500 tons (450 mg) of mix or once every 4 hours, whichever is greater.

END OF SECTION

SECTION 32 31 13
CHAIN LINK FENCES AND GATES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A121, Standard Specification for Metallic-Coated Carbon Steel Barbed Wire.
   b. A313/A313M, Standard Specification for Stainless Steel Spring Wire.
   c. A392, Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.
   d. A491, Standard Specification for Aluminum-Coated Steel Chain-Link Fence Fabric.
   e. A497/A497M, Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.
   f. A615/A615M, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   g. A780, Standard Specification for Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings.
   h. A824, Standard Specification for Metallic-Coated Steel Marcelled Tension Wire for Use with Chain Link Fence.
   i. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
   j. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   k. C150, Standard Specification for Portland Cement.
   l. C387, Standard Specifications for Packaged, Dry, Combined Materials for Mortar and Concrete.
   m. F552, Standard Terminology Relating to Chain Link Fencing.
   n. F567, Standard Practice for Installation of Chain-Link Fence.
   o. F626, Standard Specification for Fence Fittings.
   p. F668, Standard Specification for Polyvinyl Chloride (PVC) and Other Organic Polymer-Coated Steel Chain-Link Fence Fabric.
   q. F900, Standard Specification for Industrial and Commercial Swing Gates.
   r. F934, Standard Specification for Standard Colors for Polymer-Coated Chain Link Fence Materials.
   s. F1043, Standard Specification for Strength and Protective Coatings on Metal Industrial Chain Link Fence Framework.
   t. F1083, Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures.

u. F1183, Standard Specifications for Aluminum Alloy Chain Link Fence Fabric.
v. F1184, Standard Specifications for Industrial and Commercial Horizontal Slide Gates.
w. F1379, Standard Terminology Relating to Barbed Tape.
x. F1911, Standard Practice for Installation of Barbed Tape.
y. F1916, Standard Specification for Selecting Chain Link Barrier Systems with Coated Chain Link Fence Fabric and Round Posts for Detention Applications.

2. Institute of Electrical and Electronic Engineers (IEEE), Inc.: C2, National Electrical Safety Code.
3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 volts max.).

1.02 DEFINITIONS

A. Terms as defined in ASTM F552.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product Data: Include construction details, material descriptions, dimensions of individual components, and finishes for chain link fences and gates.
      1) Fence, gate posts, rails, and fittings.
      2) Chain link fabric.
      3) Gates and hardware.
      4) Gate operators, motors, and mounting arrangements, switches, and controls; include operating instructions.
      5) Gate access system, including access control features, power and control wiring diagrams, and operating instructions.
      6) Accessories: Barbed wire.
2. Samples:
   a. Chain Link Fabric: Approximately 6 inches square.
   b. Posts, Rails, Braces, Wire, and Ties: Approximately 6 inches long.
   c. Fittings: 1 each.
   d. PVC or Polymer Coated Fabric Including Manufacturer’s Color Selections: Approximately 6 inches square.
   e. Privacy Slats Including Manufacturer’s Color Selections: Approximately 6 inches long.
3. Test Reports: Field test result for compliance of installation of chain link fence, gates, and gate operators.

B. Informational Submittals:

1. Manufacturer's recommended installation instructions.
2. Evidence of Supplier and installer qualifications.
3. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Automatic Gate Operator System Supplier: 5 years' experience in gate operator systems.
2. Automatic Gate Operator System Installer: Experienced installer who has completed chain link fences and gates similar in material, design, and extent to those indicated for Project and whose work has resulted with a record of successful in-service performance with a minimum 3 years' experience.

B. Design, supply of equipment and components, installation, and on-call service shall be product of individual company with record of installations meeting requirements specified.

C. Preinstallation Conference: Conduct conference at project Site with gate installer to verify layout and operations of automatic gate operating system.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Site in undamaged condition. Store materials off the ground to provide protection against oxidation caused by ground contact.

1.06 SCHEDULING AND SEQUENCING

A. Complete necessary Site preparation and grading before installing chain link fence and gates.

B. Interruption of Existing Utility Service: Notify owner of utility 72 hours prior to interruption of utility services. Do not proceed with interruption of utility service without written permission from utility owner.

1.07 SPECIAL GUARANTEE

A. Provide manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of the following items found defective during a period of 5 years after the date of Substantial Completion. Duties and obligations for correction or removal

and replacement of defective Work shall be as specified in the General Conditions.

1. Faulty operations of gate operators and controls.
2. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
3. Deflection of fence fabric beyond limits.

PART 2 PRODUCTS

2.01 GENERAL

A. Match style, finish, and color of each fence component with that of other fence components.

2.02 CHAIN LINK FENCE FABRIC

A. Galvanized fabric conforming to ASTM A392, Type II, Class 1, 1.2 ounces per square foot galvanized after weaving.

B. PVC-coated or Polymer-coated galvanized fabric conforming to ASTM F668, Class 1 or Class 2a over metallic-coated steel wire.

C. Aluminum-coated fabric conforming to ASTM A491, Type I, 0.4 ounce per square foot may be substituted for galvanized fabric.

D. Aluminum-alloy fabric conforming to ASTM F1183, with mill finish, may be substituted for galvanized fabric.

E. Height: 72 inches, unless otherwise shown.

F. Core Wire Gauge: No. 6.

G. Pattern: 2-inch diamond-mesh.

H. Diamond Count: Manufacturer’s standard and consistent for fabric furnished of same height.

I. Loops of Knuckled Selvages: Closed or nearly closed with space not exceeding diameter of wire.

J. Wires of Twisted Selvages:

1. Twisted in a closed helix three full turns.
2. Cut at an angle to provide sharp barbs that extend minimum 1/4 inch beyond twist.

2.03 POSTS

A. General:

1. Strength and Stiffness Requirements: ASTM F1043, heavy, industrial fence, except as modified in this section.
2. Round Steel Pipe, Schedule 40: ASTM F1083.
3. Roll-Formed Steel Shapes: Roll-formed from ASTM A1011/A1011M, Grade 45, High-Strength Low-Alloy steel.
4. Lengths: Manufacturer's standard with allowance for minimum embedment below finished grade of 34 inches.
5. Protective Coatings:
   a. Zinc Coating: ASTM F1043, Type A external and internal coating.
   b. Zinc with Polymer Film Coating: ASTM F1043, Type B external and internal coating.
   c. Zinc-5 Percent Aluminum-Mischmetal Alloy Coating: ASTM F1043, Type C external and internal coating.
   d. Zinc with Polymer Film Exterior Coating and Zinc Pigmented Interior Coating: ASTM F1043, Type B external coating, Type D interior coating.
6. Color Coating: ASTM F1043, minimum 10 mils thickness over zinc coating to match color of chain link fabric.

B. Line Posts:

1. Round Steel Pipe:
   a. Outside Diameter: 2.375 inches.
   b. Weight: 3.65 pounds per foot.
2. Roll-Formed Steel C Shape:
   a. Outside Dimensions: 2.25 inches by 1.625 inches.
   b. Weight: 2.70 pounds per foot.
3. Steel H-Section:
   a. Outside Dimensions: 2.25 inches by 1.70 inches.
   b. Weight: 3.26 pounds per foot.

C. End, Corner, Angle, and Pull Posts:

1. Round Steel Pipe:
   a. Outside Diameter: 2.875 inches.
   b. Weight: 5.79 pounds per foot.
2. Roll-Formed Steel Shape:
   a. Outside Dimensions: 3.5 inches by 3.5 inches.
   b. Weight: 5.10 pounds per foot.

D. Posts for Removable Fence Panels: As specified for end, corner, angle, and pull posts.

E. Posts for Swing Gates 8 Feet High and Under:

1. ASTM F900.
2. Round Steel Pipe:
   a. Outside Diameter: 4 inches.
   b. Weight: 9.12 pounds per foot.

F. Posts for Swing Gates Over 8 Feet High: As recommended by fence manufacturer.

G. Posts for Horizontal Sliding Gates:

1. ASTM F1184, Type II, Class 1.
2. Round Steel Pipe:
   a. Outside Diameter: 4 inches.
   b. Weight: 9.12 pounds per foot.
3. Guide posts for Class 1 horizontal-slide gates, equal gate post height, one size smaller, but weight is not less than 3.11 pounds per foot, installed adjacent to gate post to permit gate to slide in space between.

2.04 TOP AND BRACE RAILS

A. Galvanized Round Steel Pipe:

1. ASTM F1083.
2. Outside Diameter: 1.66 inches.
3. Weight: 2.27 pounds per foot.

B. Galvanized Roll-Formed Steel C Shapes:

1. Roll formed from ASTM A1011/A1011M, Grade 45.
2. Outside Dimensions: 1.625 inches by 1.25 inches.
3. Weight: 1.40 pounds per foot.

C. Protective Coatings: As specified for posts.

D. Color Coating: ASTM F1043, minimum 10-mil thickness over zinc coating to match color of chain link fabric.

E. Strength and Stiffness Requirements: ASTM F1043, top rail, heavy, industrial fence.

2.05 FENCE FITTINGS

A. General: In conformance with ASTM F626, except as modified by this article.

B. Post and Line Caps: Designed to accommodate passage of top rail through cap, where top rail required.

C. Tension and Brace Bands: No exceptions to ASTM F626.

D. Tension Bars:

1. One-piece vinyl-clad.
2. Length not less than 2 inches shorter than full height of chain link fabric.
3. Provide one bar for each gate and end post, and two for each corner and pull post.

E. Truss Rod Assembly: 3/8-inch diameter, steel, hot-dip galvanized after threading rod and turnbuckle or other means of adjustment.

F. Tie Wires, Clips, and Fasteners: According to ASTM F626.

G. Barbed Wire Supporting Arms: Aluminum Alloy 360 with clips, slots, or other means for attaching strands of barbed wire integral with post cap for each post, with single 45-degree arms for supporting 3 strands of barbed wire. Arms shall withstand 250 pounds of downward pull at outermost ends of the arms without failure.

2.06 TENSION WIRE

A. Zinc-coated steel marcelled tension wire conforming to ASTM A824, Type II, Class 2.

2.07 BARBED WIRE

A. Zinc-Coated Barbed Wire: ASTM A121, Chain Link Fence Grade:

1. Line Wire: Two strands of No. 12-1/2 gauge.
2. Barbs:
   a. Number of Points: Four.
   b. Length: 3/8 inch minimum.
   c. Shape: Round.
   d. Diameter: No. 14 gauge.
   e. Spacing: 5 inches.

2.08 GATES

A. General:

1. Gate Operation: Opened and closed easily by one person.
2. Metal Pipe and Tubing: Galvanized steel. Comply with ASTM F1043 and ASTM F1083 for materials and protective coatings.
3. Frames and Bracing: Fabricate members from round galvanized steel tubing with outside dimension and weight according to ASTM F900.

4. Gate leaves more than 8-feet wide shall have intermediate tubular members and diagonal truss rods to provide rigid construction, free from sag or twist.
5. Gate Fabric Height: Same as for adjacent fence height.
6. Welded Steel Joints: Paint with zinc-based paint.
7. Chain Link Fabric: Attached securely to gate frame at intervals not exceeding 15 inches.
8. Gate Posts and Frame Members: Extend gateposts and frame end members above top of chain-link fabric at both ends of gate frame to attach barbed wire assemblies.
9. Latches: Arranged for padlocking so padlock will be accessible from both sides of gate.

B. Swing Gates: Comply with ASTM F900 for single and or double swing gate types.

1. Leaf Width: As shown.
2. Hinges: Offset type, malleable iron.
   a. Furnished with large bearing surfaces for clamping in position.
   b. Designed to swing either 180 degrees outward, 180 degrees inward, or 90 degrees in or out, as shown, and not twist or turn under action of gate.
3. Latches: Plunger bar arranged to engage stop, except single gates of openings less than 10 feet wide may each have forked latch.
4. Gate Stops: Mushroom type or flush plate with anchors, suitable for setting in concrete.
5. Locking Device and Padlock Eyes: Integral part of latch, requiring one padlock for locking both leaves of double gate.
6. Hold-Open Keepers: Designed to automatically engage gate leaf and hold it in open position until manually released.

C. Cantilever Horizontal Sliding Gates:

1. Comply with ASTM F1184 for single slide gate types II Class 1 with external roller assemblies.
2. Cantilever Gate Support Posts: Spaced on maximum 10-foot centers.
3. Overhead Track Assembly: Manufacturer’s standard track, with overhead framing supports, bracing, and accessories, designed to support size, weight, width, operation, and design of gate and roller assemblies.
4. Roller Guards: As required per ASTM F1184 for Type II, Class 1 gate.
5. Hangers, roller assemblies, and stops fabricated from galvanized malleable iron.

D. Rolling Gate:

1. Track Rollers: Malleable iron or heavy pressed steel with provision for grease lubrication.
2. Ground Rollers: Malleable iron or heavy pressed steel with provision for grease lubrication.
3. Support Posts: Spaced on maximum 7-foot centers.
4. Gates more than 8 feet in height shall have three tracks.
5. Frames: ASTM F1184, Type I.
6. Gate Accessories: ASTM F1184.

2.09 GATE OPERATOR SYSTEM

A. General: Provide factory-assembled automatic operating system designed for gate size, type, weight, and operation frequency. Provide operation control system with characteristics suitable for Project conditions, safety devices, and weatherproof enclosures; coordinate electrical requirements with Division 26, Electrical.

1. Provide operator designed so motor may be removed without disturbing limit-switch adjustment and without affecting auxiliary emergency operator.
2. Provide operator with UL approved components.
3. Provide electronic components with built-in troubleshooting diagnostic feature.
4. Provide unit designed and wired for both right-hand/left-hand opening, permitting universal installation.

B. Motor Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, within installed environment, with indicated operating sequence, and without exceeding nameplate rating or considering service factor.

C. Gate Operator:

1. Heavy-duty, high frequency, electrical models designed to open and close gates provided.
2. For each gate, supply manufacturer of gate operator with complete details of gate, hardware, track rollers, adjacent fence posts, and fence construction for development and detailing of gate operator.
3. Furnish with following features:
    a. Metal enclosure, including attachments shall be constructed with finish and design suitable for exterior installation in all-weather environment.
    b. Minimum 1-hp motor, 208V ac, three-phase, 60-Hz electric power, reversible.
    c. Electric motor driven hydraulic power pack with hard rubber wheels in contact with operating type secured to gate.

Transmission of opening or closing forces to gate shall be by rotation of wheels against operating type.

d. Positive limit switch, to sense position of gate and provide control to prevent damage to gate operator.
e. NEMA 250, Type 12 enclosure for motor control components.
f. Motor Overload Protection: Industrial quality with manual reset.
g. 24V ac control circuit to power remote control gate activation devices.
h. Manual operation feature or disconnect, without use of tools, for easy operation during power failure, malfunction, or emergency.
i. Aluminum drive rail designed for attachment to sliding gate in manner that reinforces gate assembly.
j. Gate Travel Speed:
    1) Minimum 1 foot per second.
    2) Speed adjusting feature that provides range of appropriate speeds for slide gate operation is acceptable but not required.
    3) Maximum Gate Weight: 3,000 pounds.
    4) Frequency of Use: 10 cycles per hour.
    5) Operating Type: Wheel and drive with manual release.
k. Compatible with gate operator control devices provided.

4. Manufacturers:
    a. Hy-Security Gate Operator, Seattle, WA.
    b. Automated Equipment Co., Seattle, WA.
    c. Stanley.
    d. Richards Wilcox, Aurora, IL.

D. Access System:

1. Digital keypad in weatherproof enclosure mounted on steel tube post anchored to concrete foundation outside gate. Face lighted unit fully visible at night.
    a. Digital Keypad:
        1) Multiple-programmable code capability of not less than 5 possible individual codes, consisting of 5-digit codes.
        2) Features:
            a) Capable of monitoring and auditing gate activity.
2. For safety, provide loop detectors minimum of 4 feet away from each side of gate.
3. Gate Operation:
    a. Entry: Gate opens when activated by valid card code in reader. Gate closes after adjustable time period up to 90 seconds.
    b. Exit: Gate opens when activated by detector loop in pavement or pushbutton inside gate. Gate closes as for entry.
    c. Override or 7-day timer to allow gate to remain open for up to 12 hours with equipment at rest.

4. Serial communication interface, including cable, with Supervisory Control System specified in Section 40 90 01, Instrumentation and Control for Process Systems, for remote monitoring of gate activity. Gate usage shall send code after each access to plant.
5. Manufacturers:
    a. Power Door Engineering, Seattle, WA.
    b. Quentin Control Systems, NW, Inc., Seattle, WA.
    c. Continental Instruments Corp., Westbury, NY.
    d. Richards Wilcox, Aurora, IL.

2.10 REMOVABLE FENCE PANELS

A. Panel Length:

1. Equal division of total length of removable fence section.
2. Maximum 10 feet.

B. Frames: ASTM F1184, Type I.

2.11 CONCRETE

A. Provide as specified in Section 03 30 00, Cast-in-Place Concrete.

2.12 CONCRETE

A. Provide as specified in Section 03 30 00, Cast-in-Place Concrete.

2.13 CONCRETE

A. Materials: ASTM C387, packaged, dry, combined ingredients with Type I cement.

B. Mixing: In a clean metal container, mix package of dry materials by hand or machine. Following manufacturer's instructions, add clean water in sufficient quantity to produce a slump of 2 inches to 3 inches.

2.14 FENCE GROUNDING

A. Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.

1. Material above Finished Grade: Copper.
2. Material on or below Finished Grade: Copper.
3. Bonding Jumpers: Braided copper tape, 1-inch wide, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.

B. Connectors and Grounding Rods: Comply with UL 467.

1. Connectors for Below-Grade Use: Exothermic welded type.
2. Grounding Rods: Copper-clad steel.

PART 3 EXECUTION

3.01 GENERAL

A. Install chain link fences and gates in accordance with ASTM F567, except as modified in this section, and in accordance with fence manufacturer's recommendations, as approved by Engineer. Erect fencing in straight lines between angle points.

B. Provide necessary hardware for a complete fence and gate installation.

C. Any damage to galvanized surfaces, including welding, shall be repaired with paint containing zinc dust in accordance with ASTM A780.

D. Drainage Crossings: Where the chain-link fence must cross drainage ditches or swales, the main fence shall be carried across a ditch or swale with additional fence added below.

1. Frames and Bracing: The fence added below shall be fabricated with galvanized round steel pipe conforming to the requirements for top and brace rails.
2. The construction of the frame shall be welded or assembled with corner fittings. The frame shall be rigid and to the extent necessary to maintain a 2-inch clearance between bottom of the frame and finish grade. If necessary to maintain rigidity, attach to the frame a series of 3/8-inch diameter galvanized steel pipe stakes that are embedded a minimum of 2 feet to the sides and bottom of the ditch.
3. Attach chain link fabric securely to frame at intervals not exceeding 12 inches.

3.02 PREPARATION

A. Clear area on either side of fence to the extent specified in Section 31 10 00, Site Clearing. Eliminate ground surface irregularities along fence line to the extent necessary to maintain a 2-inch clearance between bottom of fabric and finish grade.

B. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

C. Embedment Coating: Coat portion of galvanized or aluminum-coated steel posts that will be embedded in concrete as specified in Section 09 90 00, Painting and Coating. Extend coating 1 inch above top of concrete.

3.03 POST SETTING

A. Drill or hand-excavate holes for posts to diameters and spacing indicated, in firm, undisturbed soil. Driven posts are not acceptable. Postholes shall be clear of loose materials. Waste materials from postholes shall be removed from Site or regraded into slopes on Site.

B. Posthole Depth:

1. Minimum 3 feet below finished grade.
2. 2 inches deeper than post embedment depth below finish grade.

C. Set posts with minimum embedment below finished grade of 34 inches and with top rail at proper height above finished grade. Verify posts are set plumb, aligned, and at correct height and spacing. Brace posts, as necessary, to maintain correct position and plumbness until concrete sets.

D. Backfill postholes with concrete to 2 inches above finished grade. Vibrate or tamp concrete for consolidation. Protect above ground portion of posts from concrete splatter.

E. Before concrete sets, crown and finish top of concrete to readily shed water.

F. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more.

G. Line Posts: Space line posts uniformly at 10 feet on centers between terminal end, corner, and gate posts.

3.04 POST BRACING

A. Install according to ASTM F567, maintaining plumb position, and alignment of fencing. Install braces at gate, end, pull, and corner posts diagonally to adjacent line posts to ensure stability. Install braces on both sides of corner and pull posts.

1. Locate horizontal braces at mid-height of fabric or higher, on fences with top rail, and 2/3-fabric height on fences without top rail. Install so posts are plumb when diagonal truss rod assembly is under proper tension.

3.05 TOP RAILS

A. Install according to ASTM F567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps and terminating into rail end attached to posts or posts caps fabricated to receive rail at terminal posts. Install top rail sleeves with springs at 105 feet maximum spacing to permit expansion in rail.

3.06 BARBED WIRE SUPPORTING ARMS

A. Barbed wire supporting arms shall be installed as indicated and as recommended by manufacturer. Bolt or rivet supporting arm to top of post in a manner to prevent easy removal with hand tools. Angle single arms to outside of fence.

3.07 TENSION WIRE

A. Install according to ASTM F567 and ASTM F1916, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with tie wires at a maximum spacing of 24 inches on center.

B. Install tension wire within 6 inches of bottom of fabric and tie to each post with not less than same diameter and type of wire.

3.08 CHAIN LINK FABRIC

A. Do not install fabric until concrete has cured minimum 7 days.

B. Install fabric with twisted and barbed selvage at top.

C. Apply fabric to outside of enclosing framework. Pull fabric taut to provide a smooth and uniform appearance free from sag, without permanently distorting fabric diamond or reducing fabric height. Tie fabric to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.

D. Splicing shall be accomplished according to ASTM F1916 by weaving a single picket into the ends of the rolls to be joined.

E. Leave 2 inches between finish grade or surface and bottom selvage, unless otherwise indicated.

F. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than 15 inches on center.

G. Tie Wires: Fasten ties to wrap a full 360 degrees around rail or post and a minimum of one complete diamond of fabric. Twist ends of tie wire three full twists, and cut off protruding ends to preclude untwisting by hand.

1. Maximum Spacing: Tie fabric to line posts at 12 inches on center and to brace and top rails at 24 inches on center.

3.09 BARBED WIRE

A. Install barbed wire uniformly in configurations of 3 strands of barbed wire on supporting arms. Pull wire taut and install securely to supporting arms and secure to end terminal post or terminal arms.

3.10 BARBED TAPE

A. Install barbed tape uniformly on top of the barbed wire and V-shaped supporting arms in the configuration shown on Drawings. Secure each loop to arms or single strand of barbed wire to prevent movement or displacement according to ASTM F1911.

3.11 GATES

A. Install gates according to manufacturer's written instructions, level, plumb and secure for full opening without interference. Attach fabric and hardware to gate using tamper-resistant or concealed means. Adjust hardware for smooth operation and lubricate where necessary so gates operate satisfactorily from open or closed position.

B. Set gate stops in concrete to engage center drop rod or plunger bar.

3.12 GATE OPERATOR SYSTEMS

A. Install gate operator systems in accordance with manufacturer's recommendations, aligned and true to fence line and grade.

B. Furnish with equipment and accessories necessary for complete installation.

C. Hand excavate holes for pads in firm undisturbed soil to dimensions, depths, and locations as required by gate operator component manufacturer's written instructions and as shown on the drawings.

D. Vehicle Loop Detector System: Cut grooves in pavement and bury and seal wire loop according to manufacturer's written instructions. Connect to equipment operated by detector.

3.13 ELECTRICAL GROUNDING

A. Ground fences at a maximum interval of 1,000 feet in accordance with applicable requirements of IEEE C2, National Electrical Safety Code.

B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet on each side of crossing.

C. Grounding Method: At each grounding location, drive a grounding rod vertically until top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.

3.14 FIELD QUALITY CONTROL

A. Post and Fabric Testing: Test fabric tension and line post rigidity according to ASTM F1916.

B. Gate Tests:

1. Prior to acceptance of installed gates, demonstrate proper operation of gates under each possible open and close condition specified.
2. Adjust gate to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range.
3. Confirm that latches and locks engage accurately and securely without forcing and binding.

C. Automatic Gate Operator:

1. Energize circuits to electrical equipment and devices.
2. Adjust operators, controls, safety devises, and limit switches.
3. Start units to confirm proper motor rotation and unit operation free of binding. Test and adjust all gate controls for proper operation.
4. Replace damaged and malfunctioning controls and equipment.
5. Lubricate hardware, gate operator and other moving parts.

3.15 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, to train Owner's personnel to adjust, operate, and maintain gates.

3.16 CLEANUP

A. Remove excess fencing materials and other debris from Site.

END OF SECTION

SECTION 32 92 00
TURF AND GRASSES

PART 1 GENERAL

1.01 DEFINITIONS

A. Maintenance Period: Begin maintenance immediately after each area is planted (seed, sod, or sprig) and continue for a period of 12 weeks after all planting under this section is completed.

B. Satisfactory Stand: Lawn or section of lawn that has:

1. No bare spots larger than 3 square feet.
2. Not more than 10 percent of total area with bare spots larger than 1 square foot.
3. Not more than 15 percent of total area with bare spots larger than 6 square inches.

C. Standard Specifications: CT DOT Form 818.

1.02 SUBMITTALS

A. Action Submittals: Product labels/data sheets.

B. Informational Submittals:

1. Seed: Certification of seed analysis, germination rate, and inoculation:
   a. Certify that each lot of seed has been tested by a testing laboratory certified in seed testing, within 6 months of date of delivery. Include with certification:
      1) Name and address of laboratory.
      2) Date of test.
      3) Lot number for each seed specified.
      4) Test Results: (i) name, (ii) percentages of purity and of germination, and (iii) weed content for each kind of seed furnished.
   b. Mixtures: Proportions of each kind of seed.
2. Seed Inoculant Certification: Bacteria prepared specifically for legume species to be inoculated.
3. Certification of sod; include source and harvest date of sod, and sod seed mix.
4. Certification of sprig type and name.
5. Description of required maintenance activities and activity frequency.

1.03 DELIVERY, STORAGE, AND PROTECTION

A. Seed:

1. Furnish in standard containers with seed name, lot number, net weight, percentages of purity, germination, and hard seed and maximum weed seed content, clearly marked for each container of seed.
2. Keep dry during storage.

B. Sod:

1. Do not harvest if sod is excessively dry or wet to the extent survival may be adversely affected.
2. Harvest and deliver sod only after laying bed is prepared for sodding.
3. Roll or stack to prevent yellowing.
4. Deliver and lay within 24 hours of harvesting.
5. Keep moist and covered to protect from drying from time of harvesting until laid.

C. Sprigs:

1. Cut and deliver only after planting area is prepared for planting.
2. Deliver and plant within 24 hours of harvesting.
3. Keep moist and covered to protect from drying from time of cutting until planted.

D. Hydroseeding Mulch: Mark package of wood fiber mulch to show air dry weight.

1.04 WEATHER RESTRICTIONS

A. Perform Work under favorable weather and soil moisture conditions as determined by accepted local practice.

1.05 SEQUENCING AND SCHEDULING

A. Complete Work under this section within 10 days following completion of soil preparation.

B. Notify Engineer at least 3 days in advance of:

1. Each material delivery.
2. Start of planting activity.

C. Planting Season: In accordance with Section 9.50 of the Standard Specification.

1.06 MAINTENANCE SERVICE

A. Contractor: Perform maintenance operations during maintenance period to include:

1. Watering: Keep surface moist.
2. Washouts: Repair by filling with topsoil, liming, fertilizing, seeding, and mulching.
3. Mulch: Replace wherever and whenever washed or blown away.
4. Mowing: Mow to 2 inches after grass height reaches 3 inches, and mow to maintain grass height from exceeding 3-1/2 inches.
5. Fence: Repair and maintain until satisfactory stand of grass is established.
6. Reseed unsatisfactory areas or portions thereof immediately at the end of the maintenance period if a satisfactory stand has not been produced.
7. Reseed/replant during next planting season if scheduled end of maintenance period falls after periods defined in Section 9.50 of the Standard Specification.
8. Reseed/replant entire area if satisfactory stand does not develop by July 1 of the following year.

PART 2 PRODUCTS

2.01 FERTILIZER

A. Commercial, uniform in composition, free-flowing, suitable for application with equipment designed for that purpose. Minimum percentage of plant food by weight.

B. Application Rates: Determined by soil analysis results.

C. Mix: In accordance with Section M.13.03 of the Standard Specification.

D. Top Dress Type: In accordance with section 9.50.02 of the Standard Specification.

2.02 SEED

A. Fresh, clean new-crop seed that complies with the tolerance for purity and germination established by Official Seed Analysts of North America.

B. Seeds of Legumes: Inoculated with pure culture of nitrogen-fixing bacteria prepared specifically for legume species in accordance with inoculant manufacturer’s instructions.

C. In accordance with M.13.04 of the Standard Specifications.

2.03 STRAW MULCH

A. Threshed straw of oats, wheat, barley, or rye, free from (i) seed of noxious weeds or (ii) clean salt hay.

2.04 HYDROSEEDING MULCH

A. Wood Cellulose Fiber Mulch shall be in accordance with Section M.13.05 of the Standard Specification.

PART 3 EXECUTION

3.01 PREPARATION

A. Grade areas to smooth, even surface with loose, uniformly fine texture.

1. Roll and rake, remove ridges, fill depressions to meet finish grades.
2. Limit such Work to areas to be planted within immediate future.
3. Remove debris, and stones larger than 1-1/2-inch diameter, and other objects that may interfere with planting and maintenance operations.

B. Moisten prepared areas before planting if soil is dry. Water thoroughly and allow surface to dry off before seeding. Do not create muddy soil.

C. Restore prepared areas to specified condition if eroded or otherwise disturbed after preparation and before planting.

3.02 FERTILIZER

A. Apply evenly over area in accordance with manufacturer's instructions and in accordance with section 9.50.03 of the Standard Specifications.

3.03 SEEDING

A. Start within 2 days of preparation completion.

B. Hydroseed slopes steeper than 3H:1V. Flatter slopes may be mechanically seeded.

C. Mechanical: Broadcast seed in two different directions, compact seeded area with cultipacter or roller.

1. Sow seed at uniform rate of no less than175 pounds per acre.
2. Use Brillion type seeder.
3. Broadcasting will be allowed only in areas too small to use Brillion type seeder. Where seed is broadcast, increase seeding rate 20 percent.
4. Roll with ring roller to cover seed, and water with fine spray.

D. Hydroseeding: In accordance with Section 9.50 of the Standard Specifications.

E. Mulching: In accordance with Section 9.50 of the Standard Specifications.

F. Netting: Immediately after mulching, place over mulched areas with slopes steeper than 3:1, in accordance with manufacturer's instructions. Locate strips parallel to slope and completely cover seeded areas.

G. Water: Apply with fine spray after mulching to saturate top 4 inches of soil.

3.04 SODDING

A. Do not plant dormant sod, or when ground is frozen.

B. Lay sod to form solid mass with tightly fitted joints; butt ends and sides, do not overlap.

1. Stagger strips to offset joints in adjacent courses.
2. Work from boards to avoid damage to subgrade or sod.
3. Tamp or roll lightly to ensure contact with subgrade; work sifted soil into minor cracks between pieces of sod, remove excess to avoid smothering adjacent grass.
4. Complete sod surface true to finished grade, even, and firm.

C. Fasten sod on slopes to prevent slippage with wooden pins 6 inches long driven through sod into subgrade, until flush with top of sod. Install at sufficiently close intervals to securely hold sod.

D. Water sod with fine spray immediately after planting. During first week, water daily or more frequently to maintain moist soil to depth of 4 inches.

E. Apply top dress fertilizer at recommended rate.

3.05 FIELD QUALITY CONTROL

A. 12 weeks after seeding is complete and on written notice from Contractor, Engineer will, within 15 days of receipt, determine if a satisfactory stand has been established.

B. If a satisfactory stand has not been established, Engineer will make another determination after written notice from Contractor following the next growing season.

END OF SECTION

SECTION 40 05 15
PIPING SUPPORT SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Civil Engineers (ASCE): 7, Minimum Design Loads for Buildings and Other Structures.
2. American Society of Mechanical Engineers (ASME): B31.1, Power Piping.
3. ASTM International (ASTM):
   a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   b. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanealed) by the Hot-Dip Process.
   c. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
4. International Code Council (ICC):
5. International Building Code (IBC).
6. International Mechanical Code (IMC).
7. Manufacturers' Standardization Society (MSS):
   a. SP 58, Pipe Hangers and Supports—Materials, Design and Manufacture.
   b. SP 127, Bracing for Piping Systems Seismic-Wind-Dynamic Design, Selection, and Application.

1.02 DEFINITIONS

A. Wetted or Submerged: Submerged, less than 1 foot above liquid surface, below top of channel wall, under cover or slab of channel or tank, or in other damp locations.

1.03 SUBMITTALS

A. Action Submittals:

1. Catalog information and drawings of piping support system, locating each support, sway brace, seismic brace, hanger, guide, component, and anchor for piping. Identify support, hanger, guide, and anchor type by catalog number and Shop Drawing detail number.

2. Revisions to support systems resulting from changes in related piping system layout or addition of flexible joints.
    a. Submit calculations and drawings signed and sealed by a CT PE for support of piping systems installed differently than shown on the Contract Documents.
3. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Maintenance information on piping support system.

1.04 QUALIFICATIONS (NOT USED)

1.05 DESIGN REQUIREMENTS

A. General:

1. This section applies to process piping, HVAC systems and electrical conduits.
2. Design, size, and locate support systems throughout facility, whether shown or not.
3. Process piping 36" and Smaller: Required supports are shown on the Drawings; additional pipe supports may be required if piping is installed different than shown on the Drawings. If additional pipe supports are required, drawings and calculations signed and sealed by a Professional Engineer licensed in the State of Connecticut shall be submitted for approval. Follow guidelines specified herein for design of additional pipe supports.
4. Meet requirements of MSS SP 58 and ASME B31.1 or as modified by this section.

B. Pipe Support Systems:

1. Design pipe support systems for gravity and thrust loads imposed by weight of pipes or internal pressures, including insulation and weight of fluid in pipes.
2. Seismic loads in accordance with governing codes and as shown on Structural General Drawings.
3. Wind loads in accordance with governing codes and as shown on Structural General Drawings.
4. Maximum Support Spacing and Minimum Rod Size: In accordance MSS SP 58 Table 3 and Table 4.

C. Anchoring Devices: Design, size, and space support anchoring devices, including anchor bolts, inserts, and other devices used to anchor support, to

withstand shear and pullout loads imposed by loading and spacing on each particular support.

D. Vertical Sway Bracing: 10-foot maximum centers or as shown.

E. Existing Support Systems: Use existing supports systems to support new piping only if Contractor can show they are adequate for additional load, or if they are strengthened to support additional load.

PART 2 PRODUCTS

2.01 GENERAL

A. When specified items are not available, fabricate pipe supports of correct material and to general configuration indicated.

B. Special support and hanger details may be required for cases where standard catalog supports are not applicable.

C. Materials: In accordance with Table 1 and Table 2, attached as Supplements at end of section.

2.02 HANGERS

A. Clevis: MSS SP 58, Type 1:

1. Anvil; Figure 260 for steel pipe, sizes 1/2 inch through 30 inches.
2. Insulated Steel Pipe: Anvil; Figure 260 with insulated saddle system (ISS), sizes 1/2 inch through 12 inches (up to 2 inches of insulation).
3. B-Line; Figure B3100, sizes 1/2 inch through 30 inches.

B. Three-bolt clamp: MSS SP 58, Type 3:

1. Anvil; Figure 295 for steel pipe with up to 4 inches of insulation; sizes 6 inch through 36 inches.

C. Steel Pipe Rolls and Roller Hanger Supports: MSS SP 58, Type 41 or Type 43:

1. Anvil; Figure 181 for sizes 2-1/2 inches through 20 inches, (pipe OD including insulation) and Figure 171 for sizes 1 inch through 30 inches (pipe OD including insulation).
2. Provide Figure 163 for 2-1/2 inches of insulation.
3. B-Line; Figure B3110 for sizes 2 inches through 24 inches and Figure B3114 for 30 inches.

D. Pipe Rollers and Supports: MSS SP 58, Type 44:

1. Anvil; Figure 175, sizes 2 inches through 30 inches.
2. B-Line; Figure B3120, sizes 2 inches through 24 inches.

2.03 WALL BRACKETS, SUPPORTS, AND GUIDES

A. Welded Steel Wall Bracket: MSS SP 58, Type 33 (heavy-duty):

1. Anvil; Figure 199, 3,000-pound rating.
2. B-Line; Figure B3067, 3,000-pound rating.

B. Adjustable “J” hanger MSS SP 58, Type 5:

1. Anvil; Figure 67, sizes 1/2 inch through 8 inches.
2. B-Line; Figure B3690, sizes 1/2 inch through 8 inches.

C. Offset Pipe Clamp: Anvil; Figure 103, sizes 3/4 inch through 8 inches.

D. Channel Type:

1. Unistrut.
2. Anvil; Power-Strut.
3. B-Line; Strut System.
4. Aickinstrut (FRP).

2.04 PIPE SADDLES

A. Provide 90-degree to120-degree pipe saddle for pipe 6 inches and larger with baseplates drilled for anchors bolts.

1. In accordance with Standard Detail 4005-515.
2. Sizes 20 inches though 60 inches, Piping Technology & Products, Inc.; Fig. 2000.

B. Saddle Supports, Pedestal Type:

1. Minimum standard weight pipe stanchion, saddle, and anchoring flange.
2. Nonadjustable Saddle: MSS SP , Type 37 with U-bolt.
   a. Anvil; Figure 259, sizes 4 inches through 36 inches with Figure 63C base.
   b. B-Line; Figure B3095, sizes 1 inch through 36 inches with B3088S base.
3. Adjustable Saddle: MSS SP 58, Type 38 without clamp.
   a. Anvil; Figure 264, sizes 2-1/2 inches through 36 inches with Figure 63T base with stanchion size as indicated on Drawings.
   b. B-Line; Figure B3092, sizes 3/4 inch through 36 inches with Figure B3088S base.

2.05 CHANNEL TYPE SUPPORT SYSTEMS

A. Channel Size: 12-gauge, 1-5/8-inch wide minimum steel, or 1-1/2-inch wide, minimum FRP.

B. Members and Connections: Design for loads using one-half of manufacturer's allowable loads.

C. Fasteners: 316 SS.

D. Manufacturers and Products:

1. B-Line; Strut System.
2. Unistrut.
3. Anvil; Power-Strut.

2.06 PIPE CLAMPS

A. Riser Clamp: MSS SP 58, Type 8.

1. Anvil; Figure 261, sizes 3/4 inch through 24 inches.
2. B-Line; Figure B3373, sizes 1/2 inch through 30 inches.

2.07 ELBOW AND FLANGE SUPPORTS

A. Elbow with Adjustable Stanchion: Sizes 2 inches through 18 inches, Anvil; Figure 62C base.

B. Elbow with Nonadjustable Stanchion: Sizes 2-1/2 inches through 42 inches, Anvil; Figure 63A or Figure 63B base.

C. Flange Support with Adjustable Base: Sizes 2 inches through 24 inches, Standon; Model S89.

2.08 INTERMEDIATE PIPE GUIDES

A. Type: Hold down pipe guide.

1. Manufacturer and Product: B-Line; Figure B3552, 1-1/2 inches through 30 inches.

B. Type: U-bolts with double nuts to provide nominal 1/8-inch to 1/4-inch clearance around pipe; MSS SP 58, Type 24.

1. Anvil; Figure 137 and Figure 137S.
2. B-Line; Figure B3188 and Figure B3188NS.

2.09 PIPE ALIGNMENT GUIDES

A. Type: Spider.

B. Manufacturers and Products:

1. Anvil; Figure 255, sizes 1/2 inch through 24 inches.
2. B-Line; Figure B3281 through Figure B3287, sizes 1/2 inch through 24 inches.

2.10 PIPE ANCHORS

A. Type: Anchor chair with U-bolt strap.

B. Manufacturer and Product: B-Line; Figure B3147A or Figure B3147B.

2.11 SEISMIC RESTRAINTS

A. Solid pipe bracing attachment to pipe clevis with clevis cross brace and angle rod reinforcement.

B. Manufacturers:

1. Mason Industries.
2. B-Line.
3. Anvil.

2.12 ACCESSORIES

A. Anchor Bolts:

1. Size and Material: 1/2-inch minimum diameter, and as specified in Section 05 50 00, Metal Fabrications.
2. Bolt Length (Extension Above Top of Nut):
   a. Minimum Length: Flush with top of nut preferred. If not flush, shall be no more than one thread recessed below top of nut.
   b. Maximum Length: No more than a full nut depth above top of nut.

B. Dielectric Barriers:

1. Plastic coated hangers, isolation cushion, or tape.
2. Manufacturer and Products:
   a. B-Line; B1999 Vibra Cushion.
   b. B-Line; Iso Pipe, Isolation Tape.

C. Insulation Shields:

1. Type: Galvanized steel or stainless steel, MSS SP 58, Type 40.
2. Manufacturers and Products:
   a. Anvil; Figure 167, sizes 1/2 inch through 24 inches.
   b. B-Line; Figure B3151, sizes 1/2 inch through 24 inches.

D. Welding Insulation Saddles:

1. Type: MSS SP 58, Type 39.
2. Manufacturers and Products:
   a. Anvil; Figure Series 160, sizes 1 inch through 36 inches.
   b. B-Line; Figure Series B3160, sizes 1/2 inch through 24 inches.

E. Plastic Pipe Support Channel:

1. Type: Continuous support for plastic pipe and to increase support spacing.
2. Manufacturer and Product: B-Line; Figure Series B3106V, sizes 1/2 inch through 6 inches with Figure B3106 Vee bottom hanger.

F. Hanger Rods, Clevises, Nuts, Sockets, and Turnbuckles: In accordance with MSS SP 58.

G. Attachments:

1. I-Beam Clamp: Concentric loading type, MSS SP 58, Type 21, Type 28, Type 29, or Type 30, which engage both sides of flange.
2. Concrete Insert: MSS SP 58, Type 18, continuous channel insert with load rating not less than that of hanger rod it supports.
3. Welded Beam Attachment: MSS SP 58, Type 22.
   a. Anvil; Figure 66.
   b. B-Line; Figure B3083.
4. Concrete Attachment Plates:
   a. Anvil; Figure 47, Figure 49, or Figure 52.
   b. B-Line; Figure B3084, Figure B3085, or Figure B3086.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install support systems in accordance with MSS SP 58, unless shown otherwise.
2. Install pipe hanger rods plumb, within 4 degrees of vertical during shut down, start up or operations.

3. Support piping connections to equipment by pipe support and not by equipment.
4. Support large or heavy valves, fittings, and appurtenances independently of connected piping.
5. Support no pipe from pipe above it.
6. Support pipe at changes in direction or in elevation, adjacent to flexible joints and couplings, and where shown.
7. Do not use adhesive anchors for attachment of supports to ceiling or walls.
8. Do not install pipe supports and hangers in equipment access areas or bridge crane runs.
9. Brace hanging pipes against horizontal movement by both longitudinal and lateral sway bracing and to reduce movement after startup.
10. Install lateral supports for seismic loads at changes in direction.
11. Install pipe anchors where required to withstand expansion thrust loads and to direct and control thermal expansion.
12. Repair mounting surfaces to original condition after attachments are completed.

B. Standard Pipe Supports:

1. Horizontal Suspended Piping:
   a. Single Pipes: Clevis hangers or adjustable swivel split-ring.
   b. Grouped Pipes: Trapeze hanger system.
2. Horizontal Piping Supported from Walls:
   a. Single Pipes: Wall brackets, or attached to wall, or to wall mounted framing with anchors.
   b. Stacked Piping: Wall mounted framing system and “J” hangers acceptable for pipe smaller than 3-inch.
   c. Pipe clamp that resists axial movement of pipe through support is not acceptable. Use pipe rollers supported from wall bracket.
3. Horizontal Piping Supported from Floors:
   a. Saddle Supports:
      1) Pedestal Type, elbow and flange.
      2) Provide minimum 1-1/2-inch grout beneath baseplate.
   b. Floor Mounted Channel Supports:
      1) Use for pipe smaller than 3-inch running along floors and in trenches at pipe elevations lower than can be accommodated using pedestal pipe supports.
      2) Attach channel framing to floors with baseplate on minimum 1-1/2-inch nonshrink grout and with anchor bolts.
      3) Attach pipe to channel with clips or pipe clamps.
   c. Concrete Cradles: Use for pipe larger than 3 inches along floor and in trenches at pipe elevations lower than can be accommodated using stanchion type.

4. Insulated Pipe:
    a. Pipe hanger and support shall be on outside of insulation. Do not enclose within insulation.
    b. Provide precut 120-degree sections of rigid insulation (minimum length same as shield), shields and oversized hangers or insulated saddle system (ISS).
    c. Wall-mounted pipe clips not acceptable for insulated piping.
5. Vertical Pipe: Support with wall bracket and elbow support, or riser clamp on floor penetration.

C. Standard Attachments:

1. New Concrete Ceilings: Concrete inserts, concrete attachment plates, or concrete anchors as limited below:
    a. Single point attachment to ceiling allowed only for 3/4-inch rod and smaller (8 inches and smaller pipe).
    b. Where there is vibration or bending considerations, do not connect a single pipe support hanger rod directly to a drilled concrete anchor (single point attachment) regardless of size.
2. Existing Concrete Ceilings: Channel type support with minimum of two anchor points, concrete attachment plates or concrete anchors as limited below:
    a. Single point attachment to ceiling is allowed only for 3/4-inch rod and smaller (8 inches and smaller pipe).
    b. Where there is vibration or bending considerations do not connect a single pipe support hanger rod directly to a drilled concrete anchor (single point attachment) regardless of size.
3. Steel Beams: I-beam clamp or welded attachments.
4. Concrete Walls: Concrete inserts or brackets or clip angles with concrete anchors.
5. Concrete Beams: Concrete inserts, or if inserts are not used attach to vertical surface similar to concrete wall. Do not drill into beam bottom.

D. Saddles for Steel or Concrete Pipe: Provide 90-degree to120-degree pipe saddle for pipe sizes 6 inches and larger when installed on top of steel or concrete beam or structure, pipe rack, trapeze, or where similar concentrated point supports would be encountered.

E. Intermediate and Pipe Alignment Guides:

1. Provide pipe alignment guides, or pipe supports that provide same function, at expansion joints and loops.
2. Guide pipe on each side of expansion joint or loop at 4 pipe and 14 pipe diameters from each joint or loop.
3. Install intermediate guides on metal framing support systems not carrying pipe anchor or alignment guide.

F. Accessories:

1. Insulation Shield: Install on insulated piping with oversize rollers and supports.
2. Welding Insulation Saddle: Install on insulated steel pipe with oversize rollers and supports.
3. Dielectric Barrier:
   a. Provide between painted or galvanized carbon steel members and copper or stainless steel pipe or between stainless steel supports and nonstainless steel ferrous metal piping.
   b. Install rubber wrap between submerged metal pipe and oversized clamps.

3.02 FIELD FINISHING

A. Paint exposed nongalvanized steel components as specified in Section 09 90 00, Painting and Coating.

3.03 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this specification:

1. Table 1: Nonchemical Areas.

END OF SECTION

Table 1 Nonchemical Areas	
Exposure Conditions	**Support Material**
Process Air Compressor Building	Hot-dipped galvanized steel for process piping Hot-dipped galvanized steel or precoated steel, plastic coated hangers for uninsulated copper or non-process stainless steel piping
Process Areas: High Humidity or Hydrogen sulfide (Aeration Basins)	Hot-dipped galvanized
Process Areas: Wetted or Submerged	Hot-dipped galvanized

Notes:

1. Precoated steel to be fusion bonded epoxy or vinyl copolymer (Plastisol).
2. Stainless steel to be Type 316.
3. Galvanized steel to be per ASTM A653/A653M, Class G90, or hot-dip galvanized after fabrication to ASTM A123/A123M.
4. Do not use galvanized steel or aluminum where lime dust can accumulate on these surfaces.

SECTION 40 27 00
PROCESS PIPING—GENERAL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section and any supplemental Data Sheets:

1. Air Force: A-A-58092, Tape, Antiseize, Polytetrafluorethylene.
2. American Association of State Highway and Transportation Officials (AASHTO): HB-17, Standard Specifications for Highway Bridges.
3. American Petroleum Institute (API): SPEC 5L, Specification for Line Pipe.
4. American Society of Mechanical Engineers (ASME):
   a. Boiler and Pressure Vessel Code, Section IX, Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.
   b. B1.20.1, Pipe Threads, General Purpose (Inch).
   c. B16.1, Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250.
   d. B16.3, Malleable Iron Threaded Fittings Classes 150 and 300.
   e. B16.5, Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24 Metric/Inch Standard.
   f. B16.9, Factory-Made Wrought Buttwelding Fittings.
   g. B16.11, Forged Fittings, Socket-Welding and Threaded.
   h. B16.15, Cast Copper Alloy Threaded Fittings Classes 125 and 250.
   i. B16.21, Nonmetallic Flat Gaskets for Pipe Flanges.
   j. B16.22, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
   k. B16.24, Cast Copper Alloy Pipe Flanges and Flanged Fittings Classes 150, 300, 600, 900, 1500, and 2500.
   l. B16.25, Buttwelding Ends.
   m. B16.42, Ductile Iron Pipe Flanges and Flanged Fittings Classes 150 and 300.
   n. B31.1, Power Piping.
   o. B31.3, Process Piping.
   p. B31.9, Building Services Piping.
   q. B36.10M, Welded and Seamless Wrought Steel Pipe.
5. American Society for Nondestructive Testing (ASNT): SNT-TC-1A, Recommended Practice for Personal Qualification and Certification in Nondestructive Testing.

6. American Water Works Association (AWWA):
    a. C104/A21.4, Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
    b. C105/A21.5, Polyethylene Encasement for Ductile-Iron Pipe Systems.
    c. C110/A21.10, Ductile-Iron and Gray-Iron Fittings.
    d. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
    e. C115/A21.15, Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
    f. C151/A21.51, Ductile-Iron Pipe, Centrifugally Cast.
    g. C153/A21.53, Ductile-Iron Compact Fittings.
    h. C207, Steel Pipe Flanges for Waterworks Service, Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm).
    i. C606, Grooved and Shouldered Joints.
7. American Welding Society (AWS):
    a. Brazing Handbook.
    b. A5.8M/A5.8, Specification for Filler Metals for Brazing and Braze Welding.
    c. D1.1/D1.1M, Structural Welding Code - Steel.
    d. QC1, Standard for AWS Certification of Welding Inspectors.
8. ASTM International (ASTM):
    a. A47/A47M, Standard Specification for Ferritic Malleable Iron Castings.
    b. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
    c. A105/A105M, Standard Specification for Carbon Steel Forgings for Piping Applications.
    d. A106/A106M, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
    e. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
    f. A135/A135M, Standard Specification for Electric-Resistance-Welder Steel Pipe.
    g. A139/A139M, Standard Specification for Electro-Fusion (Arc)–Welded Steel Pipe (NPS 4 Inches and Over).
    h. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
    i. A181/A181M, Standard Specification for Carbon Steel Forgings, for General-Purpose Piping.
    j. A182/A182M, Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
    k. A183, Standard Specification for Carbon Steel Track Bolts and Nuts.

l. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
m. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
n. A197/A197M, Standard Specification for Cupola Malleable Iron.
o. A216/A216M, Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
p. A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
q. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
r. A276, Standard Specification for Stainless Steel Bars and Shapes.
s. A269, Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
t. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
u. A312/A312M, Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
v. A320/A320M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
w. A351/A351M, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
x. A395/A395M, Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
y. A403/A403M, Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
z. A409/A409M, Standard Specification for Welded Large Diameter Austenitic Steel Pipe for Corrosive or High-Temperature Service.
aa. A536, Standard Specification for Ductile Iron Castings.
bb. A563, Standard Specification for Carbon and Alloy Steel Nuts.
cc. A587, Standard Specification for Electric-Resistance-Welded Low-Carbon Steel Pipe for the Chemical Industry.
dd. A743/A743M, Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
ee. A744/A744M, Standard Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service.
ff. A774/A774M, Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures.
gg. A778, Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.
hh. B32, Standard Specification for Solder Metal.

ii. B43, Standard Specification for Seamless Red Brass Pipe, Standard Sizes.
jj. B61, Standard Specification for Steam or Valve Bronze Castings.
kk. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
ll. B75/B75M, Standard Specification for Seamless Copper Tube.
mm. B88, Standard Specification for Seamless Copper Water Tube.
nn. B98/B98M, Standard Specification for Copper-Silicon Alloy Rod, Bar and Shapes.
oo. B462, Standard Specification for Forged or Rolled UNS N06030, UNS N06022, UNS N06035, UNS N06200, UNS N06059, UNS N10362, UNS N06686, UNS N08020, UNS N08024, UNS N08026, UNS N08367, UNS N10276, UNS N10665, UNS N10675, UNS N10629, UNS N08031, UNS N06045, UNS N06025, and UNS R20033 Alloy Pipe Flanges, Forged Fittings, and Valves and Parts for Corrosive High-Temperature Service.
pp. B464, Standard Specification for Welded UNS N08020 Alloy Pipe.
qq. B474, Standard Specification for Electric Fusion Welded Nickel and Nickel Alloy Pipe.
rr. C582, Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment.
ss. D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension.
tt. D413, Standard Test Methods for Rubber Property-Adhesion to Flexible Substrate.
uu. D543, Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents.
vv. D1248, Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.
ww. D1330, Standard Specification for Rubber Sheet Gaskets.
xx. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
yy. D1785, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
zz. D2000, Standard Classification System for Rubber Products in Automotive Applications.
aaa. D2310, Standard Classification for Machine-Made “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
bbb. D2464, Standard Specification for Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
ccc. D2466, Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
ddd. D2467, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.

eee. D2564, Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.
fff. D2837, Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products.
ggg. D2996, Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
hhh. D3222, Standard Specification for Unmodified Poly (Vinylidene Fluoride) (PVDF) Molding Extrusion and Coating Materials.
iii. D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
jjj. D4101, Standard Specification for Polypropylene Injection and Extrusion Materials.
kkk. D4894, Standard Specification for Polytetrafluoroethylene (PTFE) Granular Molding and Ram Extrusion Materials.
lll. D4895, Standard Specification for Polytetrafluoroethylene (PTFE) Resin Produced from Dispersion.
mmm. F423, Standard Specification for Polytetrafluoroethylene (PTFE) Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges.
nnn. F436, Standard Specification for Hardened Steel Washers.
ooo. F437, Standard Specification for Threaded Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
ppp. F439, Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
qqq. F441/F441M, Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
rrr. F493, Standard Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
sss. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
ttt. F656, Standard Specification for Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings.

9. FM Global (FM).
10. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS): SP-43, Wrought and Fabricated Butt-Welding Fittings for Low-Pressure, Corrosion Resistant Applications.
11. NSF International (NSF):
    a. ANSI 61: Drinking Water System Components - Health Effects.
    b. ANSI 372: Drinking Water System Components - Lead Content.
12. National Electrical Manufacturers Association (NEMA): LI 1, Industrial Laminating Thermosetting Products.
13. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

1.02 DEFINITIONS

A. Submerged or Wetted:

1. Submerged, less than 1 foot above liquid surface, below top of channel wall, under cover or slab of channel or tank, or in other damp locations.

1.03 DESIGN REQUIREMENTS

A. Where pipe diameter, thickness, pressure class, pressure rating, or thrust restraint is not shown or specified, design piping system in accordance with the following:

1. Process Piping: ASME B31.3, normal fluid service unless otherwise specified.
2. Buried Piping: H20-S16 traffic load with 1.5 impact factor, AASHTO HB-17, as applicable.
3. Thrust Restraints:
   a. Design for test pressure shown in Piping Schedule.
   b. Allowable Soil Pressure: 1000 pounds per square foot.
   c. Low Pressure Pipelines:
      1) When bearing surface of the fitting against soil provides an area equal to or greater than area required for thrust restraint, concrete thrust blocks will not be required.
      2) Determine bearing area for fittings without thrust blocks by projected area of 70 percent of internal diameter multiplied by chord length for fitting centerline curve.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Fabricated Piping:
   a. Detailed pipe fabrication or spool drawings showing special fittings and bends, dimensions, coatings, and other pertinent information.
   b. Layout drawing showing location of each pipe section and each special length; number or otherwise designate laying sequence on each piece.
2. Pipe Wall Thickness: Identify wall thickness and rational method or standard applied to determine wall thickness for each size of each different service including exposed, submerged, buried, and concrete-encased installations for Contractor-designed piping.
3. Hydraulic Thrust Restraint for Restrained Joints: Details including materials, sizes, assembly ratings, and pipe attachment methods.
4. Pipe Corrosion Protection: Product Data.
5. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Manufacturer's Certification of Compliance, in accordance with Section 01 61 00, Common Product Requirements:
a. Pipe and fittings.
b. Factory applied resins and coatings.

2. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.

3. Flanged Pipe and Fittings: Manufacturer's product data sheets for gaskets including torquing requirements and bolt tightening procedures.

4. Qualifications:
   a. Nondestructive Testing Personnel: SNT-TC-1A Level II certification and qualifications.
   b. AWS QC1 Certified Welding Inspector: Submit evidence of current certification prior to commencement of welding activities.
   c. Welders:
      1) Continuity log for welders and welding operators.
      2) Welder qualification test records conducted by Contractor or manufacturer.

5. Welding Procedures: Qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX for weld type(s) and base metal(s).

6. Nondestructive inspection and testing procedures.

7. Test logs.

8. Laboratory Testing Equipment: Certified calibrations, manufacturer's product data, and test procedures.

9. CWI inspection records and NDE test records.

1.05 QUALITY ASSURANCE

A. Qualifications:

1. Independent Inspection and Testing Agency:
   a. Ten years' experience in field of welding and welded pipe and fittings' testing required for this Project.
   b. Calibrated instruments and equipment and documented standard procedures for performing specified testing.
   c. Certified in accordance with ASNT SNT-TC-1A for testing procedures required for this Project.
   d. Testing Agency: Personnel performing tests shall be NDT Level II certified in accordance with ASNT SNT-TC-1A.
   e. Verification Welding Inspector: AWS QC1 Certified.
2. Welding Procedures: In accordance with ASME BPVC SEC IX (Forms QW-482 and QW-483) or AWS D1.1/D1.1M (Annex N Forms).
3. Welder Qualifications: In accordance ASME BPVC SEC IX (Form QW-484) or AWS D1.1/D1.1M (Annex N Forms).

4. Contractor's CWI: Certified in accordance with AWS QC1 and having prior experience with specified welding codes. Alternate welding inspector qualifications require approval by Engineer.

B. Quality Assurance: Special inspection to be provided by Owner and performed by independent inspection and testing agency for welding operations.

1. Note, the presence of Owner's Special Inspector or Verification CWI does not relieve Contractor from performing own quality control, including 100 percent visual inspection of welds.

1.06 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01 61 00, Common Product Requirements, and:

1. Flanges: Securely attach metal, hardboard, or wood protectors over entire gasket surface.
2. Threaded or Socket Welding Ends: Fit with metal, wood, or plastic plugs or caps.
3. Linings and Coatings: Prevent excessive drying.
4. Cold Weather Storage: Locate products to prevent coating from freezing to ground.
5. Handling: Use heavy canvas or nylon slings to lift pipe and fittings.
6. Stainless steel pipe shall not come into contact with ferrous metal surfaces.

PART 2 PRODUCTS

2.01 PIPING

A. As specified on Piping Data Sheet(s) and Piping Schedule located at the end of this section as Supplement.

B. Diameters Shown:

1. Standardized Products: Nominal size.
2. Fabricated Steel Piping (Except Cement-Lined): Outside diameter, ASME B36.10M.
3. Cement-Lined Steel Pipe: Lining inside diameter.

2.02 JOINTS

A. Grooved End System:

1. Rigid type.
2. Use of flexible grooved joints allowed where shown on Drawings or with prior approval by Engineer.

3. Flanges: When required, furnish with grooved type flange adapters of same manufacturer as grooved end couplings.

B. Flanged Joints:

1. Flat-faced, carbon steel, or alloy flanges when mating with flat-faced cast or ductile iron flanges.
2. Higher pressure rated flanges as required to mate with equipment when equipment flange is of higher pressure rating than required for piping.

C. Threaded Joints: NPT taper pipe threads in accordance with ASME B1.20.1.

D. Mechanical Joint Anchor Gland Follower:

1. Ductile iron anchor type, wedge action, with break-off tightening bolts.
2. Thrust rated to 250 psi minimum.
3. Rated operating deflection not less than:
   a. 3 degrees for sizes through 12 inches.
   b. 2 degrees for sizes 14 inches through 16 inches.
   c. 1.5 degrees for sizes 18 inches through 24 inches.
   d. 1 degree for sizes 30 inches through 48 inches.
4. UL and FM approved.

E. Flexible Mechanical Compression Joint Coupling:

1. Stainless steel, ASTM A276, Type 305 bands.
2. Manufacturers:
   a. Pipeline Products Corp.
   b. Fernco Joint Sealer Co.

2.03 GASKET LUBRICANT

A. Lubricant shall be supplied by pipe manufacturer and no substitute or "or-equal" will be allowed.

2.04 PIPE CORROSION PROTECTION

A. Coatings: See Section 09 90 00, Painting and Coating, for details of coating requirements.

B. Polyethylene Encasement (Bagging):

1. Encasement Tube: Black polyethylene encasement tube, 8 mils minimum thickness, conforming to AWWA C105/A21.5, free of gels, streaks, pinholes, foreign matter, undispersed raw materials, and visible defects such as tears, blisters, and thinning at folds.

2. Securing Tape: Thermoplastic tape, 8 mils minimum thickness, 1 inch wide, pressure sensitive adhesive face capable of bonding to metal, bituminous coating, and polyethylene encasement tube.

C. Insulating Flanges, Couplings, and Unions:

1. Materials:
   a. In accordance with applicable piping material specified in Pipe Data Sheet. Complete assembly shall have ASME B31.3 working pressure rating equal to or higher than that of joint and pipeline.
   b. Galvanically compatible with piping.
   c. Resistant for intended exposure, operating temperatures, and products in pipeline.
2. Union Type, 2 Inches and Smaller:
   a. Screwed or solder-joint.
   b. O-ring sealed with molded and bonded insulation to body.
3. Flange Type, 2-1/2 Inches and Larger:
   a. Flanged, complete with bolt insulators, dielectric gasket, bolts, and nuts.
   b. Bolt insulating sleeves shall be provided full length between insulating washers.
   c. Ensure fit-up of components of insulated flange assembly to provide a complete functioning installation.
   d. AWWA C207 steel flanges may be drilled oversize up to 1/8-inch to accommodate insulating sleeves.
   e. No less than minimum thread engagement in accordance with specified bolting standards will be permitted to accommodate thicknesses of required washers, flanges, and gasket.
4. Flange Insulating Kits:
   a. Gaskets: Full-face, Type E with elastomeric sealing element. Sealing element shall be retained in a groove within retainer portion of gasket.
   b. Insulating Sleeves: Full-length fiberglass reinforced epoxy (NEMA LI-1, G-10 grade).
   c. Insulating Washers: Fiberglass-reinforced epoxy (NEMA LI-1, G-10 grade).
   d. Steel Washers: Plated, hot-rolled steel, 1/8 inch thick.
      1) Flange Diameters 36 Inches or Less: Provide two washers per bolt.
      2) Flange Diameters Larger Than 36 Inches: Provide four washers per bolt.
5. Manufacturers and Products:
   a. Dielectric Flanges and Unions:
      1) PSI, Houston, TX.
      2) Advance Products and Systems, Lafayette, LA.

b. Insulating Couplings:
   1) Dresser; STAB-39.
   2) Baker Coupling Company, Inc.; Series 216.

2.05 THRUST TIES

A. Steel Pipe: Joint harness as specified in Section 40 27 01, Process Piping Specialties.

B. Buried Ductile Iron Pipe and Fittings: Unless restraint is otherwise specified or shown, conform to NFPA 24. Tie-rod attachments relying on clamp friction with pipe barrel to restrain thrust are unacceptable.

2.06 VENT AND DRAIN VALVES

A. Pipeline 2-Inch Diameter and Smaller: 1/2-inch vent, 1-inch drain, unless shown otherwise.

B. Pipelines 2-1/2-Inch Diameter and Larger: 3/4-inch vent, 1-inch drain, unless shown otherwise.

2.07 FABRICATION

A. Mark each pipe length on outside with the following:

1. Size or diameter and class.
2. Manufacturer's identification and pipe serial number.
3. Location number on laying drawing.
4. Date of manufacture.

B. Code markings according to approved Shop Drawings.

C. Shop fabricate flanged pipe in shop, not in field, and delivered to Site with flanges in place and properly faced. Threaded flanges are not acceptable.

D. Design fabricated piping to minimize field connections. Shop drawings shall indicate flanged or field-welded connections to be made by Contractor in the field. Flanged connections are only permissible for flanged couplings, valves equipment connections or as shown on the Drawings.

2.08 FINISHES

A. Factory prepare, prime, and finish coat in accordance with Pipe Data Sheet(s) and Piping Schedule.

B. Galvanizing:

1. Hot-dip applied, meeting requirements of ASTM A153/A153M.
2. Electroplated zinc or cadmium plating is unacceptable.
3. Stainless steel components may be substituted where galvanizing is specified.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify size, material, joint types, elevation, horizontal location, and pipe service of existing pipelines to be connected to new pipelines or new equipment.

B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.

3.02 PREPARATION

A. See Piping Schedule and Section 09 90 00, Painting and Coating, for additional requirements.

B. Notify Engineer at least 2 weeks prior to field fabrication of pipe or fittings.

C. Inspect pipe and fittings before installation, clean ends thoroughly, and remove foreign matter and dirt from inside.

D. Damaged Coatings and Linings: Repair using original coating and lining materials in accordance with manufacturer's instructions.

3.03 WELDING

A. Perform in accordance with Section IX, ASME Boiler and Pressure Vessel Code and ASME B31.3 for Process Piping, as may be specified on Piping Data Sheets, and if recommended by piping or fitting manufacturer.

B. Weld Identification: Keep paper record of which welder welded each joint.

C. Pipe End Preparation:

1. Machine Shaping: Preferred.
2. Oxygen or Arc Cutting: Smooth to touch, true, and slag removal by chipping or grinding.
3. Beveled Ends for Butt Welding: ASME B16.25.

D. Surfaces:

1. Clean and free of paint, oil, rust, scale, slag, or other material detrimental to welding.
2. Clean stainless steel joints with stainless steel wire brushes or stainless steel wool prior to welding.
3. Thoroughly clean each layer of deposited weld metal, including final pass, prior to deposition of each additional layer of weld metal with a power-driven wire brush.

E. Alignment and Spacing:

1. Align ends to be joined within existing commercial tolerances on diameters, wall thicknesses, and out-of-roundness.
2. Root Opening of Joint: As stated in qualified welding procedure.
3. Minimum Spacing of Circumferential Butt Welds: Minimum four times pipe wall thickness or 1 inch, whichever is greater.

F. Climatic Conditions:

1. Do not perform welding if there is impingement of any rain, snow, sleet, or wind exceeding 5 mph on the weld area, or if ambient temperature is below 32 degrees F.
2. Stainless Steel and Alloy Piping: If ambient is less than 32 degrees F, local preheating to a temperature warm to the hand is required.

G. Tack Welds: Performed by qualified welder using same procedure as for completed weld, made with electrode similar or equivalent to electrode to be used for first weld pass, and not defective. Remove those not meeting requirements prior to commencing welding procedures.

H. Surface Defects: Chip or grind out those affecting soundness of weld.

I. Weld Quality: Meet requirements of governing welding codes.

3.04 INSTALLATION—GENERAL

A. Join pipe and fittings in accordance with manufacturer’s instructions, unless otherwise shown or specified.

B. Remove foreign objects prior to assembly and installation.

C. Flanged Joints:

1. Install perpendicular to pipe centerline.
2. Bolt Holes: Straddle vertical centerlines, aligned with connecting equipment flanges or as shown.

3. Use torque-limiting wrenches to ensure uniform bearing and proper bolt tightness.
4. Plastic Flanges: Install annular ring filler gasket at joints of raised-face flange.
5. Grooved Joint Flange Adapters: Include stainless steel washer plates as required for mating to serrated faces and lined valves and equipment.
6. Raised-Face Flanges: Use flat-face flange when joining with flat-faced ductile or cast iron flange.
7. Verify compatibility of mating flange to adapter flange gasket prior to selecting grooved adapter flanging.
8. Flange fillers are to be avoided but, if necessary, may be used to make up for small angles up to 6 degrees and for filling gaps up to 2 inches between flanges. Stacked flange fillers shall not be used.
9. Threaded flanged joints shall be shop fabricated and delivered to Site with flanges in-place and properly faced.
10. Manufacturer: Same as pipe manufacturer or grooved joint flange adapter manufacturer.

D. Threaded and Coupled Joints:

1. Conform to ASME B1.20.1.
2. Produce sufficient thread length to ensure full engagement when screwed home in fittings.
3. Countersink pipe ends, ream and clean chips and burrs after threading.
4. Make connections with not more than three threads exposed.
5. Lubricate male threads only with thread lubricant or tape as specified on Piping Data Sheets.

E. Grooved-End Joints:

1. Piping shall be grooved in accordance with manufacturer's latest published instructions and shall be accurately cut with tools conforming to coupling manufacturer's standards and to AWWA C606.
2. Install grooved joint couplings and gaskets in accordance with manufacturer's latest published installation instructions.

F. Soldered Joints:

1. Use only solder specified for particular service.
2. Cut pipe ends square and remove fins and burrs.
3. After thoroughly cleaning pipe and fitting of oil and grease using solvent and emery cloth, apply noncorrosive flux to the male end only.
4. Wipe excess solder from exterior of joint before hardened.
5. Before soldering, remove stems and washers from solder joint valves.

G. Pipe Connections at Concrete Structures: As specified in Article Piping Flexibility Provisions in Section 40 27 01, Process Piping Specialties.

H. PVC and CPVC Piping:

1. Provide Schedule 80 threaded nipple where necessary to connect to threaded valve or fitting.
2. Use strap wrench for tightening threaded plastic joints. Do not overtighten fittings.
3. Do not thread Schedule 40 pipe.

I. Ductile Iron Piping:

1. Cutting Pipe: Cut pipe with milling type cutter, rolling pipe cutter, or abrasive blade cutter. Do not flame cut.
2. Dressing Cut Ends:
   a. General: As required for the type of joint to be made.
   b. Rubber Gasketed Joints: Remove sharp edges or projections.
   c. Push-On Joints: Bevel, as recommended by pipe manufacturer.
   d. Flexible Couplings, Flanged Coupling Adapters, and Grooved End Pipe Couplings: As recommended by the coupling or adapter manufacturer.

3.05 INSTALLATION—EXPOSED PIPING

A. Piping Runs:

1. Parallel to building or column lines and perpendicular to floor, unless shown otherwise.
2. Piping upstream and downstream of flow measuring devices shall provide straight lengths as required for accurate flow measurement.

B. Supports: As specified in Section 40 05 15, Piping Support Systems.

C. Group piping wherever practical at common elevations; install to conserve building space and not interfere with use of space and other work.

D. Unions or Flanges: Provide at each piping connection to equipment or instrumentation on equipment side of each block valve to facilitate installation and removal.

E. Install piping so that no load or movement in excess of that stipulated by equipment manufacturer will be imposed upon equipment connection; install to allow for contraction and expansion without stressing pipe, joints, or connected equipment.

F. Piping clearance, unless otherwise shown:

1. Over Walkway and Stairs: Minimum of 7 feet 6 inches, measured from walking surface or stair tread to lowest extremity of piping system

including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.

2. Between Equipment or Equipment Piping and Adjacent Piping: Minimum 3 feet, measured from equipment extremity and extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
3. From Adjacent Work: Minimum 1 inch from nearest extremity of completed piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
4. Do not route piping in front of or to interfere with access ways, ladders, stairs, platforms, walkways, openings, doors, or windows.
5. Headroom in front of openings, doors, and windows shall not be less than the top of the opening.
6. Do not install piping containing liquids or liquid vapors in transformer vaults or electrical equipment rooms.
7. Do not route piping over, around, in front of, in back of, or below electrical equipment including controls, panels, switches, terminals, boxes, or other similar electrical work.

3.06 INSTALLATION—BURIED PIPE

A. Joints:

1. Dissimilar Buried Pipes:
   a. Provide flexible mechanical compression joints for pressure pipe.
   b. Provide concrete closure collar for gravity piping or as shown.
2. Concrete Encased or Embedded Pipe: Do not encase joints in concrete, unless specifically shown.

B. Placement:

1. Keep trench dry until pipe laying and joining are completed.
2. Pipe Base and Pipe Zone: As specified in Section 31 23 23.15, Trench Backfill.
3. Exercise care when lowering pipe into trench to prevent twisting or damage to pipe.
4. Measure for grade at pipe invert, not at top of pipe.
5. Excavate trench bottom and sides of ample dimensions to permit visual inspection and testing of entire flange, valve, or connection.
6. Prevent foreign material from entering pipe during placement.
7. Close and block open end of last laid pipe section when placement operations are not in progress and at close of day’s work.
8. Lay pipe upgrade with bell ends pointing in direction of laying.
9. Install closure sections and adapters for gravity piping at locations where pipe laying changes direction.
10. Deflect pipe at joints for pipelines laid on a curve using unsymmetrical closure of spigot into bell. If joint deflection of standard pipe lengths

will not accommodate horizontal or vertical curves in alignment, provide:

a. Shorter pipe lengths.
b. Special mitered joints.
c. Standard or special fabricated bends.

11. After joint has been made, check pipe alignment and grade.
12. Place sufficient pipe zone material to secure pipe from movement before next joint is installed.
13. Prevent uplift and floating of pipe prior to backfilling.

C. PVC, CPVC, or HDPE Pipe Placement:

1. Lay pipe snaking from one side of trench to other.
2. Offset: As recommended by manufacturer for maximum temperature variation between time of solvent welding and during operation.
3. Do not lay pipe when temperature is below 40 degrees F, or above 90 degrees F when exposed to direct sunlight.
4. Shield ends to be joined from direct sunlight prior to and during the laying operation**.**

D. Tolerances:

1. Deflection from Horizontal Line except PVC, CPVC, or HDPE: Maximum 2 inches.
2. Deflection From Vertical Grade: Maximum 1/4 inch.
3. Joint Deflection: Maximum of 75 percent of manufacturer's recommendation.
4. Horizontal position of pipe centerline on alignment around curves maximum variation of 1.75 feet from position shown.
5. Pipe Cover: Minimum 3 feet, unless otherwise shown.

3.07 INSTALLATION—CONCRETE ENCASED

A. Provide reinforced concrete pipe encasement where shown on Drawings and where otherwise required. Some piping may be required to be concrete encased for pipe strength requirements that are included in the Specifications. Piping under and within the influence of buildings, utility trenches, vaults, slabs, and other structures shall be concrete encased. See details on Drawings for encasement requirements.

B. Where concrete encased piping crosses structure construction and expansion joints, provide flexible piping joints to coincide with structure joints to prevent excessive pipe stress and breakage.

3.08 PIPE CORROSION PROTECTION

A. Ductile Iron Pipe:

1. Exposed: As specified in Section 09 90 00, Painting and Coating, and as shown in Piping Schedule.
2. Buried: Wrap with polyethylene bagging.
3. Submerged. Embedded or Encased in Flowable Fill: Coat with coal-tar epoxy as specified in Section 09 90 00, Painting and Coating. If in potable water service, use NSF/ANSI 61 approved epoxy.

B. Carbon Steel Pipe:

1. Exposed: As specified in Section 09 90 00, Painting and Coating.
2. Submerged or Embedded: Shop coat with coal-tar epoxy as specified in Section 09 90 00, Painting and Coating. If in potable water service, use NSF/ANSI 61 approved epoxy.

C. PVC and CPVC Pipe, Exposed: As specified in Section 09 90 00, Painting and Coating.

D. Piping Accessories:

1. Exposed:
   a. Field paint black and galvanized steel, brass, copper, and bronze piping components as specified in Section 09 90 00, Painting and Coating, as applicable to base metal material.
   b. Accessories include, but are not limited to, pipe hangers, supports, expansion joints, pipe guides, flexible couplings, vent and drain valves, and fasteners.
2. Buried:
   a. Ferrous Metal and Stainless Steel Components: Coat with coal-tar epoxy as specified in Section 09 90 00, Painting and Coating.
   b. Bolts, Nuts, and Similar Items: Coat with bituminous paint.
   c. Flexible Couplings, Grooved Couplings, and Similar Items: Wrap with heat shrink wrap.
   d. Buried Valves and Similar Elements on Wrapped Pipelines: Coat with bituminous paint and wrap entire valve in polyethylene encasement.
   e. Cement-Coated Pipelines: Cement coat appurtenances same as pipe.

E. Polyethylene Encasement: Install in accordance with AWWA C105/A21.5 and manufacturer’s instructions.

F. Tape Coating System: As specified in Section 09 90 00, Painting and Coating.

G. Heat Shrink Wrap: Apply in accordance with manufacturer's instructions to surfaces that are cleaned, prepared, and primed.

H. Insulating Flanges, Couplings, and Unions:

1. Applications:
   a. Dissimilar metal piping connections.
   b. Cathodically protected piping penetration to buildings and watertight structures.
   c. Submerged to unsubmerged metallic piping connections.
   d. Where required for electrically insulated connection.
2. Pipe Installation:
   a. Insulating joints connecting immersed piping to nonimmersed piping shall be installed above maximum water surface elevation.
   b. Submerged carbon steel, ductile iron, or galvanized piping in reinforced concrete shall be isolated from the concrete reinforcement steel.
   c. Align and install insulating joints as shown on the Drawings and according to manufacturer's recommendations. Bolt lubricants that contain graphite or other metallic or electrically conductive components that can interfere with the insulating capabilities of the completed flange shall not be used.

3.09 THRUST RESTRAINT

A. Location:

1. Buried Piping: Where shown and where required to restrain force developed at pipeline tees, plugs, caps, bends, and other locations where unbalanced forces exist because of hydrostatic testing and normal operating pressure.
2. Exposed Piping: At all joints in piping.

B. Thrust Ties:

1. Steel Pipe: Attach with joint harness specified in Section 40 27 01, Process Piping Specialties**.**
2. Ductile Iron Pipe: Attach with socket clamps anchored against grooved joint coupling or flange.
3. Flanged Coupling Adapters: For exposed installations, install manufacturer's anchor studs through coupling sleeve or use dismantling joints.

C. Mechanical Joint Valve Restraint in Proprietary Restrained Joint Piping: Install pipe joint manufacturer's adapter gland follower and pipe end retainer, or mechanical joint anchor gland follower.

3.10 SLAB, FLOOR, WALL, AND ROOF PENETRATIONS

A. Application and Installation: As specified in Section 40 27 01, Process Piping Specialties.

3.11 BRANCH CONNECTIONS

A. Do not install branch connections smaller than 1/2-inch nominal pipe size, including instrument connections, unless shown otherwise.

B. When line of lower pressure connects to a line of higher pressure, requirements of Piping Data Sheet for higher pressure rating prevails up to and including first block valve in the line carrying the lower pressure, unless otherwise shown.

C. Threaded Pipe Tap Connections:

1. Ductile Iron Piping: Connect only with service saddle or at tapping boss of a fitting, valve body, or equipment casting.
2. Welded Steel or Alloy Piping: Connect only with welded threadolet or half-coupling as specified on Piping Data Sheet.
3. Limitations: Threaded taps in pipe barrel are unacceptable.

3.12 VENTS AND DRAINS

A. Vents and drains at high and low points in piping required for completed system may or may not be shown. Install vents on high points and drains on low points of pipelines as shown.

3.13 INSULATION

A. See Section 40 42 13, Process Piping Insulation.

3.14 FIELD FINISHING

A. Notify Engineer at least 3 days prior to start of surface preparation or coating application work.

B. As specified in Section 09 90 00, Painting and Coating.

3.15 PIPE IDENTIFICATION

A. As specified in Section 10 14 00, Signage and 09 90 00, Painting and Coating.

3.16 FIELD QUALITY CONTROL

A. Pressure Leakage Testing: As specified in Section 40 80 01, Process Piping Leakage Testing.

B. Minimum Duties of Welding Inspector:

1. Job material verification and storage.
2. Qualification of welders.
3. Certify conformance with approved welding procedures.
4. Maintenance of records and preparation of reports in a timely manner.
5. Notification to Engineer of unsatisfactory weld performance within 24 hours of weld test failure.

C. Required Weld Examinations:

1. Perform examinations in accordance with Piping Code, ASME B31.3 for Normal Fluid Service, except that 5 percent of circumferential butt welds shall be random radiographed.
2. Perform examinations for every pipe thickness and for each welding procedure, progressively, for piping covered by this section.
3. Examine at least one of each type and position of weld made by each welder or welding operator.
4. For each weld found to be defective under the acceptance standards or limitations on imperfections contained in the applicable Piping Code, examine two additional welds made by the same welder that produced the defective weld. Such additional examinations are in addition to the minimum required above. Examine, progressively, two additional welds for each tracer examination found to be unsatisfactory.

3.17 CLEANING

A. Following assembly and testing, and prior to final acceptance, flush pipelines, except as stated below, with water at 2.5 fps minimum flushing velocity until foreign matter is removed.

B. Blow clean of loose debris plant process air with compressed air at 4,000 fpm; do not flush with water.

C. If impractical to flush large diameter pipe at 2.5 fps or blow at 4,000 fpm velocity, clean in-place from inside by brushing and sweeping, then flush or blow line at lower velocity.

D. Insert cone strainers in flushing connections to attached equipment and leave in-place until cleaning is complete.

E. Remove accumulated debris through drains 2 inches and larger or by removing spools and valves from piping.

3.18 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this Specification:

1. Piping Schedule.
2. Data Sheets.

Number	Title
40 27 00.01	Cement-Mortar-Lined Ductile Iron Pipe and Fittings
40 27 00.20	Stainless Steel Pipe and Fittings—Thin Wall

END OF SECTION

PIPING SCHEDULE LEGEND

SERVICE

ALP	Air-Low Pressure
FWP	Fire Water Protection
PW	Plant Water
SD	Scum Drain
WAS	Waste Activated Sludge

EXPOSURE

ALL	All
BUR	Buried
EXP	Exposed
SUB	Submerged
ENC	Concrete or Flowable Fill Encased

MATERIAL

CLDI	Cement-Lined Ductile Iron
GLDI	Glass-Lined Ductile Iron
FRPX	Fiberglass Reinforced Plastic Pipe Type (X = 1 to 3)
SST	Stainless Steel

JOINT TYPE

FL	Flanged
GR	Grooved
RM	Restrained Mechanical
W	Welded (including solvent and fusion)

PRESSURE TEST

G	Gravity Service: Test pressure is not shown on gravity services. Test to highest liquid level that pipe can be subject to.
H	Hydrostatic
I	In Service
P	Pneumatic
PC	Test per Uniform Plumbing Code
NA	Not Applicable

Piping Schedule									
Service	**Legend**	**Size(s) (In.)[1]**	**Exposure**	**Piping Material**	**Specification Section**	**Joint Type**	**Lining/ Coating[2]**	**Test Pressure and Type (psig-x), x = Type indicated in Legend**	**Remarks**
Air Low Pressure	ALP	ALL	EXP/SUB	SST	40 27 00.20	W/FL/GR	NA	16 P	
Fire Water Protection	FWP	8”	BUR	CLDI	40 27 00.01	RM	ALL	100 H	
Plant Water	PW	ALL	BUR	CLDI	40 27 00.01	RM	ALL	100 H	
Scum Drain	SD	6”	BUR	GLDI	40 27 00.01	RM	ALL	100 H	
Waste Activated Sludge	WAS	6”	BUR	CLDI	40 27 00.01	RM	ALL	100 H	

[1]“>” Greater Than
“<” Less Than
“<=” Less Than or Equal To
“>=” Greater Than or Equal To
“All” All Sizes

[2]Coating system number as specified in Section 09 90 00, Painting and Coating**,** and as specified in Article Pipe Corrosion Protection.

SECTION 40 27 00.01 CEMENT-MORTAR AND GLASS-LINED DUCTILE IRON PIPE AND FITTINGS	
Item	**Description**
General	Materials in contact with potable water shall conform to NSF 61 acceptance. Pipe manufacturer shall submit certification that source manufacturing facility has been producing ductile iron pipe of specified diameters, dimensions, and standards for a period of not less than 10 years. Testing of pipe required by AWWA C151/A21.51 shall be conducted in testing and laboratory facilities located in the USA and operating under USA laws and regulations. Pipe shall be handled during manufacture and shipped without nesting (without insertion of one pipe inside another).
Pipe	Buried Liquid Service Using Mechanical or Proprietary Restrained Joints: AWWA C111/A21.11, and AWWA C151/A21.51, pressure class conforming to Table 5 and Table 7 for Type 4 trench, 250 psi minimum working pressure. Follower glands shall be ductile iron. Exposed Pipe Using Grooved End and Flange Joints: AWWA C115/A21.15, thickness Class 53 minimum, 250 psi minimum working pressure.
Lining	Cement-mortar: AWWA C104/A21.4. Glass: ASTM B1000.
Fittings	Lined and coated same as pipe. Mechanical: AWWA C110/A21.10, AWWA C111/A21.11, and AWWA C153/A21.53 ductile iron, 250 psi minimum working pressure. Follower glands shall be ductile iron. Proprietary Restrained: AWWA C110/A21.10, AWWA C111/A21.11, and AWWA C153/A21.53, ductile iron, 250 psi minimum working pressure. Restraint shall be achieved with removable metal elements fitted between a welded bar on the pipe barrel and the inside of the joint bell or fitting sizes smaller than 16 inches may be mechanical joint, restrained by anchor gland followers, ductile iron anchor type, wedge action, with break-off tightening bolts. Assembled joints shall be rated for deflection in operation at rated pressure. Rated deflection shall be not less than 1-1/2 degrees for 36-inch and smaller pipe. Rated deflection shall be not less than 1/2 degree for 42-inch and larger pipe. Clow Corp., American Cast Iron Pipe Co., U.S. Pipe. Restrained joints relying on metal teeth molded into the gasket to prevent joint separation under pressure will not be accepted.

SECTION 40 27 00.01 CEMENT-MORTAR AND GLASS-LINED DUCTILE IRON PIPE AND FITTINGS	
Item	**Description**
	Grooved End: AWWA C606 and AWWA C110/A21.10, ductile iron, 250 psi minimum working pressure; Victaulic. Flange: AWWA C110/A21.10 ductile iron, faced and drilled, Class 125 flat face. Gray cast iron will not be allowed.
Joints	Mechanical: 250 psi minimum working pressure. Proprietary Restrained: 150 psi minimum working pressure. Clow Corp., Super-Lock; American Cast Iron Pipe Co., Flex-Ring or Lok-Ring; U.S. Pipe, TR Flex. Grooved End: Rigid type radius cut conforming to AWWA C606, 250 psi minimum working pressure; Victaulic. Flange: Dimensions per AWWA C110/A21.10 flat face, ductile iron, threaded conforming to AWWA C115/A21.15. Gray cast iron will not be allowed. Branch connections 3 inches and smaller, except from glass-lined pipe, shall be made with service saddles as specified in Section 40 27 01, Process Piping Specialties. Branch connections: 3 inches and smaller from glass-lined pipe shall be made with glass-lined tee with a flanged branch for adapting to branch piping.
Couplings	Grooved End: 250 psi minimum working pressure, malleable iron per ASTM A47/A47M or ductile iron per ASTM A536; Victaulic. Grooved End Adapter Flanges: 250 psi minimum working pressure, malleable iron per ASTM A47/A47M or ductile iron per ASTM A536; Victaulic.
Bolting	Mechanical, Proprietary Restrained, and Grooved End Joints: Manufacturer's standard. Flanged: ASTM A307, Grade B carbon steel heavy hex head or stud bolts, ASTM A563, Grade A carbon steel heavy hex head nuts and ASTM F436 hardened steel washers at nuts and bolt heads. Stud bolts are not allowed when bolting to tapped flanges. Torque bolts per gasket manufacturer recommendations. Flanged Joints in Sumps, Wet Wells, and Submerged and Wetted Installations: Type 316 stainless steel, ASTM A320/A320M, Grade B8M heavy hex head or stud bolts; ASTM A194/A194M, Grade 8M heavy hex nuts and ASTM F436 Type 3 alloy washers at

SECTION 40 27 00.01 CEMENT-MORTAR AND GLASS-LINED DUCTILE IRON PIPE AND FITTINGS	
Item	**Description**
	nuts and bolt heads. Stud bolts are not allowed when bolting to tapped flanges. Torque bolts per gasket manufacturer recommendations.
Gaskets	General: Gaskets in contact with potable water shall be NSF ANSI 61 certified. Mechanical and Proprietary Restrained Joints; Water and Sewage Service: Halogenated butyl or EPDM, Shore A hardness durometer 60, conforming to AWWA C111/A21.11. Mechanical and Proprietary Restrained Joints; Hot Air Service: EPDM or Viton, Shore A hardness durometer 60, conforming to AWWA C111/A21.11. Grooved End Joints: Halogenated butyl conforming to ASTM D2000 and AWWA C606. Flanged, Water, Sewage and Hot Air Services: 1/8-inch-thick, homogeneous black rubber (EPDM), hardness 60-80 (Shore A), rated to 275 degrees F, conforming to ASME B16.21 and ASTM D2000. Full face for flat-faced flanges, flat-ring type for raised-face flanges. Blind flanges shall be epoxy-lined in accordance with the system specified above. Gasket pressure rating to equal or exceed the system hydrostatic test pressure.
Joint Lubricant	Manufacturer's standard.

END OF SECTION

SECTION 40 27 00.20 STAINLESS STEEL PIPE AND FITTINGS—THIN WALL		
Item	**Size**	**Description**
Pipe	2-1/2" & smaller	Schedule 40S: ASTM A312/A312M, Type 316 seamless, pickled and passivated.
	3" thru 12"	Schedule 10S: ASTM A778, “as-welded” grade, Type 316L, pickled, and passivated.
	14" & larger	Schedule 10S: ASTM A778, “as-welded” grade, Type 316L, pickled, and passivated.
Joints	1-1/2" & smaller	Threaded or flanged at equipment as required or shown.
	2" thru 12"	Butt-welded or flanged at valves and equipment.
		Provide stainless steel roll-groove coupling system where grooved joints are shown on the Drawings. Type 316 stainless conforming to ASTM A351/A351M, ASTM A743/A743M, ASTM A744/A744M; Grade CF-8M. Victaulic™ Style 489 (rigid) or approved equal.
		*Note: Flexible couplings require additional supports.
	14" thru 24"	Butt-welded or flanged at valves and equipment.
		Provide ductile iron rigid coupling system specifically designed for stainless steel pipe where grooved joints are shown on the Drawings. Housing ASTM A536, Grade 65-45-12, dip galvanized. Victaulic™ Style W89 or approved equal.
		*Note: Wedge-groove not for use in corrosive external atmospheres.

SECTION 40 27 00.20 STAINLESS STEEL PIPE AND FITTINGS—THIN WALL		
Item	**Size**	**Description**
Fittings	1-1/2" & smaller	Threaded: Forged 1,000 CWP minimum, ASTM A182/A182M, Grade F316 or cast Class 150, ASTM A351/A351M, Grade CF8M/316.
	2" thru 2-1/2"	Butt Welded: ASTM A403/A403M, Grade WP316L conforming to ASME B16.9 and MSS SP 43, annealed, pickled and passivated; fitting wall thickness to match adjoining pipe; long radius elbows, unless shown otherwise.
	3" & larger	Butt-Welded: ASTM A774/A774M conforming to MSS SP 43, "as-welded" grade, Type 316L pickled and passivated; fitting wall thickness to match adjoining pipe; long radius elbows, unless shown otherwise.
Branch Connections	1-1/2" & smaller	Tee or reducing tee in conformance with fittings above.
	2" & larger	Butt-welding tee or reducing tee in accordance with fittings above.
Flanges	All	Forged Stainless Steel: ASTM A182/A182M, Grade F316L, ASME B16.5 Class 150 or Class 300, slip-on weld neck or raised face. Weld slip-on flanges inside and outside. Cast Carbon Steel: ASTM A216/A216M Grade WCA, drilled, ASME B16.5 Class 150 or Class 300 Van Stone Type with stainless steel stub ends, ASTM A240/A240M Type 316L "as-welded grade", conforming to MSS SP 43, wall thickness same as pipe. Blind Flanges, exposed to the atmosphere and not buried nor immersed in liquid, may be either stainless steel or Class 125 ductile iron or Class 150 carbon steel with gaskets as specified herein.
Bolting/Nuts	Couplings	Type 316 stainless steel with antigalling coating. ASTM F593, Group 2, Condition CW.

SECTION 40 27 00.20 STAINLESS STEEL PIPE AND FITTINGS—THIN WALL		
Item	**Size**	**Description**
	Flanges	Forged Flanges: Type 316 stainless steel, ASTM A320/A320M Grade B8M hex head bolts, ASTM A194/A194M Grade 8M hex head nuts and ASTM F436 Type 3 alloy washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress. Van Stone Flanges and anywhere mating flange on equipment is cast iron and gasket is flat ring: Carbon steel ASTM A307 Grade B hex head bolts, ASTM A563 Grade A hex head nuts and ASTM F436 hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress. Flanged Joints in Sumps, Wet Wells, and Submerged and Wetted Installations: Type 316 stainless steel, ASTM A320/A320M, Grade B8M hex head bolts and ASTM A194/A194M, Grade 8M hex nuts and ASTM F436 Type 3 alloy washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.
Gaskets	Couplings	Grade "L" Silicone: Temperature range minus 30 degrees F to plus 350 degrees F/minus 34 degrees C to plus 177 degrees C. Dry heat, air without hydrocarbons to plus 350 degrees F/plus 177 degrees C.
	Flanges	Flanged, Hot Air and Fuel Gas Service: 1/8-inch thick, unless otherwise specified, homogeneous black rubber (EPDM), hardness 60 (Shore A), rated to 300 degrees F, conforming to ASME B16.21 and ASTM D1330 Steam Grade. Blind flanges shall be gasketed covering entire inside face with gasket cemented to blind flange.
Thread Lubricant	2" & smaller	General Service: 100 percent virgin PTFE Teflon tape.

END OF SECTION

SECTION 40 27 01
PROCESS PIPING SPECIALTIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250).
   b. B16.5, Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard.
2. American Water Works Association (AWWA):
   a. C110/A21.10, Ductile-Iron and Gray-Iron Fittings.
   b. C153/A21.53, Ductile-Iron Compact Fittings for Water Service.
   c. C210, Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
   d. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
   e. C219, Bolted, Sleeve-Type Couplings for Plain-End Pipe.
   f. Manual M11, Steel Pipe—A Guide for Design and Installation.
3. ASTM International (ASTM):
   a. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   b. A276, Standard Specification for Stainless Steel Bars and Shapes.
4. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.
5. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer’s data on materials, construction, end connections, ratings, overall lengths, and live lengths (as applicable).
2. Manufacturer’s sizing information for expansion joints per locations shown on approved piping layout submittal.

B. Informational Submittals:

1. Coupling Harness:
   a. Details, ratings, calculations and test reports for thrust restraints relying on welded bars or rings.
   b. Weld procedure qualifications.
   c. Load proof-testing report of prototype restraint for any size coupling.

C. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data**.**

1.03 EXTRA MATERIALS (NOT USED)

PART 2 PRODUCTS

2.01 GENERAL

A. Provide required piping specialty items, whether shown or not shown on Drawings, as required by applicable codes and standard industry practice.

B. Rubber ring joints, mechanical joints, flexible couplings, and proprietary restrained ductile iron pipe joints are considered flexible joints; welded, screwed, and flanged pipe joints are not considered flexible.

C. All specialty items connected to or in contact with ALP piping shall be rated for 300 degrees F.

D. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 COUPLINGS

A. General:

1. Coupling linings for use in potable water systems shall be in conformance with NSF/ANSI 61.
2. Couplings shall be rated for working pressure not less than indicated in Piping Schedule for the service and not less than 150 psi.

3. Couplings shall be lined and coated with fusion-bonded epoxy in accordance with AWWA C213.
4. Unless thrust restraint is provided by other means, couplings shall be harnessed in accordance with requirements of AWWA Manual M11 or as shown on Drawings.
5. Sleeve type couplings shall conform to AWWA C219 and shall be hydraulically expanded beyond minimum yield for accurate sizing and proofing of tensile strength.

B. Flexible Sleeve Type Coupling:

1. Manufacturers and Products:
   a. Steel Pipe:
      1) Dresser Piping Specialties; Style 38.
      2) Smith-Blair, Inc.; Style 411.
   b. Ductile Iron Pipe:
      1) Dresser Piping Specialties; Style 253.
      2) Smith-Blair, Inc.; Style 441.

C. Transition Coupling for Steel Pipe:

1. Manufacturers and Products:
   a. Dresser Piping Specialties; Style 162.
   b. Smith-Blair, Inc.; Style 413.

D. Flanged Coupling Adapter:

1. Manufacturers and Products:
   a. Steel Pipe:
      1) Dresser Piping Specialties; Style 128.
      2) Smith-Blair, Inc.; Style 913.
   b. Ductile Iron Pipe:
      1) Dresser Piping Specialties; Style 128.
      2) Smith-Blair, Inc.; Style 912.

E. Restrained Flange Adapter:

1. Pressure Rating:
   a. Minimum Working Pressure Rating: Not less than 150 psi.
   b. Safety Factor: Not less than two times working pressure and shall be supported by manufacturer's proof testing.
2. Thrust Restraint:
   a. Provide hardened steel wedges that bear against and engage outer pipe surface and allow articulation of pipe joint after assembly while wedges remain in their original setting position on pipe surface.
   b. Products employing set screws that bear directly on pipe will not be acceptable.

3. Manufacturer and Product: EBAA Iron Sales Co.; Mega-Flange.

F. Restrained Coupling:

1. Pressure Rating:
   a. Minimum Working Pressure Rating: Not less than 150 psi.
   b. Safety Factor: Not less than two times working pressure and shall be supported by manufacturer's proof testing.
2. Thrust Restraint:
   a. Provide hardened steel wedges that bear against and engage outer pipe surface and allow articulation of pipe joint after assembly while wedges remain in their original setting position on pipe surface.
   b. Products employing set screws that bear directly on pipe will not be acceptable.
3. For use with ductile iron, steel, HDPE or PVC pipe. Provide wall stiffening insert when used with HDPE pipe.
4. Material: Ductile iron conforming to ASTM A536.
5. Manufacturers and Products:
   a. EBAA Iron Sales Co.; Mega-Coupling.
   b. Approved equal.

G. Restrained Dismantling Joints:

1. Pressure Rating:
   a. Minimum working pressure rating shall not be less than rating of the connecting flange.
   b. Proof testing shall conform to requirements of AWWA C219 for bolted couplings.
2. Manufacturers and Products:
   a. Dresser Piping Specialties; Style 131.
   b. Smith Blair, Inc.; Model 975.

H. Exposed Metallic Piping Plain End Couplings:

1. Plain end pipe couplings shall be self-restrained against hydrostatic thrust forces equal to not less than two times the working pressure rating of the coupling. Couplings shall accommodate 4 degrees angular deflection at the time of installation and subsequent to pressurization.
2. Casing, bolts, and nuts shall be Type 316 stainless steel. The sealing sleeve shall be FKM elastomer and rated for 300 degrees F.
3. Couplings manufacturer and products shall be Straub Couplings, Grip-L or Metal Grip, or equal.

2.03 EXPANSION JOINTS

A. Metal Bellows:

1. Type: Single-ply, annular corrugated metal bellows with limit rods. Circumferential convolution welds not permitted.
2. Material: Type 316 stainless steel.
3. End Connections: ASME 150-pound carbon steel flanges.
4. Minimum Design Working Pressure: 50 psig at 300 degrees F.
5. Length: Minimum of eight convolutions and minimum axial compression of 3/4 inches.
6. Axial Compression: Sized for a temperature differential of 300 degrees Fahrenheit. Manufacturer shall size based on locations shown on approved piping layout submittals.
7. Manufacturers and Products:
   a. U.S. Bellows, Inc.; Universal Tied expansion joint.
   b. Metraflex, Model MN.
   c. Senior Flexonics Pathway, Inc.; Expansion Joints.

2.04 SERVICE SADDLES

A. Double-Strap Iron:

1. Pressure Rating: Capable of withstanding 150 psi internal pressure without leakage or over stressing.
2. Run Diameter: Compatible with outside diameter of pipe on which saddle is installed.
3. Taps: Iron pipe threads.
4. Materials:
   a. Body: Malleable or ductile iron.
   b. Straps: Galvanized steel.
   c. Hex Nuts and Washers: Steel.
   d. Seal: Rubber.
5. Manufacturers and Products:
   a. Smith-Blair; Series 313 or 366.
   b. Dresser; Style 91.

2.05 OUTLET/TAPPING SADDLES

A. Materials:

1. Straps: Alloy steel with 3/4-inch threaded ends.
2. Seal: O-Ring SBR rubber gasket.
3. Compatible with ductile iron pipe.

B. Connection: Mechanical joint outlet.

C. Pressure Rating: Capable of withstanding 250 psi internal pressure without leakage over stressing.

D. Manufacturer and Product: American Ductile Iron; Outlet/Tapping Saddle.

2.06 PIPE SLEEVES

A. Steel Pipe Sleeve:

1. Minimum Thickness: 3/16 inch.
2. Seep Ring:
   a. Center steel flange for water stoppage on sleeves in exterior or water-bearing walls, 3/16-inch minimum thickness.
   b. Outside Diameter: Unless otherwise shown, 3 inches greater than pipe sleeve outside diameter.
   c. Continuously fillet weld on each side all around.
3. Factory Finish:
   a. Galvanizing:
      1) Hot-dip applied, meeting requirements of ASTM A153/A153M.
      2) Electroplated zinc or cadmium plating is unacceptable.
   b. Shop Lining and Coating: Factory prepare, prime, and finish coat in accordance with Section 09 90 00, Painting and Coating.

B. Molded Polyethylene Pipe Sleeve:

1. Molded HDPE with integral water stop ring not less than 3 inches larger than sleeve.
2. Provided with end caps for support during concrete placement.
3. Manufacturer and Product: Century-Line, Model CS sleeves as manufactured by PSI-Thunderline/Link-Seal.

C. Insulated and Encased Pipe Sleeve:

1. Manufacturer and Product: Pipe Shields, Inc.; Models WFB, WFB-CS and -CW Series, as applicable.

D. Modular Mechanical Seal:

1. Type: Interconnected synthetic rubber links shaped and sized to continuously fill annular space between pipe and wall sleeve opening.
2. Fabrication:
   a. Assemble interconnected rubber links with ASTM A276, Type 316 stainless steel bolts and nuts.
   b. Pressure plates shall be reinforced nylon polymer.
3. Size: According to manufacturer’s instructions for size of pipes shown to provide a watertight seal between pipe and wall sleeve opening.

4. Temperature: Seals shall be rated for 300 degrees F working temperature.
5. Manufacturer: Thunderline Corp., Link-Seal Division.

2.07 SLAB, FLOOR, WALL AND ROOF PENETRATIONS

A. Ductile Iron Wall Pipe:

1. Diameter, Lining, and Ends: Same as connecting ductile iron pipe.
2. Thickness: Equal to or greater than remainder of pipe in line.
3. Fittings: In accordance with applicable Pipe Data Sheet.
4. Thrust Collars:
   a. Rated for thrust load developed at 250 psi.
   b. Safety Factor: 2, minimum.
   c. Material and Construction: Ductile iron or cast iron, cast integral with wall pipe wherever possible, or thrust rated, welded attachment to wall pipe.
5. Manufacturers:
   a. American Cast Iron Pipe Co.
   b. U.S. Pipe and Foundry Co.

B. Steel or Stainless Steel Wall Pipe:

1. Same material and thickness as connecting pipe, except 1/4-inch minimum thickness.
2. Lining: Same as connecting pipe.
3. Thrust Collar:
   a. Outside Diameter: Unless otherwise shown, 3 inches greater than outside diameter of wall pipe.
   b. Continuously fillet welded on each side all around.

PART 3 EXECUTION

3.01 GENERAL

A. Provide accessibility to piping specialties for control and maintenance.

3.02 PIPING FLEXIBILITY PROVISIONS

A. General:

1. Thrust restraint shall be provided as specified in Section 40 27 00, Process Piping—General.
2. Install flexible couplings to facilitate piping installation, in accordance with approved shop drawings.

B. Flexible Joints at Concrete Backfill or Encasement: Install within 18 inches or one-half pipe diameter, whichever is less, from the termination of any concrete backfill or concrete encasement.

C. Flexible Joints at Concrete Structures: Install 18 inches or less from face of structures; joint may be flush with face.

D. Flexible expansion joints shall be provided to compensate for earth settlement at buried piping connections to structure wall pipes. Wrap complete joint assembly in a double layer of polyethylene encasement, as specified in Section 40 27 00, Process Piping—General.

3.03 PIPING TRANSITION

A. Applications:

1. Provide complete closure assembly where pipes meet other pipes or structures.
2. Pressure Pipeline Closures: Plain end pieces with double flexible couplings, unless otherwise shown.
3. Restrained Joint Pipe Closures: Install with thrust tie-rod assemblies as shown or in accordance with NFPA 24.
4. Gravity Pipe Closures: As specified for pressure pipelines, or concrete closures.
5. Concrete Closures: Use to make connections between dissimilar pipe where standard rubber gasketed joints or flexible couplings are impractical, as approved.
6. Elastomer sleeves bonded to pipe ends are not acceptable.

B. Installation:

1. Flexible Transition Couplings: Install in accordance with coupling manufacturer’s instructions to connect dissimilar pipe and pipes with a small difference in outside diameter.
2. Concrete Closures:
   a. Locate away from structures so there are at least two flexible joints between closure and pipe entering structure.
   b. Clean pipe surface before placing closure collars.
   c. Wet nonmetallic pipe thoroughly prior to pouring collars.
   d. Prevent concrete from entering pipe.
   e. Extend collar a minimum of 12 inches on each side of joint with minimum thickness of 6 inches around outside diameter of pipe.
   f. Make entire collar in one placement.
   g. After concrete has reached initial set, cure by covering with well-moistened earth.

3.04 PIPING EXPANSION

A. Piping Installation: Allow for thermal expansion due to differences between installation and operating temperatures.

B. Expansion Joints:

1. Grooved Joint and Flanged Piping Systems: Metal bellows expansion joint.
2. Nonmetallic Pipe: Teflon bellows expansion joint.
3. Screwed and Soldered Piping Systems: Copper or galvanized and black steel pipe expansion compensator, as applicable.
4. Air and Water Service above 120 Degrees F: Metal bellows expansion joint.
5. Pipe Run Offset: Flexible metal hose.

C. Anchors: Install as specified in Section 40 05 15, Piping Support Systems, to withstand expansion joint thrust loads and to direct and control thermal expansion.

3.05 SERVICE SADDLES

A. Ferrous Metal Piping (except stainless steel): Double-strap iron.

B. Plastic Piping: Nylon-coated iron.

3.06 OUTLET/TAPPING SADDLE

A. Install in accordance with manufacturer's written instructions.

3.07 COUPLINGS

A. General:

1. Install in accordance with manufacturer's written instructions.
2. Before coupling, clean pipe holdback area of oil, scale, rust, and dirt.
3. Do not remove pipe coating. If damaged, repair before joint is made.
4. Application:
   a. Metallic Piping Systems: Flexible couplings, transition couplings, and flanged coupling adapters.
   b. Concrete Encased Couplings: Flexible coupling.

3.08 FLEXIBLE PIPE CONNECTIONS TO EQUIPMENT

A. Install to prevent piping from being supported by equipment, for vibration isolation, and where shown.

B. Product Applications Unless Shown Otherwise:

1. Nonmetallic Piping: Teflon bellows connector.
2. Copper Piping: Flexible metal hose connector.
3. Compressor and Blower Discharge: Metal bellows connector.
4. All Other Piping: Elastomer bellows connector.

C. Limit Bolts and Control Rods: Tighten snug prior to applying pressure to system.

3.09 PIPE SLEEVES

A. Application:

1. As specified in Section 40 27 00, Process Piping—General.
2. Above Grade in Nonsubmerged Areas: Hot-dip galvanized after fabrication.
3. Below Grade or in Submerged or Damp Environments: Shop-lined and coated.
4. Alternatively, Molded Polyethylene Pipe Sleeve as specified may be applied.

B. Installation:

1. Support noninsulating type securely in formwork to prevent contact with reinforcing steel and tie-wires.
2. Caulk joint with specified sealant in non-submerged applications and seal below grade and submerged applications with wall penetration seal.

3.10 SLAB, FLOOR, WALL AND ROOF PENETRATIONS

A. Applications:

1. Watertight and Below Ground Penetrations:
   a. Wall pipes with thrust collars.
   b. Provide taps for stud bolts in flanges to be set flush with wall face.
2. Nonwatertight Penetrations: Pipe sleeves with seep ring.
3. Existing Walls: Rotary drilled holes.
4. Fire-Rated or Smoke-Rated Walls, Floors or Ceilings: Insulated and encased pipe sleeves.

B. Wall Pipe Installation:

1. Isolate embedded metallic piping from concrete reinforcement.
2. Support wall pipes securely by formwork to prevent contact with reinforcing steel and tie-wires.

END OF SECTION

SECTION 40 27 02
PROCESS VALVES AND OPERATORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Gas Association (AGA): 3, Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids.
2. American National Standards Institute (ANSI): Z21.15, Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves.
3. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   b. B16.44, Manually Operated Metallic Gas Valves for Use in Above Ground Piping Systems up to 5 psi.
4. American Society of Sanitary Engineers (ASSE): 1011, Performance Requirements for Hose Connection Vacuum Breakers.
5. American Water Works Association (AWWA):
   a. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   b. C500, Metal-Seated Gate Valves for Water Supply Service.
   c. C504, Rubber-Seated Butterfly Valves, 3 In. (75 mm) Through 72 In. (1,800 mm).
   d. C508, Swing-Check Valves for Waterworks Service, 2-In. Through 24-In. (50-mm Through 600-mm) NPS.
   e. C509, Resilient-Seated Gate Valves for Water Supply Service.
   f. C510, Double Check Valve Backflow Prevention Assembly.
   g. C511, Reduced-Pressure Principle Backflow Prevention Assembly.
   h. C512, Air-Release, Air/Vacuum, and Combination Air Valves for Waterworks Service.
   i. C515, Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service.
   j. C541, Hydraulic and Pneumatic Cylinder and Vane-Type Actuators for Valves and Slide Gates.
   k. C542, Electric Motor Actuators for Valves and Slide Gates.
   l. C550, Protective Interior Coatings for Valves and Hydrants.
   m. C606, Grooved and Shouldered Joints.
   n. C800, Underground Service Line Valves and Fittings.

6. ASTM International (ASTM):
    a. A276, Standard Specification for Stainless Steel Bars and Shapes.
    b. A351/A351M, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
    c. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
    d. A564/A564M, Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes.
    e. B61, Standard Specification for Steam or Valve Bronze Castings.
    f. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
    g. B98/B98M, Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.
    h. B127, Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip.
    i. B139/B139, Standard Specification for Phosphor Bronze Rod, Bar and Shapes.
    j. B164, Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire.
    k. B194, Standard Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar.
    l. B584, Standard Specification for Copper Alloy Sand Castings for General Applications.
    m. D429, Standard Test Methods for Rubber Property-Adhesion to Rigid Substrates.
    n. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
7. Canadian Standards Association, Inc. (CSA): 9.1, Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves.
8. Chlorine Institute (CI): Pamphlet 6, Piping Systems for Dry Chlorine.
9. FM Global (FM).
10. Food and Drug Administration (FDA).
11. International Association of Plumbing and Mechanical Officials (IAPMO).
12. Manufacturers Standardization Society (MSS):
    a. SP-80, Bronze Gate, Globe, Angle, and Check Valves.
    b. SP-81, Stainless Steel, Bonnetless, Flanged Knife Gate Valves.
    c. SP-85, Gray Iron Globe and Angle Valves, Flanged and Threaded Ends.
    d. SP-88, Diaphragm Valves.
    e. SP-110, Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.
13. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).

14. NSF International (NSF):
    a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
    b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
15. Underwriters Laboratories (UL).
16. USC Foundation for Cross-Connection Control and Hydraulic Research.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
    a. Product data sheets for each make and model. Indicate valve Type Number, applicable Tag Number, and facility name/number or service where used.
    b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
    c. Power and control wiring diagrams, including terminals and numbers.
    d. For each power actuator provided, manufacturer's standard data sheet, with application specific features and options clearly identified.
    e. Sizing calculations for open-close/throttle and modulating valves.
    f. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, for:
    a. Electric actuators; full compliance with AWWA C542.
    b. Butterfly valves; full compliance with AWWA C504.
3. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
4. Tests and inspection data.
5. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
6. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

PART 2 PRODUCTS

2.01 GENERAL

A. Valves to include operator, actuator, handwheel, chain wheel, extension stem, floor stand, operating nut, chain, wrench, and accessories to allow a complete operation from the intended operating level.

B. Valve to be suitable for intended service. Renewable parts not to be of a lower quality than specified.

C. Valve same size as adjoining pipe, unless otherwise called out on Drawings or in Supplements.

D. Valve ends to suit adjacent piping.

E. Resilient seated valves shall have no leakage (drip-tight) in either direction at valve rated design pressure. All other valves shall have no leakage (drip-tight) in either direction at valve rated design pressure, unless otherwise allowed for in this section or in stated valve standard.

F. Size operators and actuators to operate valve for full range of pressures and velocities.

G. Valve to open by turning counterclockwise, unless otherwise specified.

H. Factory mount operator, actuator, and accessories.

I. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 SCHEDULE

A. Additional requirements relative to this section are shown on Electric Actuated Valve Schedule located at the end of this section.

2.03 MATERIALS

A. Bronze and brass valve components and accessories that have surfaces in contact with water to be alloys containing less than 16 percent zinc and 2 percent aluminum.

1. Approved alloys are of the following ASTM designations: B61, B62, B98/B98M (Alloy UNS No. C65100, C65500, or C66100), B139/B139M (Alloy UNS No. C51000), B584 (Alloy UNS No. C90300 or C94700), B164, B194, and B127.
2. Stainless steel Alloy 18-8 may be substituted for bronze.

B. Valve materials in contact with or intended for drinking water service to meet the following requirements:

1. Materials to comply with requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements.
2. Coatings materials to be formulated from materials deemed acceptable to NSF/ANSI 61.

2.04 FACTORY FINISHING

A. General:

1. Interior coatings for valves and hydrants shall be in accordance with AWWA C550, unless otherwise specified.
2. Exterior coating for valves and hydrants shall be in accordance with Section 09 90 00, Painting and Coating.
3. Material in contact with potable water shall conform to NSF/ANSI 61.
4. Exposed safety isolation valves and lockout valves with handles, handwheels, or chain wheels shall be “safety yellow.”

B. Where epoxy lining and coating are specified, factory finishing shall be as follows:

1. In accordance with AWWA C550.
2. Either two-part liquid material or heat-activated (fusion) material except only heat-activated material if specified as “fusion” or “fusion bonded” epoxy.
3. Minimum 7-mil dry film thickness except where limited by valve operating tolerances.

2.05 VALVES

A. Ball Valves:

1. Type V300 Ball Valve 3 Inches and Smaller for General Water and Air Service:
   a. Two-piece, standard port, NPT threaded ends, bronze body and end piece, hard chrome-plated solid bronze or brass ball, RTFE seats and packing, blowout-proof stem, adjustable packing gland, zinc-coated steel hand lever operator with vinyl grip, rated 600-pound WOG, 150-pound SWP, complies with MSS SP-110.
   b. Manufacturers and Products:
      1) Threaded:
         a) Conbraco Apollo; 70-100.
         b) Nibco; T-580-70.
      2) Soldered:
         a) Conbraco Apollo; 70-200.
         b) Nibco; S-580-70.

B. Butterfly Valves:

1. General:
   a. AWWA C504 valves shall meet the following requirements:
      1) Suitable for throttling operations and infrequent operation after periods of inactivity.
      2) Elastomer seats which are bonded or vulcanized to the body shall have adhesive integrity of bond between seat and body assured by testing, with minimum 75-pound pull in accordance with ASTM D429, Method B.
      3) Bubble-tight with rated pressure applied from either side. Test valves with pressure applied in both directions.
      4) No travel stops for disc on interior of body.
      5) Self-adjusting V-type or O-ring shaft seals.
      6) Isolate metal-to-metal thrust bearing surfaces from flowstream.
      7) Provide traveling nut or worm gear actuator with handwheel. Valve actuators to meet the requirements of AWWA C504.
      8) Buried service operators shall withstand 450 foot-pounds of input torque at fully open and fully closed positions.
      9) Provide linings and coatings per AWWA, unless otherwise indicated on Drawings or specified herein.
      10) Valves to be in full compliance with NSF/ANSI 61.
   b. Non-AWWA butterfly valves to meet the following actuator requirements:
      1) For above ground installations, provide handle and notch plate for valves 6 inches and smaller and heavy-duty, totally enclosed gearbox type operators with handwheel, position

indicator and travel stops for valves 8 inches and larger, unless otherwise indicated on Drawings or specified herein.

2. Type V510 Lug Style Butterfly Valve, Resilient Seated, 2 Inches to 24 Inches for Low Pressure Process Air Service:
   a. Lug style cast-iron body, aluminum bronze discs, Type 316 stainless steel one-piece stem, self-lubricating sleeve type bushings, FKM replaceable resilient seat suitable for operating temperatures up to 400 degrees F, 150 psi working pressure rating, bubble-tight at 50 psi differential pressure, valve body to fit between ASME B16.1 Class 125/150 flanges.
   b. Manufacturers and Products:
      1) Bray Controls; Series 31.
      2) Tyco/Keystone; Model AR2.
3. Type V511 Flanged Style Butterfly Valve, Resilient Seated, 24 Inches to 48 Inches for Low Pressure Process Air Service:
   a. Flanged style cast-iron body, aluminum bronze discs, Type 304 stainless steel one-piece stem, self-lubricating bronze sleeve type bearing, FKM replaceable resilient seat suitable for operating temperatures up to 400 degrees F, 150 psi working pressure, rating, bubble-tight at 50 psi differential pressure, externally adjustable bronze packing gland with Buna N packing, valve body to fit between ASME B16.1 Class 125/150 flanges.
   b. Manufacturers and Products:
      1) Bray Controls; Series 35.
      2) Tyco/Keystone; Figure 106.

2.06 OPERATORS AND ACTUATORS

A. Manual Operators:

1. General:
   a. For AWWA valves, operator force not to exceed requirements of applicable valve standard. Provide gear reduction operator when force exceeds requirements.
   b. For non-AWWA valves, operator force not to exceed applicable industry standard or 80 pounds, whichever is less, under operating condition, including initial breakaway. Provide gear reduction operator when force exceeds requirements.
   c. Operator self-locking type or equipped with self-locking device.
   d. Position indicator on quarter-turn valves.
   e. Worm and gear operators one-piece design, worm-gears of gear bronze material. Worm of hardened alloy steel with thread ground and polished. Traveling nut type operator's threaded steel reach rod with internally threaded bronze or ductile iron nut.
2. Exposed Operator:
   a. Galvanized and painted handwheel.
   b. Cranks on gear type operator.

c. Chain wheel operator with tieback, extension stem, floor stand, and other accessories to permit operation from normal operation level.
d. Valve handles to take a padlock and wheels a chain and padlock.

3. Buried Operator:
   a. Buried service operators on valves larger than 2-1/2 inches shall have a 2-inch AWWA operating nut. Buried operators on valves 2 inches and smaller shall have cross handle for operation by forked key. Enclose moving parts of valve and operator in housing to prevent contact with the soil.
   b. Buried service operators to be grease packed and gasketed to withstand submersion in water to 20 feet minimum.
   c. Buried valves shall have extension stems, bonnets, and valve boxes.

B. Electric Operators, 120 Volts:

1. General:
   a. Unit shall be low profile to reduce amount of required space and weigh 15 pounds or less.
   b. Size to 1-1/2 times required operating torque. Motor stall torque not to exceed torque capacity of the valve.
   c. Provide operator mounting bracket to mount operator to valve providing minimal torque to piping system when operating.
   d. Provide non-intrusive electronic actuators. Mechanical type actuators will not be accepted.
2. Operator Operation, General:
   a. Suitable for full 90-degree rotation of quarter-turn valves.
   b. Manually override handwheel.
   c. Mechanical valve position indication.
3. Electronic Control:
   a. Torque Limiting Switches: Two single pole, double throw mechanical switches. Switches operate at any point in valve travel.
   b. Jammed-valve detection and protection.
   c. Motor over-temperature detection and protection.
   d. Travel limit switches, single pole double throw.
4. Open-Close (O/C) Service:
   a. Duty cycle for intermittent ON-OFF operation shall be 25 percent.
   b. Operator shall power to OPEN and power to CLOSE.
   c. Local Indication and Control:
      1) Integral mechanical valve POSITION indication, 0 percent to 100 percent OPENED.
      2) Integral OPENED and CLOSED indication lights.
      3) Integral LOCAL-OFF-REMOTE (L-O-R).

4) Integral OPEN maintained switch which causes the valve to stroke full OPENED, even if OPEN switch is released, while L-O-R switch is in LOCAL.
5) Integral CLOSE maintained switch which causes valve to stroke full CLOSED, even if CLOSED switch is released, while L-O-R switch is in LOCAL.
6) Sealed terminal compartment.

d. Remote Indication and Control:
1) Relay contact that closes when valve is capable of being controlled remotely (L-O-R switch in REMOTE) for connection to and monitoring by plant control system.
2) Limit switch that closes when valve is fully OPENED for connection to and monitoring by plant control system.
3) Limit switch that closes when valve is fully CLOSED for connection to and monitoring by plant control system.

e. Modulating (M) Service:
1) Operator rated for continuous duty with servo shall be rated for 100 percent modulating operation.
2) Operator shall modulate based on an externally applied 4 mA to 20 mA dc signal.
3) Operator shall be equipped with an electronic servo module for valve modulation.
a) Module shall provide serial communications with provided cable for setup of valve operation.

f. Local Indication and Control:
1) Integral mechanical valve POSITION indication, 0 percent to 100 percent OPENED.
2) Integral OPENED and CLOSED indication lights.
3) Integral LOCAL-OFF-REMOTE (L-O-R).
4) Integral OPEN momentary switch which causes valve to stroke towards OPENED, as long as OPEN switch is held, while L-O-R switch is in LOCAL.
5) Integral CLOSE momentary switch which causes valve to stroke towards CLOSED, as long as CLOSED switch is held, while L-O-R switch is in LOCAL.
6) Position valve proportionally 0 to 100 percent OPEN with external 4 mA to 20 mA dc signal while in REMOTE.
7) Sealed terminal compartment.

g. Remote Indication and Control:
1) Relay contact that closes when valve is capable of being controlled remotely (L-O-R switch in REMOTE) for connection to and monitoring by plant control system.
2) Limit switch that closes when valve is fully OPENED for connection to and monitoring by plant control system.
3) Limit switch that closes when valve is fully CLOSED for connection to and monitoring by plant control system.

4) Current Position Transmitter, 4 mA to 20 mA dc signal in proportion to 0 percent to 100 percent OPENED, with 0.5 percent accuracy and 0.5 percent repeatability, capable of driving a 750-ohm load, for connection to and monitoring by Plant Control System.

5. Control Features: Electric motor actuators with features as noted above, and as modified/supplemented in Electric Actuated Valve Schedule.
6. Manufacturer and Product:
   a. Rotork.
   b. Limitorque.

C. Electric Motor Actuators, 480 Volts:

1. General:
   a. Comply with latest version of AWWA C542.
   b. Size to 1-1/2 times required operating torque. Motor stall torque not to exceed torque capacity of valve.
   c. Controls integral with actuator and fully equipped as specified in AWWA C542.
   d. Stem protection for rising stem valves.
2. Actuator Operation—General:
   a. Suitable for full 90-degree rotation of quarter-turn valves or for use on multiturn valves, as applicable.
   b. Manual override handwheel.
   c. Valve position indication.
   d. Operate from FULL CLOSED to FULL OPEN positions or the reverse in the number of seconds given in Electric Actuated Valve Schedule.
   e. Nonintrusive Electronic Control: Local controls, diagnostics, and calibration, including limit and torque settings, shall be accomplished nonintrusively. Electronic valve position display with capability to show continuous torque output. If applicable, provide two hand-held configuration units for every 10 actuators provided, two minimum.
3. Open-Close(O/C)/Throttling(T) Service:
   a. Size motors for one complete OPEN-CLOSE-OPEN cycle no less than once every 10 minutes.
   b. Actuator suitable for throttling operation of valve at intermediate positions.
   c. LOCAL-OFF-REMOTE Selector Switch, padlockable in each position:
      1) Integral OPEN-STOP-CLOSE momentary pushbuttons with seal-in circuits to control valve in LOCAL position.
      2) Remote OPEN-STOP-CLOSE momentary control dry contact inputs in REMOTE position. Integral seal-in circuits for remote OPEN and CLOSE commands; valve travel stops when remote STOP contact opens.

3) Auxiliary contact that closes in REMOTE position.
d. OPEN and CLOSED indicating lights.
e. Integral reversing motor starter with built-in overload protection.
f. Sealed terminal compartment.

4. Modulating (M) Service:
a. Size actuators for continuous modulating duty.
b. Feedback potentiometer, or equivalent, and integral electronic positioner/comparator circuit to maintain valve position.
c. HAND-OFF-AUTO (Local-Off-Remote) Selector Switch, padlockable in each position:
1) Integral OPEN-STOP-CLOSE momentary pushbuttons with seal-in circuits to control valve in HAND (Local) position.
2) 4 mA to 20 mA dc input signal to control valve in AUTO (Remote) position.
3) Auxiliary contact that closes in AUTO (Remote) position.
d. OPEN and CLOSED indicating lights.
e. Ac motor with solid state reversing starter or dc motor with solid state reversing controller, and built-in overload protection. Controller capable of 1,200 starts per hour.
f. Duty cycle limit timer and adjustable band width, or equivalent, to prevent actuator hunting.
g. Valve position output converter that generates isolated 4 mA to 20 mA dc signal in proportion to valve position and is capable of driving into loads of up to 500 ohms at 24 volts dc.
h. Sealed terminal compartment.

5. Limit Switch:
a. Single-pole, double-throw (SPDT) type, field adjustable, with contacts rated for 5 amps at 120 volts ac.
b. Each valve actuator to have a minimum of two auxiliary transfer contacts at end position, one for valve FULL OPEN and one for valve FULL CLOSED.
c. Housed in actuator control enclosure.

6. Control Features: Electric motor actuators with features as noted above, and as modified/supplemented in Electric Actuated Valve Schedule.

7. Manufacturers and Products:
a. Rotork Controls; IQ Series.
b. Flowserve Limitorque; MX Series.

2.07 ACCESSORIES

A. Tagging: 1-1/2-inch diameter heavy brass or stainless steel tag attached with No. 16 solid brass or stainless steel jack chain for each valve operator, bearing valve tag number shown on Electric Actuated Valve Schedule.

B. Limit Switch:

1. Factory installed NEMA 4X limit switch by actuator manufacturer.
2. SPST, rated at 5 amps, 120 volts ac.

C. Chain Wheel and Guide:

1. Handwheel direct-mount type.
2. Complete with chain.
3. Galvanized or cadmium-plated.
4. Manufacturers and Products:
   a. Clow Corp.; Figure F-5680.
   b. Walworth Co.; Figure 804.
   c. DeZurik Corp.; Series W or LWG.

PART 3 EXECUTION

3.01 INSTALLATION

A. Flange Ends:

1. Flanged valve bolt holes shall straddle vertical centerline of pipe.
2. Clean flanged faces, insert gasket and bolts, and tighten nuts progressively and uniformly.

B. Screwed Ends:

1. Clean threads by wire brushing or swabbing.
2. Apply joint compound.

C. PVC and CPVC Valves: Install using solvents approved for valve service conditions.

D. Valve Installation and Orientation:

1. General:
   a. Install valves so handles operate from fully open to fully closed without encountering obstructions.
   b. Install valves in location for easy access for routine operation and maintenance.
   c. Install valves per manufacturer's recommendations.
2. Gate, Globe, and Ball Valves:
   a. Install operating stem vertical when valve is installed in horizontal runs of pipe having centerline elevations 4 feet 6 inches or less above finished floor, unless otherwise shown.
   b. Install operating stem horizontal in horizontal runs of pipe having centerline elevations greater than 4 feet 6 inches above finish floor, unless otherwise shown.

3. Eccentric Plug Valves:
    a. Unless otherwise restricted or shown on Drawings, install valve as follows:
        1) Liquids with suspended solids service with horizontal flow: Install valve with stem in horizontal position with plug up when valve is open. Install valve with seat end upstream (flow to produce unseating pressure).
        2) Liquids with suspended solids service with vertical flow: Install valve with seat in highest portion of valve (seat up).
        3) Clean Liquids and Gas Service: Install valve with seat end downstream of higher pressure when valve is closed (higher pressure forces plug into seat).
4. Butterfly Valves:
    a. Unless otherwise restricted or shown on Drawings, install valve a minimum of 8 diameters downstream of a horizontal elbow or branch tee with shaft in horizontal position.
    b. For vertical elbow or branch tee immediately upstream of valve, install valve with shaft in vertical position.
    c. For horizontal elbow or branch tee immediately upstream of valve, install valve with shaft in horizontal position.
    d. When installed immediately downstream of swing check, install valve with shaft perpendicular to swing check shaft.
    e. For free inlet or discharge into basins and tanks, install valve with shaft in vertical position.
5. Check Valves:
    a. Install valve in accordance with manufacturer's instructions and provide required distance from immediate upstream fitting.
    b. Install valve in vertical flow (up) piping only for gas services.
    c. Install swing check valve with shaft in horizontal position.
    d. Install double disc swing check valve to be perpendicular to flow pattern when discs are open.
6. Solenoid Valves: Install in accordance with manufacturer's instructions.

E. Install line size ball valve and union upstream of each solenoid valve, in-line flow switch, or other in-line electrical device, excluding magnetic flowmeters, for isolation during maintenance.

F. Locate valve to provide accessibility for control and maintenance. Install access doors in finished walls and plaster ceilings for valve access.

G. Extension Stem for Operator: Where depth of valve operating nut is 3 feet or greater below finish grade, furnish operating extension stem with 2-inch operating nut to bring operating nut to a point within 6 inches of finish grade.

H. Torque Tube: Where operator for quarter-turn valve is located on floor stand, furnish extension stem torque tube of a type properly sized for maximum torque capacity of valve.

I. Floor Box and Stem: Steel extension stem length shall locate operating nut in floor box.

J. Chain Wheel and Guide: Install chain wheel and guide assemblies or chain lever assemblies on manually operated valves over 6 feet 9 inches above finish floor. Install chain to within 3 feet of finish floor. Where chains hang in normally traveled areas, use appropriate "L" type tie-back anchors. Install chains to within operator horizontal reach of 2 feet 6 inches maximum, measured from normal operator standing location or station.

3.02 TESTS AND INSPECTION

A. Valve may be either tested while testing pipelines, or as a separate step.

B. Test that valves open and close smoothly under operating pressure conditions. Test that two-way valves open and close smoothly under operating pressure conditions from both directions.

C. Inspect air and vacuum valves as pipe is being filled to verify venting and seating is fully functional.

D. Count and record number of turns to open and close valve, account for discrepancies with manufacturer's data.

E. Set, verify, and record set pressures for relief and regulating valves.

F. Automatic valves to be tested in conjunction with control system testing. Set opening and closing speeds, limit switches, as required or recommended by Engineer.

G. Test hydrostatic relief valve seating; record leakage. Adjust and retest to maximum leakage of 0.1 gpm per foot of seat periphery.

3.03 MANUFACTURER'S SERVICES

A. Valve(s) as listed below require manufacturer's field services:

1. V510.
2. V514.

B. Manufacturer's Representative: Present at Site for minimum person-days listed below, travel time excluded:

1. 4 person-days for installation assistance and inspection.
2. 4 person-days for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.

C. See Section 01 43 33, Manufacturers' Field Services, and Section 01 91 14, Equipment Testing and Facility Startup.

3.04 SUPPLEMENTS

A. The supplements listed below, following “End of Section,” are part of this Specification.

1. Electric Actuated Valve Schedule.

END OF SECTION

Electric Actuated Valve Schedule									
Tag Number	**Valve Type**	**Actuator Power Supply**	**Valve Size (inches)**	**Process Fluid**	**Maximum Operating Flow (scfm)**	**Maximum ΔP (psi)**	**Service**	**Travel Time (Seconds)**	**Control Feature Modifications/ Supplements**
FCV-21-3-1A	V510	120-volt, single-phase	6	ALP	2250	1	M	30	C, G, L
FCV-21-3-1B	V510	120-volt, single-phase	6	ALP	2250	1	M	30	C, G, L
FCV-21-3-2A	V510	120-volt, single-phase	6	ALP	2250	1	M	30	C, G, L
FCV-21-3-2B	V510	120-volt, single-phase	6	ALP	2250	1	M	30	C, G, L
FCV-21-3-3A	V510	120-volt, single-phase	6	ALP	2250	1	M	30	C, G, L
FCV-21-3-3B	V510	120-volt, single-phase	6	ALP	2250	1	M	30	C, G, L
FCV-21-3-4A	V510	120-volt, single-phase	6	ALP	2250	1	M	30	C, G, L
FCV-21-3-4B	V510	120-volt, single-phase	6	ALP	2250	1	M	30	C, G, L
FCV-21-4-1	V510	120-volt, single-phase	8	ALP	3750	1	M	30	C, G, L
FCV-21-4-2	V510	120-volt, single-phase	8	ALP	3750	1	M	30	C, G, L
FCV-21-4-3	V510	120-volt, single-phase	8	ALP	3750	1	M	30	C, G, L
FCV-21-4-4	V510	120-volt, single-phase	8	ALP	3750	1	M	30	C, G, L

Electric Actuated Valve Schedule									
Tag Number	**Valve Type**	**Actuator Power Supply**	**Valve Size (inches)**	**Process Fluid**	**Maximum Operating Flow (scfm)**	**Maximum ΔP (psi)**	**Service**	**Travel Time (Seconds)**	**Control Feature Modifications/ Supplements**
FCV-21-5-1	V510	120-volt, single-phase	5	ALP	1310	1	M	30	C, G, L
FCV-21-5-2	V510	120-volt, single-phase	5	ALP	1310	1	M	30	C, G, L
FCV-21-5-3	V510	120-volt, single-phase	5	ALP	1310	1	M	30	C, G, L
FCV-21-5-4	V510	120-volt, single-phase	5	ALP	1310	1	M	30	C, G, L
FCV-21-6-1	V510	120-volt, single-phase	5	ALP	1350	1	M	30	C, G, L
FCV-21-6-2	V510	120-volt, single-phase	5	ALP	1350	1	M	30	C, G, L
FCV-21-6-3	V510	120-volt, single-phase	5	ALP	1350	1	M	30	C, G, L
FCV-21-6-4	V510	120-volt, single-phase	5	ALP	1350	1	M	30	C, G, L

Electric Actuated Valve Schedule									
Tag Number	**Valve Type**	**Actuator Power Supply**	**Valve Size (inches)**	**Process Fluid**	**Maximum Operating Flow (scfm)**	**Maximum ΔP (psi)**	**Service**	**Travel Time (Seconds)**	**Control Feature Modifications/ Supplements**

Service: O/C = Open-Close, T = Throttling, M = Modulating

Control Feature Modifications/Supplements:

A = Actuator shall open valve upon loss of signal.

B = Actuator shall close valve upon loss of signal.

C = Actuator shall remain in last position upon loss of signal.

D = Local OPEN-CLOSE momentary pushbuttons that must be continuously depressed to initiate/maintain valve travel; travel stops when pushbutton is released or when end of travel limit is reached.

E = Remote OPEN-CLOSE maintained dry contacts; travel stops when remote contact opens, or when end of travel limit is reached.

F = Three 24-volt dc interposing relays for remote OPEN-STOP-CLOSE control. Relays powered externally, thereby permitting valve control from greater distances.

G = Motor and control enclosure(s) NEMA 250, Type 4X with 120-volt space heaters.

H = Motor and control enclosure(s) NEMA 250, Type 6 (IP 68) with 120-volt space heaters.

I = Motor and control enclosure(s) NEMA 250, Type 7 with 120-volt space heaters.

J = Valve position output converter that generates isolated 4 mA to 20 mA dc signal in proportion to valve position, and is capable of driving into loads of up to 500 ohms at 24 volts dc.

K = 120-volt secondary control power transformer.

L = Externally operable power disconnect switch.

SECTION 40 42 13
PROCESS PIPING INSULATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Heating, Refrigerating and Air Conditioning Engineers Inc. (ASHRAE): 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
2. ASTM International (ASTM):
   a. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   b. C165, Standard Test Method for Measuring Compressive Properties of Thermal Insulations.
   c. C177, Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
   d. C518, Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
   e. C534/C534M, Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
   f. C547, Standard Specification for Mineral Fiber Pipe Insulation.
   g. C552, Standard Specification for Cellular Glass Thermal Insulation.
   h. C585, Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing.
   i. C1136, Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
   j. C1729, Standard Specification for Aluminum Jacketing for Insulation.
   k. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
   l. E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials.
3. International Code Council (ICC): International Energy Conservation Code (IECC).
4. Underwriters Laboratories Inc. (UL).

1.02 SUBMITTALS

A. Action Submittals: Manufacturer's descriptive literature.

B. Informational Submittals: Maintenance information.

PART 2 PRODUCTS

2.01 PIPE AND FITTING INSULATION

A. Type 1—Elastomeric:

1. Material: Flexible elastomeric pipe insulation, closed-cell structure in accordance with ASTM C534/C534M.
2. Temperature Rating: Minus 297 degrees F to 220 degrees F.
3. Nominal Density: 3 pcf to 6 pcf.
4. Conductivity in accordance with ASHRAE 90.1 and maximum numerical value of 0.25 Btu-in./hr-square foot degrees F at 75 degrees F per ASTM C177 or ASTM C518.
5. Maximum water vapor transmission of 0.06 perm-inch per ASTM E96/E96M, Procedure A.
6. Joints: Manufacturer's adhesive.
7. Flame Spread Rating: Less than 25 per ASTM E84.
8. Smoke Developed Index: Less than 50 per ASTM E84.
9. Manufacturers and Products:
   a. Nomaco; K-Flex.
   b. Armacell; AP Armaflex.

B. Type 2—Fiberglass:

1. Material: UL rated, preformed, sectional bonded fiberglass per ASTM C585 with factory applied, Kraft paper with aluminum foil vapor barrier jacket with pressure-sensitive, self-sealing lap.
2. Insulation Temperature Rating: Zero to 850 degrees F.
3. Conductivity in accordance with ASHRAE 90.1 and maximum numerical value of 0.23 Btu-in./hr-square foot degrees F at 75 degrees F.
4. Jacketing per ASTM C1136 with minimum water vapor transmission for jacket of 0.02 perm-inch per ASTM E96/E96M. Furnish with no jacket if field finish system specified.
5. Joints: Matching pressure-sensitive butt strips for sealing circumferential joints.
6. Flame Spread Rating: Less than 25 per ASTM E84.
7. Smoke Developed Index: Less than 50 per ASTM E84.
8. Manufacturers and Products:
   a. Owens Corning Fiberglass; ASJ/SSL-11.
   b. John Manville; Micro-Lok with Jacket.

C. Type 3—Foamglass:

1. Material: Cellular glass per ASTM C552.
2. Nominal Density: 7.5 pcf.
3. Compressive Strength: 90 psi per ASTM C165.
4. Temperature Rating: Minus 290 degrees F to 900 degrees F.
5. Conductivity in accordance with ASHRAE 90.1 and maximum numerical value of 0.29 Btu-in./hr-square foot degrees F.
6. Minimum water vapor transmission for insulation of 0.00 perm-inch per ASTM E96/E96M.
7. Joints: Matching pressure-sensitive butt strips for sealing circumferential joints.
8. Flame Spread Rating: 0 per ASTM E84.
9. Smoke Developed Index: 0 per ASTM E84.
10. Follow manufacturer's recommendation, based upon temperature of piping to be insulated.
11. Manufacturer and Product: Pittsburgh Corning; Foamglas One.

2.02 ROOF DRAIN AND OVERFLOW DRAIN SUMP INSULATION

A. Type 1: 1 inch thick.

2.03 INSULATION AT PIPE HANGERS AND SUPPORTS

A. Refer to Section 40 05 15, Piping Support Systems.

B. Copper, Ductile Iron, and Nonmetallic Pipe: High-density insert, thickness equal to adjoining insulation of Type 3 or other rigid insulation or manufactured pre-insulated pipe hanger and insulation shield. Extend insert beyond shield.

C. Steel Pipe: Insulation saddle or high-density insert, thickness equal to adjoining insulation of Type 3 or other rigid insulation or manufactured pre-insulated pipe hanger and insulation shield at support location. Extend insert beyond shield.

2.04 INSULATION FINISH SYSTEMS

A. Type F1—PVC:

1. Polyvinyl chloride (PVC) jacketing, minimum 20 mils indoors and 30 mils outdoors, for straight run piping and fitting locations, temperatures to 140 degrees F.
2. Color: PVC jacketing shall be color coded to match colors listed in pipe schedule where suitable matching colors are available. If no suitable colors are available jacketing shall be white.
3. Flame Spread Rating: 25 per ASTM E84.
4. Smoke Developed Index: 50 per ASTM E84.

5. Manufacturers and Products:
    a. Knauf Insulation; Proto 1000.
    b. Johns Manville; Zeston 2000 or 300.
    c. Speedline; 25/50 Smoke-Safe.

B. Type F2—Paint:

1. Type 1 Insulation: Acrylic latex paint, white, and suitable for outdoor use.
    a. Manufacturer and Product: Armacell; WB Armaflex finish.
2. Type 2 Insulation: In accordance with Section 09 90 00, Painting and Coating.

C. Type F3—Aluminum:

1. Aluminum Roll Jacketing: For straight run piping, wrought aluminum Alloy 3003, 5005, 1100, or 3105 to ASTM B209 with H-14 temper, in accordance with ASTM C1729, minimum 0.016-inch thickness, with smooth mill finish.
2. Vapor Barrier: Provide factory applied vapor barrier, heat and pressure bonded to inner surface of aluminum jacketing.
3. Fitting Covers: Material as for aluminum roll jacketing, premolded, one or two piece covers, which includes elbows, tee/valves, end caps, mechanical line couplings, and specialty fittings.
4. Manufacturers:
    a. RPR Products; Insul-Mate.
    b. ITW, Pabco-Childers.

D. Type F4—Foamglass Jacketing:

1. Type 3 Insulation—Buried and Up to 1 Foot Above Grade: 70-mil bituminous resin with woven, glass fabric, aluminum foil layer, and plastic film coating, self-sealing manual pressure seals; Pittsburgh Corning Pittwrap SS.
2. Type 3 Insulation—Greater that 1 Foot Above Grade: 30-mil modified bituminous membrane with self-sealing manual pressure seals; Pittsburgh Corning Pittwrap CW30.

PART 3 EXECUTION

3.01 APPLICATION

A. General:

1. Insulate valve bodies, flanges, and pipe couplings.
2. Insulate and vapor seal hangers, supports, anchors, and other piping appurtenances that are secured directly to cold surfaces.
3. Do not insulate flexible pipe couplings and expansion joints.

4. Service and Insulation Thickness: Refer to Supplement Service and Insulation Thickness table following “End of Section” and to Piping Schedule in Section 40 27 00, Process Piping—General.

3.02 INSTALLATION

A. General:

1. Install in accordance with manufacturer’s instructions and as specified herein.
2. Install after piping system has been pressure tested and leaks corrected.
3. Install over clean dry surfaces.
4. Use insulating cements, lagging adhesives, and weatherproof mastics recommended by insulation manufacturer.
5. Do not allow insulation to cover nameplates or code inspection stamps.
6. Run insulation or insulation inserts continuously through pipe hangers and supports, wall openings, ceiling openings, and pipe sleeves, unless otherwise shown.
7. Install removable insulation sections on devices that require access for maintenance of equipment or removal, such as unions and strainer end plates.
8. Personnel Protection: Install on pipes from floor to 8 feet high. Install on pipes within 4 feet of platforms and to 8 feet high above platforms.

B. Connection to Existing Piping: Cut back existing insulation to remove portion damaged by piping revisions. Install new insulation.

C. Cold Surfaces: Provide continuous vapor seal on insulation on cold surfaces where vapor barrier jackets are used.

D. Placement:

1. Insulate valves and fittings with sleeved or cut pieces of same material.
2. Seal and tape joints.

E. Heat Traced Piping: Apply insulation after heat-tracing work is completed and inspected.

F. Roof Drains: Insulate vertical drops from roof drains to horizontal pipe, exposed and concealed horizontal piping, and 2 feet down on vertical risers from horizontal pipe.

G. Roof Drains and Overflow Drains: Insulate entire pipe runs. Where roof and overflow drains exist through an exterior wall ensure annular space between pipes and walls are properly sealed prior to insulating.

H. Roof Drain and Overflow Drain Sumps: Insulate entire sumps.

I. Vapor Barrier:

1. Provide continuous vapor barrier at joints between rigid insulation and pipe insulation.
2. Install vapor barrier jackets with pipe hangers and supports outside jacket.
3. Do not use staples and screws to secure vapor sealed system components.

J. Aluminum Jacket:

1. Use continuous friction type joint to hold jacket in place, providing positive weatherproof seal over entire length of jacket.
2. Secure circumferential joints with preformed snap straps containing weatherproof sealant.
3. On exterior piping, apply coating over insulation and vapor barrier to prevent damage when aluminum fitting covers are installed.
4. Do not use screws or rivets to fasten fitting covers.
5. Install removable prefabricated aluminum covers on exterior flanges and unions.
6. Caulk and seal exterior joints to make watertight.

3.03 FIELD FINISHING

A. Apply coating of insulating cement where needed to obtain smooth and continuous appearance.

B. Where pipe labels or banding are specified, apply to finished insulation, not to pipe.

C. Painting Piping Insulation (Exposed to View):

1. Aluminum or color coded PVC jacketing does not require painting.
2. If insulated piping system is indicated to be painted in Section 40 27 00, Process Piping—General, piping shall receive the following:
   a. Prime coat in accordance with Section 09 90 00, Painting and Coating.
   b. Finished insulation (and not pipe) shall be painted in accordance with Section 09 90 00, Painting and Coating.

3.04 SUPPLEMENTS

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Service and Insulation Thickness Table.

END OF SECTION

Service and Insulation Thickness Table									
					Finish Systems				
Service Type	**Pipe Legend**	**Thickness**	**Fluid Temperature (degrees F)***	**Insulation**	**Concealed from View**	**Indoors Exposed**	**Outdoors**	**Buried**	**Location**
PE–Personnel Exposure	ALP	ASHRAE 90.1 or IECC whichever results in the thickest insulation	300	Type 2 Minimum 2.5-inch thick	No insulation or finish	F3	N/A	NA	All ALP in PAC building shall be insulated except 8-inch blow-off connection. Exterior ALP does not require insulation.

*Use these fluid temperatures unless otherwise noted in the Piping Schedule.
Inches*: Based upon insulation with glass fiber per ASTM C547, outdoors with 20 mph wind with 10 percent safety and no value assigned to cladding or air space at cladding. 2012 IECC requires 1-inch minimum thickness.

SECTION 40 80 01
PROCESS PIPING LEAKAGE TESTING

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Testing Plan: Submit prior to testing and include at least the information that follows.
   a. Testing dates.
   b. Piping systems and section(s) to be tested.
   c. Test type.
   d. Method of isolation.
   e. Calculation of maximum allowable leakage for piping section(s) to be tested.
2. Certifications of Calibration: Testing equipment.
3. Certified test report.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PREPARATION

A. Notify Engineer in writing 5 days in advance of testing. Perform testing in presence of Engineer.

B. Pressure Piping:

1. Install temporary thrust blocking or other restraint as necessary to protect adjacent piping or equipment and make taps in piping prior to testing.
2. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by pressure testing.
3. New Piping Connected to Existing Piping:
   a. Isolate new piping with grooved-end pipe caps, spectacle blinds, blind flanges, or as acceptable to Engineer.
   b. Test joint between new piping and existing piping by methods that do not place entire existing system under test load, as approved by Engineer.
4. Items that do not require testing include tank overflows to atmospheric vented drains and as indicated on Piping Schedule supplement to Section 40 27 00, Process Piping – General.
5. Test Pressure: As indicated on Piping Schedule.

C. Test section may be filled with water and allowed to stand under low pressure prior to testing.

D. Gravity Piping:

1. Perform testing after service connections, manholes, and backfilling have been completed between stations to be tested.
2. Determine groundwater level at time of testing by exploratory holes or other method acceptable to Engineer.
3. Pipe 42 Inches Diameter and Larger: Joint testing device may be used to isolate and test individual joints.

3.02 HYDROSTATIC TEST FOR PRESSURE PIPING

A. Fluid: Clean water of such quality to prevent corrosion of materials in piping system.

B. Exposed Piping:

1. Perform testing on installed piping prior to application of insulation.
2. Maximum Filling Velocity: 0.25 foot per second, applied over full area of pipe.
3. Vent piping during filling. Open vents at high points of piping system or loosen flanges, using at least four bolts, or use equipment vents to purge air pockets.
4. Maintain hydrostatic test pressure continuously for 30 minutes, minimum, and for such additional time as necessary to conduct examinations for leakage.
5. Examine joints and connections for leakage.
6. Correct visible leakage and retest as specified.
7. Empty pipe of water prior to final cleaning or disinfection.

C. Buried Piping:

1. Test after backfilling has been completed.
2. Expel air from piping system during filling.
3. Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.
4. Maintain hydrostatic test pressure continuously for 2 hours minimum, reopening isolation valve only as necessary to restore test pressure.
5. Determine actual leakage by measuring quantity of water necessary to maintain specified test pressure for duration of test.

6. Maximum Allowable Leakage:

$$L = \frac{SD(P)^{1/2}}{133{,}200}$$

where:

L = Allowable leakage, in gallons per hour.
S = Length of pipe tested, in feet.
D = Nominal diameter of pipe, in inches.
P = Test pressure during leakage test, in pounds per square inch.

7. Correct leakage greater than allowable, and retest as specified.

3.03 PNEUMATIC TEST FOR PRESSURE PIPING

A. Do not perform on:

1. PVC or CPVC pipe.
2. Piping larger than 18 inches in diameter.
3. Buried and other non-exposed piping.

B. Fluid: Oil-free, dry air.

C. Procedure:

1. Apply preliminary pneumatic test pressure of 25 psig maximum to piping system prior to final leak testing, to locate visible leaks. Apply soap bubble mixture to joints and connections; examine for leakage.
2. Correct visible leaks and repeat preliminary test until visible leaks are corrected.
3. Gradually increase pressure in system to half of specified test pressure. Thereafter, increase pressure in steps of approximately one-tenth of specified test pressure until required test pressure is reached.
4. Maintain pneumatic test pressure continuously for minimum of 10 minutes and for such additional time as necessary to conduct soap bubble examination for leakage.
5. Correct visible leakage and retest as specified.

D. Allowable Leakage: Piping system, exclusive of possible localized instances at pump or valve packing, shall show no visual evidence of leakage.

E. After testing and final cleaning, purge with nitrogen those lines that will carry flammable gases to assure no explosive mixtures will be present in system during filling process.

3.04 HYDROSTATIC TEST FOR GRAVITY PIPING

A. Testing Equipment Accuracy: Plus or minus 1/2-gallon water leakage under specified conditions.

B. Maximum Allowable Leakage: 0.16 gallon per hour per inch diameter per 100 feet. Include service connection footage in test section, subjected to minimum head specified.

C. Gravity Sanitary and Roof Drain Piping: Test with 15 feet of water to include highest horizontal vent in filled piping. Where vertical drain and vent systems exceed 15 feet in height, test systems in 15-foot vertical sections as piping is installed.

D. Exfiltration Test:

1. Hydrostatic Head:
   a. At least 6 feet above maximum estimated groundwater level in section being tested.
   b. No less than 6 feet above inside top of highest section of pipe in test section, including service connections.
2. Length of Pipe Tested: Limit length such that pressure on invert of lower end of section does not exceed 30 feet of water column.

E. Infiltration Test:

1. Groundwater Level: At least 6 feet above inside top of highest section of pipe in test section, including service connections.

F. Piping with groundwater infiltration rate greater than allowable leakage rate for exfiltration will be considered defective even if pipe previously passed a pressure test.

G. Defective Piping Sections: Replace or test and seal individual joints, and retest as specified.

3.05 FIELD QUALITY CONTROL

A. Test Report Documentation:

1. Test date.
2. Description and identification of piping tested.
3. Test fluid.
4. Test pressure.

5. Remarks, including:
   a. Leaks (type, location).
   b. Repair/replacement performed to remedy excessive leakage.
6. Signed by Contractor and Engineer to represent that test has been satisfactorily completed.

END OF SECTION

SECTION 40 90 01
INSTRUMENTATION AND CONTROL FOR PROCESS SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Work Includes:

1. Engineering, furnishing, installing, storing, protecting, unpacking, integrating, calibrating, adjusting, testing, documenting, commissioning, and providing training for a complete process instrumentation and control system (PICS) for the Project.
2. Major parts are:
   a. Primary elements, transmitters, and control devices.
   b. The overall Work includes modifying existing PLC control panels hardware.
   c. Disconnection of existing aeration blowers signals connected to existing Aeration Control PLC Panel CP-50 located in Sub-Station No. 2 Building.
   d. Termination of new signals from aeration basins to existing Aeration Control PLC Panel CP-50 located in Sub-Station No. 2 Building. Detailed termination information to be provided after contract award.
   e. Interfaces with package control systems furnished by others.
   f. Coordination with electrical subcontractor for the sequencing and timing of PICS work.
   g. Coordination with Owner, Engineer, Systems Integrator (SI), and equipment suppliers.
   h. Assistance during startup, performance testing, and training.

B. Work Not Included: The application programming for the plant PLC and SCADA systems will be provided by a Systems Integrator (SI), contracted directly by the Engineer. This excludes application programming for any package control systems that may be procured with equipment. The Contractor shall provide appropriate notices to the SI for application software installation and allow sufficient time for testing; minimum 2 weeks.

C. Detailed Design: PICS as shown and specified includes functional and performance requirements and component specifications. Finish the detailed PICS design for a complete and functional control system.

1.02 DEFINITIONS

A. Abbreviations:

1. FOCS: Fiber optic communication subsystem.
2. HMI: Human-machine interface.
3. I&C: Instrumentation and control.
4. I/O: Inputs and outputs.
5. MCC: Motor control center.
6. OIT: Operator interface terminal.
7. ORT: Operational readiness test.
8. PAT: Performance acceptance test.
9. P&ID: Process and instrumentation diagrams.
10. PICS: Process instrumentation and control system.
11. PLC: Programmable logic controller.
12. PCC: Plant control center.
13. RAS: Return activated sludge.
14. SCADA: Supervisory control and data acquisition.
15. SI: Systems integrator.
16. UPS: Uninterruptible power supply.
17. WAS: Waste activated sludge.
18. WPAF: Wastewater pollution abatement facility.

B. Enclosure: Control panel, console, cabinet, or instrument housing.

C. Types of Software:

1. Standard Software: Software packages that are independent of project on which they are used. Standard software includes:
   a. System Software: Application independent software developed by digital equipment manufacturers and software companies. Includes, but is not limited to, operating systems; programming languages (C, C++, Visual C++, BASIC, Visual BASIC, etc.); office suites (word processor, spreadsheet, database, etc.), e-mail, security (firewalls, antivirus, spam, spyware, etc.), file management utilities; debugging aids; and diagnostics.
   b. Programming Software: Software packages independent of specific process control project on which they are used. Includes, but not limited to, providing capability for, data acquisition, monitoring, alarming, human-machine interface, data collection, data retrieval, trending, report generation, control, and diagnostics.

2. Application Software:
    a. Software to provide functions unique to this Project and that are not provided by standard software alone.
    b. Configuring data bases, tables, displays, reports, parameter lists ladder logic, and control strategies required to implement functions unique to this Project.

1.03 PICS SUBCONTRACTOR

A. PICS Subcontractor's Qualifications:

1. PICS Subcontractor: Minimum of 5 years' experience providing, integrating, installing, and starting up similar systems as required for this Project.
2. PICS Subcontractor's Site Representative: Minimum of 5 years' experience installing systems similar to PICS as required for this Project.

B. Evidence of Qualifications: Provide a list of at least 3 control systems comparable to system specified, which have been furnished and placed into operation by prospective PICS Subcontractor. For each system, provide Owner's name, address, telephone number, and description of control system including major equipment items. Provide resumes of all key personnel.

C. Owner acceptance of PICS Subcontractor does not exempt PICS Subcontractor or Contractor from meeting all Contract Document requirements, nor does it give prior acceptance of subsystems, equipment, materials, or services.

1.04 SUBMITTALS

A. In accordance with Section 01 33 00, Submittal Procedures, unless otherwise specified in this section.

B. Shop Drawings:

1. General:
    a. Shop Drawings, full-scaled details, wiring diagrams, catalog cuts, and descriptive literature.
    b. Identify proposed items and options. Identify installed spares and other provisions for future work (e.g., reserved panel space; unused components, wiring, and terminals).
    c. Legends and Abbreviation Lists: Complete definition of symbols and abbreviations used on this Project (e.g., engineering units, flow streams, instruments, structures, and other process items used in nameplates, legends, and data sheets).

2. Bill of Materials: For all equipment, including I&C components, electrical/mechanical devices, and control system components.
    a. Group equipment items as follows:
        1) By component identification code.
        2) By equipment type.
    b. Data Included:
        1) Equipment tag number.
        2) Description.
        3) Manufacturers' complete model number, and all options not defined by model number.
        4) Physical, electrical, and environmental requirements.
        5) Quantity supplied.
        6) Component identification code where applicable.
3. Catalog Cuts: For all equipment, including I&C Components, Electrical/Mechanical Devices and Control System Components.
    a. Catalog information, mark to identify proposed items and options.
    b. Descriptive literature.
    c. External power and signal connections.
    d. Scaled drawings showing exterior dimensions and locations of electrical and mechanical interfaces.
4. Component Data Sheets: For all equipment, including I&C components, electrical/mechanical devices, and control system components.
    a. Format and Level of Detail: In accordance with ISA-S20.
    b. Include component type identification code and tag number on data sheet.
    c. Specific features and configuration data for each component:
        1) Location or service.
        2) Manufacturer and complete model number.
        3) Size and scale range, if applicable.
        4) Set points, if applicable.
        5) Materials of construction.
        6) Options included.
    d. Name, address, and telephone number of manufacturer's local office, representative, distributor, or service facility.
5. Sizing and Selection Calculations:
    a. Primary Elements: Complete calculations plus the process data used. Example, for flow elements, minimum and maximum values, permanent head loss, and assumptions made.

C. Information Submittals:

1. For PICS equipment, provide Manufacturer's Certificate of Proper Installation and readiness for operation.
2. Owner Training Plan: Reference Section 01 43 33, Manufacturers' Field Services.

3. Operation and Maintenance (O&M) Manuals: In accordance with Section 01 78 23, Operation and Maintenance Data, unless otherwise specified in this section.
    a. Content:
        1) Complete sets of O&M manuals.
        2) Sufficient detail to allow operation, removal, installation, adjustment, calibration, maintenance and purchasing replacements for each PICS component.
        3) Final versions of legend and abbreviation lists.
    b. Include:
        1) Device O&M manuals for PICS Components, including:
            a) Operations procedures.
            b) Installation requirements and procedures.
            c) Maintenance requirements and procedures.
            d) Troubleshooting procedures.
            e) Calibration procedures.
            f) Internal schematic and wiring diagrams.
            g) Component Calibration Sheets from field quality control calibrations.
        2) List of spares, expendables, test equipment and tools provided.
        3) List of additional spares, expendables, test equipment and tools recommended.
4. Performance Acceptance Tests (PAT) Submittals:
    a. Preliminary Test Procedures: Outlines of proposed tests, forms, and checklists.
    b. Final Test Procedures: Proposed test procedures, forms, and checklists.
    c. Test Documentation: Copy of signed off test procedures when tests are completed.

1.05 QUALITY ASSURANCE

A. Calibration Instruments: Each instrument used for calibrating PICS equipment shall bear the seal of a reputable laboratory certifying that instrument has been calibrated within the previous 12 months to a standard endorsed by the NIST.

B. Coordination Meetings:

1. Location: Site.
2. Attended By: Engineer, Owner, Contractor, PICS Subcontractor, Electrical Subcontractor, and the SI.
3. Minimum of ten 4-hour meetings are required. Specific dates will be established as the Project Progresses.
4. First Meeting: Within 30 days after Notice to Proceed.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Provide storage facilities for PICS equipment.

B. Prior to shipment, include corrosive-inhibitive vapor capsules in shipping containers, and related equipment as recommended by the capsule manufacturer.

C. Prior to installation, store items in dry indoor location. Provide heating in storage areas for items subject to corrosion under damp conditions.

D. Cover panels and other elements that are exposed to dusty construction environments.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Provide equipment suitable for the NEC classification in accordance with Division 26, Electrical.

1.08 SEQUENCING AND SCHEDULING

A. Activity Completion: The following is a list of key activities and their completion criteria:

1. Shop Drawings: Reviewed and approved.
2. Submittals: Reviewed and accepted.
3. Hardware Delivery: Hardware delivered to site and inventoried by the Owner.
4. PAT: Completed and required test documentation accepted.

B. PICS Substantial Completion: When Engineer issues Certificate of Substantial Completion.

1. Prerequisites:
   a. All PICS Submittals have been completed.
   b. PICS has successfully completed PAT.
   c. Owner training plan is on schedule.
   d. All spares, expendables, and test equipment have been delivered.

C. PICS Acceptance: When Engineer issues a written notice of Final Payment and Acceptance.

1. Prerequisites:
   a. Certificate of Substantial Completion issued for PICS.
   b. Punch-list items completed.
   c. Final revisions to O&M manuals accepted.

D. Applications Software Testing:

1. Allow sufficient time for applications software testing by the SI, including:
   a. Software loading and debugging.
   b. Software configuration changes.
   c. Retesting.
2. Refer to Paragraph Prerequisite Activities and Lead Times for specified time allowances.
3. Exclude from these time allowances, time delays to SI's activities caused by substituted plant equipment or altered equipment interfaces.
4. Specified time allowances shall be included in the Project Schedule.

E. Prerequisite Activities and Lead Times: Do not start the following key project activities until prerequisite activities and lead times listed below have been completed and satisfied.

1. Submittal Reviews by Engineer: Engineer acceptance of submitted breakdown and schedule.
2. Hardware Purchasing, Fabrication, and Assembly: Associated Shop Drawing submittals completed.
3. Training: Associated training plan submittal completed.
4. ORT Part 1:
   a. Prerequisite: PICS installation completed.
5. ORT Part 2:
   a. Prerequisite:
      1) ORT Part 1 completed.
      2) Application software development by SI completed.
      3) 2-week notice required prior to start of ORT Part 2.
      4) Allowance for applications software loading and debugging by SI during ORT Part 2: 15 work days from the end date of the 2-week notice.
      5) Additional allowance for application software retesting by SI: 1 work day per change order/field order notice to SI during the test.
6. PAT:
   a. Prerequisite:
      1) ORT Part 2 completed.
      2) PAT procedures approved by Engineer and Owner.
      3) 4-week notice required prior to start of PAT.
      4) Allowance for applications software testing by SI during PAT: 15 work days from end date of the 4-week notice.
      5) Additional allowance for application software retesting by SI: One work day per change order/field order notice to SI during the test.

F. Partial Payment Limits: Following table gives partial payment limits for certain PICS work items:

PICS Work Item	Limit As a Percent of Lump Sum Item Amount
Administrative and Shop Drawing Submittals	15 percent, maximum
Operational Readiness Tests	10 percent, minimum
Performance Acceptance Test	15 percent, minimum
Training	5 percent, minimum
PICS O&M Manuals	5 percent, minimum

PART 2 PRODUCTS

2.01 GENERAL

A. PICS generally functions as shown on Drawings and as required for each Loop. Furnish equipment items as required. Furnish all materials, equipment, and software, necessary to affect required System and Loop performance.

B. First Named Manufacturer: PICS design is based on first named manufacturers of equipment and materials.

1. If an item is proposed from other than first named manufacturer, obtain approval from Engineer for such changes.
2. If alternate item requires different installation, wiring, raceway, enclosures, intrinsically safe barriers, and accessories; furnish equipment and work at no additional cost.
3. For some products, as specified herein, the use of alternate manufacturers will not be permitted.

C. Like Equipment Items:

Use products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's services. Implement all same or similar functions in same or similar manner. For example, control logic, sequence controls, and display layouts.

2.02 INSTRUMENTS

A. Components for Each Loop: Major instruments are shown on the P&IDs and included in the Instrument List in Article Supplements. Furnish all equipment that is necessary to achieve required Loop performance.

B. Component Specifications: Generalized specifications for each type of instrument are located in Article Supplements.

2.03 NAMEPLATES AND TAGS

A. Service Legends: Component identification nameplate located on face of component.

1. Materials: Adhesive backed, laminated plastic.
2. Letters: 3/16-inch white on black background, unless otherwise noted.

B. Nametags: Component identification for field devices.

1. Materials: 16-gauge, Type 316 stainless steel.
2. Letters: 3/16-inch imposed.
3. Mounting: Affix to component with 16- or 18-gauge stainless steel wire or stainless steel screws.

2.04 ELECTRICAL TRANSIENT PROTECTION

A. General:

1. Function: Protect elements of PICS against damage due to electrical transients induced in interconnecting lines by lightning and nearby electrical systems.
2. Implementation: Provide, install, coordinate, and inspect grounding of surge suppressors at:
   a. Connection of ac power to PICS equipment including panels, consoles assembles, and field mounted transmitters and receivers.
   b. At the field and at the panel connection of signal and communication circuits that have portions of the circuit extending outside of a protective building.
3. Construction shall be Bipolar silicon avalanche device. MOV or hybrid devices are not acceptable. Includes grounding wire, stud, or terminal.
4. Response: 5 nanoseconds maximum.
5. Recovery: Automatic.
6. Temperature Range: Minus 20 to 85 degrees C.

B. Suppressors on 120V ac Power Supply Connections:

1. Occurrences: Tested and rated for a minimum of 50 occurrences of IEEE 587 Category B test waveform.
2. Clamping Voltage: 350 volts or less.
3. Transtector ACP-100 series; equivalent products from Allen Bradley and Eaton; “or-equal.”

C. Suppressors on Analog Signal Lines:

1. Test Waveform: Linear 8 microsecond rise in current form 0 amps to a peak current value followed by an exponential decay of current reaching one half the peak value in 20 microseconds.
2. Surge Rating: Tested and rated for 50 occurrences of 2,000-amp peak test waveform.
   a. dc Clamping Voltage: 20 to 40 percent above operating voltage for circuit.
   b. dc Clamping Voltage Tolerance: Less than plus or minus 10 percent.
   c. Maximum Loop Resistance: 18 ohms per conductor.

D. Physical Characteristics:

1. Mounted in Enclosures: Encapsulated inflame retardant epoxy.
2. Field Mounted at Two-wire Instruments: Encapsulated in stainless steel pipe nipples.
3. Field Mounted at Four-wire Instruments: With 120V ac outlet, ac circuit breaker, and 10-ohm resistors on signal lines, all in enclosure.
   a. Enclosure: NEMA 4X fiberglass or Type 316 stainless steel with door.
   b. Maximum Size: 12 inches by 12 inches by 8 inches deep.

E. Installation and Grounding of Suppressors: All surge suppressors and related enclosures shall be furnished by the PICS and installed under Division 26, Electrical. Grounding equipment, installation of grounding equipment, and terminations for field mounted devices are provided under Division 26, Electrical.

PART 3 EXECUTION

3.01 INSTALLATION

A. Material and Equipment Installation: Retain a copy of manufacturers’ instructions at Site, available for review at all times.

B. Electrical Wiring: As specified in Division 26, Electrical.

C. Removal or Relocation of Materials and Equipment: Repair affected surfaces to conform to type, quality, and finish of surrounding surface.

3.02 FIELD QUALITY CONTROL

A. Provide a Startup and Testing Team to:

1. Thoroughly inspect installation, termination, calibration, and adjustment for components and systems.
2. Complete onsite tests.
3. Complete onsite training.
4. Provide startup assistance.

B. Operational Readiness Tests: Prior to PAT of each system/panel, inspect, test, and document that associated PICS equipment is ready for operation. Divide testing into two parts:

1. ORT Part 1: Performed by Contractor to test and document that the PICS, excluding SI provided application software, is ready for operation.
   a. Loop/Component Inspections and Tests:
      1) Check PICS for proper installation, calibration, and adjustment on component-by-component basis.
      2) Component calibration sheet for each active component. Include the following:
         a) Project name.
         b) Loop number.
         c) Component tag number.
         d) Component code number.
         e) Component manufacturer.
         f) Component model number/serial number.
         g) Summary of Functional Requirements, for Example:
            (1) Indicators scale ranges.
            (2) Transmitters/converters, input and output ranges.
            (3) Controllers, action (direct/reverse) and control modes (P&ID).
            (4) Switching elements, unit range, differential (fixed/adjustable), reset (auto/manual).
         h) Calibrations, for Example, but not Limited to:
            (1) Analog Devices: Actual inputs and outputs at zero, 10, 50, and 100 percent of span, rising and falling.
            (2) Discrete Devices: Actual trip points and reset points.
         i) Space for comments.
         j) Example instrument calibration sheet is included in Article Supplements.

3) Maintain component calibration sheets at site and make them available to Engineer and SI at all times.
4) These inspections and tests will be spot checked by Engineer, SI, and Owner.
5) Engineer, SI and Owner will review loop status sheets and component calibration sheets and spot-check their entries periodically.
6) Upon completion of ORT Part 1, correct deficiencies found.

2. ORT Part 2: Combined effort between Contractor and SI to confirm that PICS, including applications software, is ready for operation.
   a. Prerequisite: Completion of ORT Part 1.
   b. Application software tests, using real field sensors and equipment. Plant interlocking and communications with PLCs tested on loop-by-loop basis.
   c. Test procedures provided by SI based on ORT Part 1 and application software tests requirements.
   d. At completion of ORT Part 2, two copies of all ORT documentation shall be provided to the Engineer and SI.

C. Performance Acceptance Tests (PAT): These are the activities that Section 01 91 14, Equipment Testing and Facility Startup, refers to as Performance Testing.

1. General:
   a. Test all PICS elements to demonstrate that PICS satisfies all requirements.
   b. Test Format: Cause and effect.
      1) Person conducting test initiates an input (cause).
      2) Specific test requirement is satisfied if correct result (effect) occurs.
   c. Procedures, Forms, and Checklists:
      1) Conduct tests in accordance with, and documented on, Engineer accepted procedures, forms, and checklists.
      2) Describe each test item to be performed.
      3) Have space after each test item description for sign off by appropriate party after satisfactory completion.
   d. Required Test Documentation: Test procedures, forms, and checklists. All signed by Contractor, Engineer and SI.
   e. Conducting Tests:
      1) Provide special testing materials, equipment, and software.
      2) Wherever possible, perform tests using actual process variables, equipment, and data.
      3) If it is not practical to test with real process variables, equipment, and data; provide suitable means of simulation.
      4) Define simulation techniques in test procedures.

2. Test Requirements:
    a. Once facility has been started up and is operating, perform a witnessed PAT on complete PICS to demonstrate that it is operating as required. Demonstrate each required function on a paragraph-by-paragraph and loop-by-loop basis.
    b. Perform local and manual tests for each loop before proceeding to remote and automatic modes.
    c. Where possible, verify test results using visual confirmation of process equipment and actual process variable. Unless otherwise directed, exercise and observe devices supplied by others, as needed to verify correct signals to and from such devices and to confirm overall system functionality. Test verification by means of disconnecting wires or measuring signal levels is acceptable only where direct operation of plant equipment is not possible.
    d. Make updated versions of documentation required for PAT available to Engineer and SI at Site, both before and during tests.
    e. Make one copy of O&M manuals available to Engineer and SI at the Site both before and during testing.
    f. Refer to referenced examples of PAT procedures and forms in Article Supplements.

3.03 MANUFACTURER'S SERVICES

A. For equipment furnished under this Section, provide the services of a qualified manufacturer's representative as required to provide Manufacturer's Certificate of Proper Installation and assistance during installation, startup, demonstration testing, and training.

B. See Section 01 43 33, Manufacturers' Field Services, and Section 01 91 14, Equipment Testing and Facility Startup.

3.04 TRAINING

A. General:

1. Provide an integrated training program to meet specific needs of Operations and Maintenance personnel.
2. Include training sessions, classroom and field, for managers, engineers, operators, and maintenance personnel.
3. Provide instruction to accommodate the Operations and Maintenance personnel schedule.
4. Owner reserves the right to make and reuse video tapes of training sessions.

B. Maintenance Training:

1. Include a review of O&M manuals and survey of spares, expendables, and test equipment.
2. Use equipment similar to that provided.
3. Provide training suitable for instrument technicians with at least a 2-year associate engineering or technical degree, or equivalent education and experience in electronics or instrumentation.
4. Number of Training Sessions: Two.
5. Training Session Duration: 8-hour each (not counting travel)
6. Content: Provide training for each type of component and function provided, including Control System components:
    a. Component calibration.
    b. Adjustments: For example, current switch trip points, and similar items.
    c. Troubleshooting and diagnosis for components.
    d. Replacing lamps, fuses, etc.
    e. Component removal and replacement.
    f. Periodic maintenance.

3.05 CLEANING/ADJUSTING

A. Repair affected surfaces to conform to type, quality, and finish of surrounding surface.

B. Cleaning:

1. Prior to closing system using tubing, clear tubing of interior moisture and debris.
2. Upon completion of Work, remove materials, scraps, and debris from interior and exterior of equipment.

3.06 PROTECTION

A. Protect enclosures and other equipment containing electrical, instrumentation and control devices, including spare parts, from corrosion through the use of corrosion-inhibiting vapor capsules.

B. Periodically replace capsules in accordance with capsule manufacturer's recommendations. Replace capsules just prior to Final Payment and Acceptance.

3.07 SUPPLEMENTS

A. Supplements listed below, following "End of Section," are part of this Specification.

1. Component Specification.
2. Instrument List.

END OF SECTION

COMPONENT SPECIFICATIONS

A. A1 - Transmitter:

1. General:
   a. Function: Indicate and transmit various signals from same or different process measuring elements.
   b. Features and Performance:
      1) Accommodates two sensors (of same or different types).
      2) Display: LCD with LED backlighting.
      3) Operating Temperature: Minus 4 degrees F to 104 degrees F.
      4) Operating Humidity: 0 to 95 percent relative humidity, noncondensing.
         a) Control Functions: Menu-driven software.
      5) Alarms: Low and high pH alarms.
      6) Built-in data logger, with capacity to store data at 15-minute intervals for 6 months.
   c. Signal Interface:
      1) Analog Output: Two isolated 4 to 20 mA dc for load impedance 0 ohms to 500 ohms, unless otherwise noted.
   d. Enclosure:
      1) Type: NEMA 4X.
      2) Dimensions: 6 inches by 6 inches by 6 inches nominal, as required to install transmitter inside.
      3) Mounting: Handrail.
         a) Provide mounting hardware.
         b) Provide sunshield for transmitter display for outside installation.
         c) Provide stainless steel equipment tag.
   e. Power: 105V ac to 230V ac, 50/60-Hz.
2. Manufacturer and Product:
   a. Hach sc200, no exceptions. Justification: Over 18 Hach sc200 transmitters installed on Reactor Basins alone. These units provided to replace failed units in the future.

B. F51 Flow Element and Transmitter, Thermal Mass Flow:

1. General:
   a. Function: Directly measure, indicate, and transmit mass flow of gas in pipe.
   b. Type: Insertion type, thermal dispersion detection probe using platinum resistance temperature detectors (RTD).
   c. Parts: Elements, separately mounted transmitter, and interconnecting cable.

2. Performance:
    a. Gas: Process air.
    b. Flow Range at 70 Degrees F and 14.7 psia: 0.25 to 600 SFPS.
    c. Calibrated Span: As noted.
    d. Turn Down: Factory set and field adjustable.
    e. Accuracy:
        1) Flow: Plus or minus 0.75 percent of reading, plus or minus 0.5 percent full scale.
        2) Temperature: Plus or minus 2 degrees F.
    f. Repeatability:
        1) Flow: Plus or minus 0.5 percent of reading.
        2) Temperature: Plus or minus 1 degree F.
    g. Temperature, Operating:
        1) Flow Element: Minus 40 degrees F to plus 392degrees F.
        2) Transmitter Housing: 0 degree F to plus 150 degrees F.
    h. Pressure, Operating, Flow Element: Up to 50 psig, unless otherwise noted.
3. Flow Element:
    a. Features:
        1) Insertion Length: Per manufacturer's recommendation.
        2) Wetted Surfaces Materials: Type 316 stainless steel.
    b. Process Connection:
        1) Pipe Size: As shown on drawings. Tip of the probe shall extend 0.5 inch past the centerline of the pipe. Follow all manufacturer recommended installation.
        2) Connection Type: Retractable sensor with graphite-packed gland with ¾ - inch MNPT, unless otherwise noted. Provide all connecting material including compression fittings.
        3) Connection Material: Type 316 stainless steel.
    c. Sensor Enclosure:
        1) Type: Aluminum, NEMA 4X.
4. Separately Mounted Transmitter:
    a. Display:
        1) 2-inch by 2-inch backlit LCD display.
        2) Numerical display of flow rate, total flow and temperature in selectable engineering units.
        3) Bar graph display of flow rate.
        4) Alarm/Relay status indication.
        5) Electronic rotation in 90-degree increments to optimize viewing.
    b. Non-intrusive optical touch keys for field calibration without opening the enclosure.
    c. Data logger: On board Micro-SD memory card, user programmable, time stamped, process variable readings. Provide 2-GB micro-SD card.

d. Signal Interface:
1) Outputs:
a) Analog: Three isolated 4 mA to 20 mA dc for maximum 600 ohm load, unless otherwise noted.
b) Discrete:
(1) Two independently adjustable 2A SPDT relays.
(2) Configurable as high or low flow or process temperature.
e. Power:
1) Selectable: 85V ac to 265V ac.
f. Electrical Connection: 1-inch FNPT.
g. Transmitter Enclosure:
1) Type: NEMA 4X, polyester powder coated aluminum.
2) Mounting: Remote from sensor. Handrail.
h. Factory calibrated at the specified flow range under given conditions on NIST traceable flow stands.

5. Cable Between Element and Transmitter:
a. Length: As required.
b. Cable Jacket: PVC rated for 220 degrees F, unless otherwise noted.

6. Manufacturer and Product:
a. Kurz Instruments similar to 454FTB-12-HT. (Existing used at plant).
b. Fluid Components International; Model ST100 thermal mass flow meter.

C. P4 Pressure Gauge:

1. General:
a. Function: Local pressure indication.
b. Type: Full size Bourdon tube element.

2. Performance:
a. Scale Range: As noted or shown.
b. Accuracy: Plus or minus 0.50 percent of span.

3. Features:
a. Dial: 4-1/2-inch diameter.
b. Pointer Vibration Reduction: Required. Method as follows:
1) Dry gauge front; internal gauge workings include:
a) Pinion cartridge with nonliquid dampening agent.
b) Dampening Agent: Silicone lubricant.
c. Case Material: Black phenolic.
d. Element Material: Type 316 stainless steel.
e. Pointer: Adjustable by removing ring and window.
f. Window: Glass.
g. Threaded reinforced polypropylene front ring.
h. Case Type: Solid front with blow-out back.
i. Movement: Teflon coated 400 series stainless steel rotary movement.

4. Process Connection:
    a. Mounting: Lower stem.
    b. Size: 1/2-inch MNPT.
5. Accessories:
    a. Throttling Device: Required.
        1) Type: Throttle screw.
        2) Material and Size: 0.020-inch, Type 316 stainless steel.
6. Manufacturer and Product:
    a. Ashcroft; Duragauge Model 1279 PLUS!
    b. Equivalent product from Ametek U.S Gauge.
    c. "Or-equal."

D. P9 Pressure Transmitter:

1. General:
    a. Function: Measure pressure and transmit signal proportional to pressure.
    b. Type:
        1) Electronic variable capacitance or silicon strain gauge.
        2) Two-wire transmitter; "smart electronics."
    c. Parts: Transmitter and accessories.
2. Performance:
    a. Range: As noted.
        1) Select transmitter's factory upper range limit (URL) such that upper boundary of noted range is as close as possible to 80 percent of factory URL but does not exceed it.
    b. Accuracy: Plus or minus 0.075 percent of span, unless otherwise noted.
    c. Ambient Operating Temperature: Minus 40 to 175 degrees F, with integral meter.
    d. Process Operating Temperature: Minus 40 to 250 degrees F.
    e. Humidity: 0 to 100 percent relative humidity.
    f. Hazardous Location Certifications: If and as noted.
3. Features:
    a. Type: Gauge pressure, unless otherwise noted.
    b. Adjustable damping.
    c. LCD indicator, unless otherwise noted.
        1) Display in either percent or engineering units, field configurable.
    d. Wetted Metallic Parts: Type 316 stainless steel, unless otherwise noted.
        1) Includes drain/vent valves; process flanges and adapters, and process isolating diaphragm.
    e. Wetted O-Rings: Glass filled TFE, graphite filled PTFE, or Viton, unless otherwise noted.
    f. Bolts and Nuts (if required): Type 316 stainless steel, unless otherwise noted.

g. Fill Fluid: Silicone, unless otherwise noted.

4. Process Connections:
   a. Line Size: 1/2 inch.
   b. Connection Type: FNPT.
   c. Direct/remote Diaphragm Seal: If and as noted.
5. Signal Interface:
   a. 4 to 20 mA dc output with digital signal based on HART protocol, unless otherwise noted below.
      1) Nominal Maximum Loop Resistance with External 24V dc Power Supply: 550 ohms.
   b. FOUNDATION fieldbus protocol: If noted.
   c. Profibus: If noted.
6. Enclosure:
   a. Type: NEMA 4X.
   b. Materials: Coated aluminum, unless otherwise noted.
   c. Mounting bracket, unless otherwise noted.
      1) Bracket and Accessories: Stainless steel; suitable for mounting transmitter to panel or 2-inch pipe.
7. Accessories:
   a. Two-valve (Isolate and Vent) Stainless Steel Manifold.
8. Manufacturers and Products:
   a. Gauge Pressure Units:
      1) Rosemount.
      2) Foxboro.
      3) SMAR.

END OF SECTION

NEW HAVEN PROCESS AIR COMPRESSOR SYSTEM
INSTRUMENT LIST

Instrument Tag	Code	Description	Options	P&ID	Note
AIT	A1	Dual Input/Output Transmitter with NEMA 4X enclosure	Transmitter Mounting: Handrail		Provide 5 transmitters and hand over to Owner
FE/FIT-21-3-1A	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 4000 SCFM Pipe Size: 12 inch Nominal Flow: 2250 SCFM	03-N-002	New, does not replace existing
FE/FIT-21-3-2A	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 4000 SCFM Pipe Size: 12 inch Nominal Flow: 2250 SCFM	03-N-002	New, does not replace existing
FE/FIT-21-3-3A	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 4000 SCFM Pipe Size: 12 inch Nominal Flow: 2250 SCFM	03-N-002	New, does not replace existing
FE/FIT-21-3-4A	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 4000 SCFM Pipe Size: 12 inch Nominal Flow: 2250 SCFM	03-N-002	New, does not replace existing
FE/FIT-21-3-1B	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 4000 SCFM Pipe Size: 12 inch Nominal Flow: 2250 SCFM	03-N-002	New, replaces existing
FE/FIT-21-3-2B	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 4000 SCFM Pipe Size: 12 inch Nominal Flow: 2250 SCFM	03-N-002	New, replaces existing

NEW HAVEN PROCESS AIR COMPRESSOR SYSTEM
INSTRUMENT LIST

Instrument Tag	Code	Description	Options	P&ID	Note
FE/FIT-21-3-3B	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 4000 SCFM Pipe Size: 12 inch Nominal Flow: 2250 SCFM	03-N-002	New, replaces existing
FE/FIT-21-3-4B	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 4000 SCFM Pipe Size: 12 inch Nominal Flow: 2250 SCFM	03-N-002	New, replaces existing
FE/FIT-21-4-1	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 5000 SCFM Pipe Size: 12 inch Nominal Flow: 3750 SCFM	03-N-002	New, replaces existing
FE/FIT-21-4-2	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 5000 SCFM Pipe Size: 12 inch Nominal Flow: 3750 SCFM	03-N-002	New, replaces existing
FE/FIT-21-4-3	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 5000 SCFM Pipe Size: 12 inch Nominal Flow: 3750 SCFM	03-N-002	New, replaces existing
FE/FIT-21-4-4	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 5000 SCFM Pipe Size: 12 inch Nominal Flow: 3750 SCFM	03-N-002	New, replaces existing
FE/FIT-21-5-1	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 2000 SCFM Pipe Size: 8 inch Nominal Flow: 1310 SCFM	03-N-002	New, replaces existing

NEW HAVEN PROCESS AIR COMPRESSOR SYSTEM
INSTRUMENT LIST

Instrument Tag	Code	Description	Options	P&ID	Note
FE/FIT-21-5-2	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 2000 SCFM Pipe Size: 8 inch Nominal Flow: 1310 SCFM	03-N-002	New, replaces existing
FE/FIT-21-5-3	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 2000 SCFM Pipe Size: 8 inch Nominal Flow: 1310 SCFM	03-N-002	New, replaces existing
FE/FIT-21-5-4	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 2000 SCFM Pipe Size: 8 inch Nominal Flow: 1310 SCFM	03-N-002	New, replaces existing
FE/FIT-21-6-1	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 2000 SCFM Pipe Size: 8 inch Nominal Flow: 1350 SCFM	03-N-002	New, replaces existing
FE/FIT-21-6-2	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 2000 SCFM Pipe Size: 8 inch Nominal Flow: 1350 SCFM	03-N-002	New, replaces existing
FE/FIT-21-6-3	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 2000 SCFM Pipe Size: 8 inch Nominal Flow: 1350 SCFM	03-N-002	Replaces existing
FE/FIT-21-6-4	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 2000 SCFM Pipe Size: 8 inch Nominal Flow: 1350 SCFM	03-N-002	New, replaces existing

NEW HAVEN PROCESS AIR COMPRESSOR SYSTEM
INSTRUMENT LIST

Instrument Tag	Code	Description	Options	P&ID	Note
PI-55-2-1 PIT-55-2-1	P4 P9	Pressure Gauge Pressure Transmitter	Range: 0 – 30 psig	03-N-001	New
FE/FIT-55-3-1	F51	Aeration Basin, Flow Element and Transmitter, Thermal Mass Flow	Process Range: 0 to 60000 SCFM Pipe Size: 36 inch	03-N-001	New

SECTION 44 42 19.06
PROCESS AIR COMPRESSOR SYSTEM (PRESELECTED)

PART 1 GENERAL

1.01 WORK OF THIS SECTION

A. The Work of this section includes the supply, delivery, unloading, storage, handling, installation, testing, start-up and commissioning, and warranty of the preselected Process Air Compressor (PAC) system.

B. Unit Responsibility: The Contractor is responsible to the Owner for purchasing the preselected equipment and providing a complete system as specified herein.

C. General Requirements: See Division 01, General Requirements, which contains information and requirements that apply to the Work specified herein and are mandatory to this Project, including, but not limited to, Codes and Regulations.

D. The Contractor shall provide the equipment and appurtenances specified in the APG-Neuros Project CWF 2019-04 Process Air Compressor Proposal Package, provided with these Contract Documents as reference documents (see Appendix A). APG-Neuros will provide all required services under Contract to the Contractor. The Owner's Contract will be with the Contractor and not with the Manufacturer.

E. The Contractor shall coordinate all Work shown on the Drawings, specified herein with APG-Neuros.

F. In general, the equipment manufacturer will provide the following Work:

1. Design, fabrication, supply, and delivery of the equipment.
2. Provide source quality control services
3. Supervision, inspection, and certification of the installation.
4. Supervision of testing and commissioning of the equipment.
5. Assistance to the Contractor with training of the Owner's operations and maintenance staff.
6. Furnishing of Shop Drawings, O&M manuals, and other submittals.

G. In general, the Contractor shall provide the following Work:

1. Purchase of preselected equipment and services from the manufacturer.
2. Acceptance and offloading of the preselected equipment at the Plant.

3. Storage of the equipment in accordance with manufacturer's instructions and assuming responsibility of relevant insurance for the preselected equipment until the completion of this Contract.
4. Installation of the equipment.
5. Assume or ensure the performance bonding of the manufacturer is maintained.
6. Assistance with initial operation, testing, and commissioning of the preselected equipment.

H. Review in detail the preselection documents to determine the extent of responsibility of the manufacturer.

I. All Work outside the requirements of preselected equipment supply that is required for successful installation and operation of the equipment is the full responsibility of the Contractor.

J. Issue purchase order for the preselected equipment to the manufacturer within 21 calendar days after the Owner's official Order to Commence Work is issued.

K. Consult with the manufacturer during the tender period regarding the intricacies of installation, the extent of work required, coordination requirements, etc., of all the suppliers' equipment.

L. Coordinate and schedule the submission of all required submittals with the manufacturer, sub-contractors, and service providers.

1.02 GENERAL

A. The PAC system price has been pre-negotiated with APG-Neuros, herein also referred to as Manufacturer. No "or equal" or substitutes shall be allowed. Contractor shall use the pre-negotiated equipment cost as the basis of the bid.

B. The Contract Drawings show the general arrangement of equipment, devices, and supports, based on preliminary drawings provided by the Manufacturer. The Contractor shall verify that the Contract Drawings are coordinated with the Manufacturer’s shop and installation drawings and shall be responsible for fully coordinating with the Manufacturer in all respects.

C. The PAC System Manufacturer shall be responsible for the design of all equipment specified in their proposal based on actual site conditions.

1.03 DEFINITIONS

A. Actual Cubic Feet per Minute (acfm): Air volume in cubic feet per minute corrected to Site conditions of elevation, temperature, and relative humidity.

B. Ambient (inlet) Pressure: Absolute pressure of the ambient air measured in the vicinity of the PAC inlet measured at the stagnation condition. This will equal barometric pressure under typical conditions.

C. Ambient (inlet) Temperature: Total temperature of the ambient air in the vicinity of the PAC package, but unaffected by it.

D. Input Horsepower (IHP): Input horsepower (or wire power) is the total horsepower required to operate the PAC motor and all ancillary equipment drive motors.

E. Input Power: Input power (or wire power) is the total kilowatts (kW) required to operate the PAC motor and all ancillary equipment drive motors.

F. PAC Package: PAC package is defined by the limits of the scope of supply as specified in the overall project contractual agreement pertaining to the PAC installation. Includes all deliverable components necessary to furnish an operational machine including but not limited to inlet, discharge, and all power devices that affect power consumption.

G. Discharge Pressure: Pressure in pounds per square inch gauge (psig) at the PAC package discharge flange. Typically measured downstream of the check valve at the rated capacity.

H. Inlet Cubic Feet per Minute (icfm): The rate of flow which is determined by delivered mass flow rate divided by inlet total density as defined by the inlet to the package. Air volume in cubic feet per minute entering PAC at inlet pressure and temperature conditions corrected for Site conditions and includes inlet filter and inlet line losses.

I. Overall (Wire to Air) Efficiency: Wire to air isentropic efficiency of the entire PAC package. This includes energy losses from all components within the PAC package. This is the ratio of total measured wire-to-air (system) power demand to the power of compression due to an assumed reversible, adiabatic compression process with constant entropy.

J. Pressure Rise: Pressure in pounds per square inch (psi). Difference between pressure at the PAC package discharge flange (typically downstream of the check valve) and the package inlet (typically upstream of the inlet filter or inlet flange).

K. Standard Cubic Feet per Minute (scfm): Air volume in cubic feet per minute corrected to standard conditions of 68 degrees F, 14.70 psia, and 36 percent relative humidity.

L. Total wire power (kW or hp): The compressor package total wire power is the electrical power measured at the power input to the compressor package. This

shall include all power consuming electrical components of the compressor package as required for installation and normal operation. i.e., drive motor, motor cooling fan, magnetic bearing and controller, bearing cooling fans, coolant pump and heat exchanger, enclosure and package cooling fan, sine wave filter or output reactor, variable frequency drive and cooling fan, input choke or line reactor, harmonic filter, local control panel, PLC or processor, HMI and miscellaneous electronics, voltage transformer(s), DC power supplies, power conditioner, etc. If the compressor package receives multiple power feeds, this is the sum of all wire powers measured individually.

1.04 SUBMITTALS

A. Shop Drawings submitted by the equipment suppliers for the preselected equipment will be reviewed by the Engineer. Approved Shop Drawings will be furnished to the Contractor prior to authorizing the manufacturing of the equipment.

B. Action Submittals: Shop Drawings and Product Data (for Each PAC Set):

1. Shop Drawings:
   a. Structural: Anchorage and bracing data sheets and Drawings as required.
   b. Bill of Materials: Complete bill of materials of all components and equipment supplied. Bill of materials shall include make and model number and replacement cost of the primary components including, but not limited to, the following:
      1) Compressor.
      2) Motor.
      3) AFD.
      4) PLC.
      5) Harmonic filters.
      6) Heat exchangers.
      7) Instruments and Sensors (temp, pressure, magnetic bearing controller, etc.).
      8) Control transformer.
      9) Local control panels
      10) Uninterruptible power supply (UPS).
      11) Master Control Panel (MCP).
   c. Spare Parts: Include a list of manufacturer-recommended spare parts and nearest supplier (identify supplier's name and address, and other pertinent contact information). Include a statement of availability of all parts.
   d. Documentation of modifications to the manufacturer's standard design to meet the requirements specified in this section and where the manufacturer's standard design does not comply with

the specified performance, features, functions, and materials of construction specified herein.

e. Mechanical:
   1) Complete Specifications, descriptive drawings, catalog cuts, and descriptive literature which shall include make, model, dimensions and weight of the compressors, motors, and accessories. Include weight of largest components requiring removal for maintenance.
   2) Number of required units for each operating design point, including one standby unit.
   3) Detailed layout drawings and dimensional data, including minimum clearance distances around equipment required to access equipment for normal service, repair, and removal.
   4) Data on the characteristics and performance of the units to indicate ability to meet the system performance specified herein:
      a) Compressor curves showing package discharge pressure and flow capacity, wire to air efficiency and compressor package total wire power demand over the entire range from shutoff to maximum capacity. Clearly show the surge pressure and surge margin associated with each of the performance speed curves. Provide compressor curves for all design operating conditions specified herein.
         (1) On the performance curves indicate the pressure (psig), flow capacity (scfm), power demand (hp), and wire to air efficiency at guarantee points.
         (2) Furnish performance curves at full speed and a at least four lower speeds including minimum speed to indicate specified volume turndown. The capacity line above which the unit should be operated to preclude surging. The capacity line below which the unit should be operated to preclude run out.
   5) Inlet and discharge flexible connectors.
   6) Inlet air filter and silencer.
   7) Heat exchangers if required.
   8) Air cooling system fans and waste heat exhaust silencer, etc.
   9) Blow-off valve (and electric actuator) and silencer.
   10) Check valve.
   11) Discharge isolation valve and electric actuator and silencer.
   12) Enclosure details.
   13) Estimated compressor sound level data, for both inlet and radiated conditions, and description of sound control measures required to meet the specified sound levels.

14) Maximum heat dissipation from compressor enclosure to the space and any ventilation requirements.
15) Provide information about internal and external heat exchangers. If external heat exchangers are required, provide remote location installation and mounting requirements.

f. Electrical:
1) Motor Data: Complete motor data shall be submitted with the driven machinery shop drawings. Motor data shall include items applicable to this motor, such as:
a) Descriptive information.
b) Nameplate data in accordance with NEMA MG 1.
c) Service factor.
d) Voltage, phase, and frequency ratings.
e) Full load current.
f) Locked rotor current.
g) No load current.
h) Full load speed.
i) Safe stall time.
j) Insulation class and temperature rise classification. Certification that motors are inverter duty rated.
k) Multispeed load classification (for example, variable torque).
l) Guaranteed maximum full load wire-to-air power. Also provide nominal air-to-airpower at 1/2 and 3/4 load.
m) Description, rating, and wiring diagram of thermal protection or over temperature protection.
n) Power factor at 1/2, 3/4, and full design flows and conditions.
2) Total wire-to air power consumption per unit for each operating design point.
3) System wiring diagrams, with recommended power feeder conductors sizes and feeder breaker sizes.
4) Bearing type, lubrication, and life.
5) Adjustable Frequency Drive Data:
a) Overall drive system operating data, including efficiencies, input currents, and power factors, at driven equipment actual load and rated system input voltage, at 0, 40, 60, 80, 100, and 110 percent of rated speed.
b) Information on harmonics generated by the drive, along with descriptive information on all reactors, filters, or other harmonics mitigation equipment.

c) Complete system rating, including all nameplate data, continuous operation load capability throughout speed range of 0 to 120 percent of rated speed.

6) UPS installed in each LCP:
   a) Estimated load when on UPS.
   b) Estimated time for UPS to power critical loads.
   c) Estimated load of Magnetic Bearing on UPS.

g. Outline drawings for all items that are shipped loose.

h. Quality of Construction and Qualifications:
   1) Proof of listing for Compressor Package by the Nationally Recognized Testing Laboratory (NRTL) such as UL/CSA certification in accordance with UL 1450 or equivalent TUV certification on the same model and size proposed. Certification must be demonstrated prior to acceptance of proposed equipment.
   2) Statement of conformance letter stating conformance to specifications with all exceptions noted. Statement of conformance must be signed by an individual authorized to make such statements.

i. American Iron and Steel Bidders Certification.

j. Manufacturer's Certification that Bidder, if not Manufacturer, is authorized by Manufacturer to submit Proposal and Manufacturer will abide by submitted Proposal.

k. Proof of Financial Strength: supply documentation to demonstrate the financial strength of the firm bidding and the Manufacturer.

C. Informational Submittals:

1. Detailed factory test procedure with complete piping and instrumentation configuration diagram per ASME PTC-13 showing inlet and discharge air test pipe size. The location, type, and quantity of all major instruments necessary for performance data, including those on air and water cooling systems with corresponding distances from reference points, shall be identified per ASME PTC-13 requirements. As a minimum, the detailed test plan shall include:
   a. Quality control procedures.
   b. Test procedure and method of calculating results.
   c. Functional testing of entire package, instrumentation, ancillary components, and LCP.
   d. Insert the actual test report in the Operations and Maintenance Manual.
   e. Field Test: Submit a detailed test procedure for complete compressor systems.
2. Sound power values when measured in accordance with ASME PTC 36, Measurement of Industrial Sound.

3. Master Control Panel (MCP) Factory Test Results:
    a. Submit factory test plan outlining all required testing activities within this section for Engineer approval a minimum of 2 weeks prior to testing.
    b. Submit factory test results including manufacturer's quality assurance.
    c. Include copies of original test data collection forms.
4. Manufacturer's Field Report: Submit manufacturer's field report of inspections, tests, and observations for all items furnished under this section.
5. Operation and maintenance data as specified in Section 01 78 23, Administrative Requirements.
6. Manufacturer's written equipment, material and spare parts storage and safeguard instructions including any special shipping, storage and protection, and handling instructions.
7. Manufacturer's printed installation instructions.
8. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturer's Field Services.

1.05 OPERATION AND MAINTENANCE MANUALS

A. As specified in Section 01 78 23, Operation and Maintenance Data. Provide one O&M Manual for each set of PACs.

B. Include the following additional information in each O&M Manual:

1. Operating and Maintenance Manuals and Maintenance Summary Forms will be submitted for the PAC systems specified herein.
2. Include certified factory test reports for motor and PAC and performance curves for PACs, field startup and test reports.
3. Certified factory test reports for motor and PAC and performance curves for PACs, field startup, and test reports.
4. Detailed list of maintenance required to maintain validity of Manufacturer's warranty.
5. Technical assistance contact information.

1.06 PAYMENT

A. Payment for the Work specified in this Section shall be in accordance with Section 01 29 00, Payment Procedures.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Shipping:

1. Ship equipment, materials and spare parts complete except where partial disassembly is required by transportation regulations or for protection of components.
2. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which they are intended.
3. Deliver spare parts at same time as pertinent equipment.

B. Receiving:

1. The Manufacturer will provide an authorized representative to witness, inspect and inventory items upon delivery to site.
2. Unloading of the equipment shall be performed by the Contractor, at his expense, in accordance with the equipment manufacturers' written instructions and utilizing methods which will not damage the equipment. Contractor shall furnish all rigging necessary to unload the equipment.
3. Verify all items on manifest have been off-loaded and are undamaged.
4. Confirmation from the Contractor that items have been received.
5. Inspect each box to confirm that each spare part has been received.
6. Photograph each item off-loaded.
7. Obtain Contractor's signature on the bill of lading confirming that each item was delivered and provide a copy to the Owner and Engineer.

C. Storage:

1. If required, place suppliers' equipment into secure on-site storage or offsite storage in a bonded warehouse.
2. Examine all shipments during offloading for damage and check against shipping papers to ensure that all parts, boxes, crates, bundles or items have been received. Do not unpack if not installed for use immediately.
3. File a written claim for any damage or shortage immediately with the equipment supplier.
4. Repair or replace all damage or shortages that may occur during the period of storage.
5. Assume the costs incurred from the date that the equipment is delivered to the Plant and maintain the equipment in proper storage, including insurance, for all the suppliers' equipment.
6. After delivery, provide routine maintenance on all the suppliers' equipment as required by the equipment supplier from the date of earliest delivery to the time of initial start-up of the equipment.
7. Provide all necessary equipment and labor to move all items supplied by the equipment suppliers and stored on the Plant site when equipment is ready for installation.

8. Move equipment only according to the equipment suppliers' instructions and under the equipment suppliers' direct supervision.
9. Provide surveillance to ensure no equipment is removed by other than the Contractor's forces nor damaged by vandalism.

1.08 SYSTEM DESCRIPTION

A. PAC system, featuring high speed turbo PAC(s) to supply air to the aeration basins.

A. The compressors shall be complete pre-packaged units. High efficiency, high speed motors shall be furnished as an integral part of the compressor core assembly. In general, each compressor shall be housed in a sound attenuating enclosure with flanged inlet and outlet connections, shall have an inlet air filter, inlet silencer, inlet and outlet flexible joints, outlet silencer, check valve, electric actuated isolation valve, blow-off valve and silencer, motor cooling air outlet silencer, adjustable frequency drive, instruments and integral local control panel, magnetic bearings, uninterruptible power supply (UPS) and other appurtenances as described in this specification section needed for a complete system. Harmonic filters required to reduce harmonic distortion to the limits specified herein, shall also be supplied either in separate enclosures or inside the compressor enclosures. The compressor system shall also be supplied with a single master control panel (MCP), located remotely, to monitor and control the compressors based on operational requirements and motor run time. The same supplier shall furnish the turbo air compressors and accessories.

1.09 PATENTS

A. The Contractor shall assume all costs of patent fees or licenses for equipment or processes, and shall safeguard and save harmless the Owner and its agents from damages, judgments, claims, and expenses arising from license fees or claimed infringements or any letters of patent or patent right, or because of royalty or fee for the use of any equipment or process, structural feature, or arrangement of any of the component parts of the installation; and the price stipulated for all such patent fees, licenses, or other costs pertaining thereto.

1.10 MANUFACTURER’S WARRANTY

A. The PACs and appurtenances shall be warranted for a period of 10 years from Owner’s acceptance of partial utilization of equipment. PACs and appurtenances shall be warranted to be free from defects in workmanship, design or material. If the equipment should fail during the warranty period due to a defective part(s), it shall be replaced, and the unit(s) restored to service at no expense to the Owner.

B. This warranty shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and is in addition to and

runs concurrent with the warranties made under the general warranty requirements of Contract Documents.

C. Time and materials required to correct defective equipment shall be provided by the PAC manufacturer at no additional cost to Owner.

D. PAC manufacturer shall guarantee to ship any parts required for emergency breakdown of repairs on all PACs within 5 working days of acknowledged receipt of the order, or the parts are free of charge to the Owner.

1.11 EXTRA MATERIALS

A. Furnish, tag, and box, for the PAC size, the following extra materials and any special tools and appliances necessary to disassemble, service, repair and adjust the equipment and appurtenances, for shipment and long-term storage. Provide extra materials at substantial completion.

Item	Quantity
Air Filters	1 per PAC
Special Tools	2 sets

1.12 SERVICE CONDITIONS, DESIGN AND PERFORMANCE REQUIREMENTS

A. The PAC system shall be capable of continuous operation at specified service conditions and design requirements, including one standby PAC:

Table 1
Design Criteria Summary Table

Total Number of Compressors	6 (5 duty, 1 standby)
Method of Operation	In parallel, continuous system operation with cycling of units as determined by air demand of the system
Compressor Type	High Speed Turbo
Drive Type	Direct coupled
Design Site Elevation (NAVD 88)	19 feet
Inlet Pressure	Ambient
Maximum Compressor Inlet Pressure Loss (air pipes, dirty filter and inlet silencer)	0.25 psi
Design Total Compressor System Capacity	43,600 scfm
Design Discharge Pressure[1]	7.7 to 10.25 psig

Table 1 Design Criteria Summary Table	
Package Discharge Flange	ANSI 150-pound. bolt pattern
Primary Air Source	Ambient air
Package Inlet Flange	ANSI 150 lb. bolt pattern[2]
Available Power Voltage	480 V
Available Power Phase/Frequency	3-Phase / 60 Hz
Maximum Noise at 3 Feet (free field)(3)	<80 dba
Allowable vibration level	<1 mm/sec

[1]The discharge pressure (delivered pressure) as measured downstream of the check valve.

[2]The inlet pipe is the piping between the inlet flange and the compressor inlet filter.

[3]When measured in accordance with ASME PTC 36, Measurement of Industrial Sound, and operating at the maximum design capacities.

B. PAC continuous duty operating conditions at specified service conditions listed above:

Table 2 Continuous Duty Operating Conditions (5 Duty, 1 Standby)					
Operating Condition (1) (2)	**Inlet Temperature (deg. F)**	**Inlet Relative Humidity (%)**	**Discharge Airflow Rate (scfm)**	**Discharge Pressure (psig)**	**Total Wire Power (kW)**
Condition 1	-5	54	9,500	7.7	232
Condition 2	-5	54	31,900	7.7	193
Condition 3	60	70	16,000	7.7	225
Condition 4	40	86	13,000	7.7	172
Condition 5	104	50	43,600	7.7	283
Condition 6	-5	54	9,500	10.25	290
Condition 7	-5	54	31,900	10.25	243
Condition 8	60	70	16,000	10.25	282
Condition 9	40	86	13,000	10.25	221
Condition 10	104	50	43,600	10.25	353

Notes:
(1) Each operating condition shall be considered with the discharge pressure and flow measured downstream of the check valve and shall include inlet losses as noted in Table 1.
(2) The PACs shall be capable of continuously operating between Operating Conditions listed. The Total Wire Power performance shall be guaranteed for each PAC with no positive tolerance.

C. PACs **shall not** overheat, surge, or exceed the nameplate motor rating over the entire operating range under continuous, intermittent or internal recirculation mode of operation.

D. Guaranteed Performance: The manufacturer shall submit guaranteed PAC package total wire power (kW), flow and pressure values at the listed Operating Conditions in Table 2. The wire power shall include all losses associated with the PAC package at all specified operating points. The PACs shall be capable of continuously operating between Operating Conditions listed. The Total Wire Power performance shall be for each PAC with no positive tolerance. The completed table will be considered the basis of the performance guarantee and all related requirements as specified herein.

E. Actual Performance: The actual performance of each PAC package will be obtained during the factory performance test as specified herein. Include the results for each PAC package with the factory performance test submittal.

F. In the event the PAC package does not perform as guaranteed, the PAC manufacturer will exercise one or both of the following options:

1. Provide all necessary material and personnel to modify the PAC package to meet the specified performance requirements and rerun the performance tests until satisfactory results are achieved.
2. Replace the unit with equipment that meets the performance requirements.

G. In the event that, after exercising the above remedies, a blower package fails to meet the total wire power guarantee, the Owner may accept the PACs by imposing a power penalty of $5,000 per horsepower, in excess of the guaranteed Total Wire Power. The penalty shall be imposed on each blower package that does not meet guaranteed performance.

PART 2 PRODUCTS

2.01 GENERAL

A. The equipment covered by these Specifications shall call attention to certain features but do not purport to cover all details of the construction of the unit. Ancillary and accessory devices, within the confines of the Contractor or PAC

manufacturer's scope, necessary for PAC system performance shall be included by the Contractor whether specified or not.

B. The equipment covered by these Specifications is intended to be standard process equipment of proven ability as manufactured by reputable concerns having long experience in the production of such equipment. The equipment furnished shall be designed, constructed and installed in accordance with the best practices and methods and shall operate satisfactorily when installed as shown on the Drawings.

C. All parts shall be so designed and proportioned as to have liberal strength and stiffness and to be especially adapted for the Work to be done. Ample room and facilities shall be provided for inspection, repairs and adjustment.

D. The nameplate ratings for the motors shall not be exceeded, nor shall the design service factor be reduced when its piece of equipment is operating at any point on its characteristic curve.

E. The location, size, and type of all piping shall be as shown on the Drawings, or as required by the equipment, if size not shown.

F. All equipment shall be designed for the loadings in Section 01 61 00, Common Product Requirements.

G. Electrical Special Requirements: All interconnecting cable/conduit required between equipment and panels and all associated motors, motor starters, VFD, SCR, and other instrumentation shall meet the requirements of Division 26 Electrical.

H. All electrical equipment, components, materials, and workmanship shall comply with the requirements of Division 26, Electrical.

2.02 INSTRUMENTATION AND CONTROLS

A. Instrumentation and Controls: In accordance with Section 40 90 01, Instrumentation and Control for Process Systems.

B. Compressors shall be automatically sequenced, through the MCP, to control compressor speed and number of compressors based on either system flow or a constant discharge header pressure with mode selection and setpoints received from Plant SCADA over a Rockwell EtherNet/IP network when MCP is remote mode or received from MCP when in local mode.

C. System Operation: PAC VFDs shall be furnished as part of the APG-Neuros PAC package.

D. Shop/Factory Finishing: Furnish manufacturer's standard enamel finish, color as selected.

2.03 ELECTRICAL COMPONENTS AND ACCESSORIES

A. Provide all necessary electrical components and wiring on the compressor skid for a complete, functional compressor system. All equipment on the compressor skid shall be prewired.

B. Wiring: The Drawings and Specifications indicate the anticipated wiring for the equipment provided under this section. All wiring shall meet the requirements of NFPA 70 or nationally recognized testing laboratory. All insulation shall be rated 600 volts, minimum. All low-voltage (24V dc) analog signals shall be run in twisted, shielded pair cable with 600-volt rated insulation.

C. Power Disconnect: Compressors shall be provided with an externally operable power disconnect located on the enclosure exterior accessible from the front of the compressor enclosure.

D. Compressor Drive Motor:

1. Each compressor shall be supplied with a Permanent Magnet Synchronous Motor (PMSM) high speed motor that has no physical connection between stator and shaft, therefore eliminating brushes, slip rings, or break resistors. The PMSM must be combined with a Sine-Wave Filter (Sinus Filter) and Input Line Reactor to maintain cool motor operation and constant motor efficiency with motor turndown. Induction or Brushless DC motors shall not be acceptable.
2. Each motor shall operate on 460/480 volts, three-phase, 60-Hz input power. The maximum allowable motor horsepower shall be as specified in the Design Criteria. Motors shall be premium efficiency type.
3. The motor shall be able to start under the starting conditions required. Compressor manufacturer shall be responsible for coordinating the starting torque requirement of the compressor and the motor with the AFD to ensure proper operation of the system.
4. Motor shall have a guaranteed minimum efficiency of 95 percent.
5. The motor rotor shaft shall be supported by magnetic bearings at all times while power is supplied to the turbo-compressor providing a smooth vibration free rotation over the entire speed range. Compressors that use bearing systems that contact stationary parts during start up or if power is lost are not an acceptable alternate.
6. The motor shall be air cooled by a cooling fan that is mounted directly to the bottom end of the motor rotor shaft or liquid cooled.
7. Additional requirements for the compressor motors are:
   a. Insulation: Epoxy coated Class H rated to 180 degrees C (356 degrees F).
   b. Stator Temperature Monitoring: Internal thermocouple embedded in motor windings with triple redundancy.

c. Maximum Ambient Temperature: 105 degrees F.
d. Minimum Ambient Temperature: 50 degrees F.

E. Adjustable Frequency Drive:

1. Adjustable frequency drive (AFD) shall be manufacturer's standard design, generally of the pulse-width modulation design, with all necessary components to provide a complete and functioning compressor system capable of meeting the design requirements.
2. A six-pulse AFD shall be acceptable provided that the harmonic mitigating equipment provided with each compressor allows the cumulative number of compressors in operation to meet the specified harmonic limits. Alternatively, higher pulse AFDs can also be provided in lieu of a six-pulse AFD to better mitigate the harmonics generated at the source of the non-linear load provided that the overall harmonic limits specified are met.
3. AFD inverter shall be listed by a National Recognized Testing Laboratory (NRTL).
4. AFD shall have a service and support facility operation in the U.S.A. for supply, support, and the provision of replacement components.
5. Drive shall be integrally mounted within the compressor enclosure.
6. AFD shall have a sinusoidal filter consisting of an inductor and capacitor filter to increase motor life.
7. The adjustable frequency drive shall be integrally mounted within compressor enclosure, the associated harmonic filter for harmonics mitigation shall be mounted in a companion standalone NEMA 12 enclosure or mounted within the compressor enclosure.
8. Adjustable frequency drive provided for each compressor shall have a components and design strategy to mitigate the impacts of heat and stress on the PMSM that decrease motor life. Each AFD shall have an integrated user interface that includes field bus connection and support software. Provide control of AFD via Compressor LCP touch screen.
9. Harmonic Distortion Limits:
   a. Normal and Standby Source Harmonic Distortion Limits: Compute the normal and standby source harmonic distortion limits. Using the one-line diagrams, compute the normal and standby source individual and total current and voltage harmonic distortion at the point identified as the PCC. The PCC is the switchgear bus the compressor is connected to. The current and voltage harmonic distortion shall not exceed limits specified herein. Use the values of short circuit current I_{SC} and demand load current I_L specified on diagrams. The harmonic calculations shall be performed with all compressors in operation.
   b. Percent total voltage harmonic distortion at the PCC shall not exceed 5 percent.

c. The short circuit current available at the PCC is 38,500A RMS symmetrical at 480V.
   1) Note that the short circuit available depends on equipment procured therefore coordination between the Vendor and Electrical System Analysis provider will be required.

d. Compute normal source and the standby source individual and total current harmonic distortion at the PCC in accordance with IEEE Standard 519. Individual current harmonic distortion and the total demand distortion expressed as percent of maximum demand load current I_L for PCC shall not exceed values specified in Table 4 below for both the normal and standby sources.

Table 4

Individual Harmonic Order (Odd Harmonics)	Harmonic Current Distortion Percent of Max. Demand Load Current IL1
h < 11	4.0
11 ≤ h < 17	2.0
17 ≤ h < 23	1.5
23 ≤ h < 35	0.6
35 ≤ h	0.3
Total Demand Distortion (TDD)	5.0

[1]For harmonic computations, assume all compressors are in operation and that these compressors are operating at full load.

[2]Limits specified in Table 1 are for AFDs utilizing six-pulse rectifiers. Supplier may choose to provide higher than six-pulse rectifiers or harmonic filters in order to meet the current distortion limits. For converters higher than six pulses, the limits for characteristic harmonics are increased by a factor of √ (q/6), where q is the pulse number, provided that the amplitudes of non-characteristic harmonics are less than 25 percent. Characteristic harmonics are defined as kq±1 where k is an integer and q is the pulse number.

F. Passive Harmonic Filter:

1. Ampere rating suitable for driven equipment, de-rated for altitude as required.
2. Open magnetics and capacitor assembly to achieve specified harmonic distortion requirements.
3. Enclosure: NEMA 2.
4. Manufacturer: MTE Matrix AP, “Or-equal.”

2.04 SHOP/FACTORY FINISHING

A. The compressor enclosure shall be factory painted per manufacturer's standard system and color for interior installation for all cast iron and carbon steel. Aluminum, stainless steel, and brass shall not be painted.

B. Manufacturer shall furnish small quantity kits for touchup painting and for painting other small areas identical to factory paint system and color.

2.05 SOURCE QUALITY CONTROL

A. Factory Performance Tests:

1. All furnished compressors and components supplied within this specification shall be tested. Testing of similar size units and components not actually furnished will not be allowed.
2. The compressor package manufacturer must submit a factory test procedure for approval. Prerequisite for scheduling the factory test is an approved test procedure at least 2 weeks prior to scheduling the factory test.
3. The test procedure shall include the completed attached supplement, Process and Fluid Components and Electrical Power Related Components – Factory Testing Summary Checklists.
4. The test procedure shall include a sketch of the test setup showing the piping and instrumentation.
5. Upon completion of assembly, the compressor system shall be tested at the place of assembly. Provide 4 weeks' notice, in writing, for the witnessing of the testing.
6. Owner and/or Engineer may witness shop tests, inspect and check testing equipment used, and observe the calibration of pressure gauges and transducers. Pressure measurement devices calibrated at a location remote from the factory will not be acceptable. The use of computer data acquisition systems shall be acceptable. However, all readings must be independently verifiable from certified and/or calibrated instruments.
7. Allow proper time for inspection and witnessing of shop testing of material and equipment. Proper time shall be defined as the time required to successfully complete the specified factory test. Each compressor package shall be factory tested for a duration not less than 4 hours under varying operating conditions.
8. Each individual compressor package including blowoff valve and LCP shall be tested before shipment. The LCP shall be connected to all enclosure instruments, and appurtenances. All start/stop and running sequences and all safety alarm systems shall be tested. The witnessing engineer shall sign the test procedures and results, certifying that the assembled compressors, auxiliaries, blowoff valves, and control panel were tested together, as a system, in the compressor manufacturer's shop.

9. Each compressor package shall be tested in accordance with the ASME Wire-to-Air Performance Test Code for Compressor Systems, PTC-13-2018. Tests shall be conducted using the job motor at actual voltage and frequency. Calibrated high-accuracy power analyzers shall measure the package wire power at the package power input terminals and include all auxiliary system electric loads as per Section 4-1 of the ASME PTC-13. The test shall include determination of the surge point and verification of the guarantee points. Power factor for each compressor shall be tested. The manufacturer shall verify the compressor motors operate at a power factor equal to or higher than that specified.
10. The compressor delivered flow rate (scfm) and discharge pressure (psi) shall be guaranteed with no negative tolerance. There shall be no other tolerances or measuring uncertainties used in reporting test results. The witnessing Engineer shall sign each copy of the test data log sheet certifying that the required tests were performed in strict accordance with these Specifications and the ASME PTC-13.
    a. The capacity of the compressor shall be defined as described in the ASME PTC-13.
    b. The test shall construct operating curves of inlet to discharge pressure plotted against delivered flow rate (SCFM).
    c. All test equipment shall be calibrated and certified by an independent test agency no more than 12 months prior to the test date. Certificates shall show the stability of calibration over a period of at least 1 year per ISO 9001. All test equipment shall be per Section 4 of ASME PTC-13.
    d. Velocity vibration versus frequency levels shall be recorded within 10-1,000 and 10-10,000 Hz frequency range.
    e. Appurtenances, fittings or specially configured piping on the inlet or the outlet of the machine will ONLY be permitted if they were submitted as part of the Shop Drawing review AND that they can be installed with the equipment and preserve the existing building design. Distance that the machine extends into the room and the centerline elevation of the common discharge header shall be maintained.
11. The compressor test report shall present computations in exact accordance with Section 5 and 6 of ASME PTC-13 with performance curves showing capacity, pressure, and wire power.
12. Provide total power consumption calculations for each compressor for each specified operating conditions.
13. Test results of the motors and compressors shall be included in the Operation and Maintenance Manual.
14. The manufacturer shall provide copies of the test data and all certifications of Factory Testing for approval by the Engineer prior to shipping equipment.
15. The equipment manufacturer shall furnish all air and ground transportation, lodging, miscellaneous travel expenses, and meals for

two representatives of Owner and the Engineer for a total of 3 people. All Factory Tests to be available for the owner and engineer to witness via remote means such as Microsoft Teams or Zoom. The equipment manufacturer shall furnish all air and ground transportation, lodging, miscellaneous travel expenses, and meals for the initial witness testing and any subsequent testing necessitated by failed tests.

B. Master Control Panel Factory Tests:

1. The Owner and Engineer reserves the right to witness the tests specified herein and to inspect the fabrication procedures at any time during the fabrication of the panel.
2. Witnessed panel factory tests shall be conducted per pre-approved factory test plan procedures.
3. Provide 4 weeks' notice, in writing, for the witnessing of the testing.
4. Perform functional tests as follows:
    a. Gather and furnish test information necessary to show conformance to specified requirements.
    b. Manufacturer's Test Representative shall certify test results.
    c. Perform tests on panel(s) actually furnished after construction is complete and final application software is loaded onto all PLCs and OITs.
    d. Simulate interlocks and signals from other connected equipment in order to demonstrate specified operator interface functions and controls.
    e. Provide temporary test software to simulate properly operating motors and valves when actual motors or valves are not connected.
5. Testing shall include, as a minimum:
    a. Inspection for proper construction.
    b. Verification of conformance with OIT standards.
    c. Verification of SCADA remote monitoring and control functions:
        1) Provide test screen for simulating outputs from SCADA and display SCADA monitored points.
    d. Monitoring and control of all connected devices, included those provided by others including two air discharge header pressure transmitters.
    e. Compressors Lead and Lag selections.
    f. Alarm functions.
    g. Switching logic between available and not available compressors.
    h. Power recovery.
    i. All automatic sequences including:
        1) Normal start.
        2) Normal stop.
        3) Controlled shutdown.
        4) Local E-stop.

5) Remote E-stop.
6) Power recovery.

j. Obtain acceptance of test reports from Engineer prior to shipment of equipment.

PART 3 EXECUTION

3.01 COORDINATION OF EQUIPMENT CONTRACTS

A. Review the Contracts for supply of the preselected equipment and coordinate all requirements with the requirements of this Contract.

3.02 INSPECTION

A. Contractor shall inspect materials and equipment for signs of pitting, rust decay or another deleterious effects of storage. Do not install material or equipment showing such effects. Contractor shall communicate with the manufacturer and return any equipment or materials deemed defective. If necessary, the Contractor shall ship the equipment as required for delivery back to the manufacturer.

3.03 INSTALLATION OF EQUIPMENT

A. Install equipment in accordance with the equipment manufacturers' written instructions and approved Shop Drawings.

B. Provide all labor for installation of the equipment.

C. The PAC manufacturer's representative shall verify all PACs and systems components such as check valves, blowoff butterfly valves, and discharge butterfly valves are properly installed and operating correctly. If adjustments are necessary, they shall be performed by Contractor in accordance with the recommendations of the PAC manufacturer’s representative.

D. Provide all necessary external piping and electrical connections and panels, where not supplied, to all the suppliers' equipment. Piping connections to be made to permit ready disconnection of equipment with minimum disturbance of adjoining piping and equipment and in accordance with manufacturer's instructions.

E. Where instruments, ancillary equipment, control panels, receptacles, switches or other devices are supplied by the equipment suppliers, provide all piping, electrical and instrument wiring and connections required for the devices.

F. Install equipment in accordance with the applicable Specification sections and Drawings of this Contract.

G. Locate, level, and align all equipment and set all lines and levels of equipment to the accuracy required.

H. Set, align and assemble equipment in conformance with the manufacturer's drawings or instructions. Runout tolerance by dial indicator method of alignment or other approved method shall be plus or minus 0.05 mm or as directed by the manufacturer, whichever is more stringent.

I. Furnish all blocking, wedges, shims, filling pieces, or other materials required for the proper support and leveling of equipment during installation. Grind as required to bring parts to proper bearing after erection.

J. Provide all anchor bolts required for installation of the equipment if such anchor bolts are not furnished by the equipment supplier. Anchor bolts and nuts shall be Type 316 stainless steel unless specified otherwise.

K. Rotate rotating assemblies and all other moving parts a minimum of once per week to ensure proper lubrication and prevent "flat-spotting" of bearings.

L. Apply an anti-seize compound to all threads in mechanical connections such as bolts, studs, cap screws, tubing, etc.

M. Coating: Touch up all damage to finish paint caused during unloading, storage, handling, and installation of the equipment. Obtain matching coatings from manufacturer.

3.04 WORKMANSHIP

A. Use proper tools for assembly of equipment and materials to prevent marring the surface of shafts, nuts or other parts.

B. Tighten all connections requiring gaskets evenly all around to ensure uniform stress over the entire gasket area.

C. Do not weld or burn any parts with machined surfaces except upon written permission of the Engineer.

3.05 START-UP, OPERATION AND COMMISSIONING

A. Field testing of the PAC system shall be carried out in accordance with Section 01 91 14, Equipment Testing and Facility Startup and Section 40 90 01, Instrumentation and Control for Process Systems. Testing in addition to listed sections, is described herein.

B. Functional Testing:

1. After the installation of the units and all appurtenances, each unit shall be subjected to functional testing as defined herein. The functional tests

shall be conducted under the installation contract by the Manufacturer's Representative. The functional tests shall demonstrate that under all conditions of operation each unit:

a. Has not been damaged by transportation or installation.
b. Has been properly installed.
c. Has no mechanical defect.
d. Is in proper alignment.
e. Has been properly connected.
f. Has current to all motor electrical leads balanced.
g. Has been properly connected.
h. Has fully functional instruments that are properly calibrated and set.
i. Will start, run, and stop in the prescribed manner.
j. Will run through entire range of specified pressure and flow.
k. Is free of overheating of any parts.
l. Is free of all objectionable vibration.
m. Is free of excessive noise.
n. Is free of overloading of any parts.
o. Shall operate as specified with the control system.

2. After each blower has passed functional testing outlined above, the blower system shall pass a functional test to prove the blowers and controls will operate as specified herein. The blower system must pass this functional test before proceeding with demonstration testing. Functional testing will be performed with the PAC system connected to existing ALP piping as shown on the construction sequence drawings.
3. All labor, and incidentals required to complete the functional tests will be provided by the Contractor under the installation contract. The compressor Manufacturer shall prepare functional testing procedures, assist during functional testing and approve functional testing results. The Contractor shall provide testing equipment including, but not limit to portable power monitoring equipment, recording devices, and pressure sensors to verify field testing results. The compressor Manufacturer shall coordinate all testing requirements with the Engineer prior to commencing functional testing.

C. Demonstration Testing:

1. Once the Manufacturer confirms compressors are correctly installed and properly functioning, and all new piping on the biological reactor basins is installed as shown on the Drawings, conduct demonstration testing.
2. Conduct a demonstration test on each set of compressors including instrumentation, controls, and valves. The test shall demonstrate that the compressors will be operated in the entire range of specified pressure and flow while in remote with control from SCADA. The test shall be conducted with the aeration basins full of plant effluent or mixed liquor at normal operating levels.

3. Conduct demonstration of each compressor's ability to be manually restarted through LCP, MCP and SCADA following a plantwide power failure.
4. A Demonstration Test Log shall be submitted to Engineer on completion of each test which records the compressor model number, compressor serial number, test date, beginning test time, ending test time, motor horsepower, motor speed, amperage draw, and all of the key operating parameters specified in the Design Criteria. In addition to this information, Table 5 must be completed during field startup and testing to demonstrate proper operation. Functional test results shall be certified by the manufacturer/manufacturer's representative and witnessed by Engineer.

Table 5
Compressor Demonstration Test Results

Design Point	Input kW Reading	Discharge Mass Flow (scfm)	Discharge Pressure (psig)	Ambient Temp. (degrees F)	Discharge Temp. (degrees F)	Relative Humidity (%)
1						
2						
3						
4						
5						
6						
7						
8						

5. The Contractor will provide, calibrate, and install all temporary gauges and meters, shall make necessary tapped holes in the pipes and install all temporary piping and wiring required for the demonstration tests. Written test procedures will be submitted to the Engineer for approval a minimum of 60 days prior to testing.
6. For any packages that do not operate properly, corrective measures shall be taken by the Manufacturer at no additional expense to the Owner.
7. Demonstration Testing shall verify that the compressors will operate across the entire range of specified pressures and flows while in remote with control from SCADA.
8. Conduct a minimum of 8-hour demonstration test on multiple scenarios where various numbers of compressors are operating. The test shall demonstrate that the compressors are able to sequence on and off as lead and lag systems as required to maintain the pressure set point received from SCADA. Demonstration testing shall verify the compressors properly operate across the entire range of specified operating flows.

D. Harmonic Distortion Tests: The manufacturer shall retain an independent harmonic testing company to conduct a harmonic distortion test on the new operational compressor system under the installation contract as outlined below:

1. With each new compressor, as well as combinations of each compressor up to the full operating load, measure current harmonic distortion at the PCC for all harmonics up to 35th harmonic.
2. Show that the percent current harmonic distortion is below specified limits.
3. Measure total voltage distortion at the MCC with two new compressors operating at full load.
4. Measured results should approximate Engineer-approved calculations submitted by the compressor manufacturer.
5. Provide distortion analyser, current, and potential transformers required for the test set up.
6. Submit a test plan for Engineer's review and approval prior to implementing the actual test. An approved test plan is mandatory before conducting a test.
7. Provide at least 2 weeks' notice before conducting test.
8. Submit all test documentation for approval.

E. Compressors failing to meet the specifications to the satisfaction of Engineer shall be corrected and re-tested by the Equipment Manufacturer. If a packaged compressor fails the second test, the unit will be rejected, and the Equipment Manufacturer shall furnish a unit which shall perform as specified.

3.06 TRAINING

A. After successful completion of required system testing, a manufacturer's factory trained representative shall provide field and classroom training to operation and maintenance staff in proper operation and maintenance of the equipment.

B. Pretraining shall be provided after successful functional testing of the PAC system and include a minimum of 2 training sessions and be scheduled to accommodate all shift schedules of operation and maintenance staff, including night shifts.

C. Operations and maintenance training shall be provided after successful demonstration testing and consist of 2 shifts for Operators and 2 shifts for maintenance staff at a minimum.

D. Manufacturer shall submit a training agenda for approval at least 2 weeks prior to the first training.

E. Training sessions shall be recorded for use by the Owner.

3.07 MANUFACTURER'S SERVICES

A. Contractor will coordinate the work schedule of the manufacturer's service personnel during construction, testing, startup, and acceptance.

B. Provide services of a factory trained service engineer, specifically trained on the type of equipment specified. Submit qualifications of service engineer for approval.

C. Manufacturer's field services provided under the installation contract include followings:

1. 1 site visit of 5 person-days for installation assistance.
2. 1 site visit of 5 person-days for functional testing.
3. 1 site visit of 5 person-days for demonstration testing.
4. 1 site visit of 2 person-days for PAC Local Control Panel and instrumentation communicate with MCP prior to startup.
5. 1 site visit of 5 person-days for coordination with SCADA.
6. 1 site visit of 4 person-days for pre-training prior to startup. Training shall not commence until a detailed lesson plan for each training activity has been reviewed and accepted by Engineer.
7. 1 site visit of 8 person-days for Operation and Maintenance Training. Training shall consist of 2 shifts for Operators and 2 shifts for maintenance staff at a minimum. Training shall not commence until a detailed lesson plan for each training activity has been reviewed and accepted by Engineer.

D. See Section 01 43 33, Manufacturer's Field Services.

3.08 SUPPLEMENTS

A. The supplement listed below, following "End of Section," is a part of this Specification.

1. Process and Fluid Components and Electrical Power Related Component – Factory Testing Summary Checklists.
2. APG-Neuros, proposal. Provided as Volume 2, for information only.

END OF SECTION

PROCESS AND FLUID COMPONENTS AND ELECTRICAL POWER RELATED COMPONENTS -- FACTORY TESTING CHECKLISTS

1. Process and Fluid Components:

No.	Component	Included in Performance Boundary		
		Included in Test	Determine by Calculation	Not Applicable
1	Inlet filter			
2	Inlet silencer			
3	Discharge silencer			
4	Inlet isolation valve			
5	Throttling valve			
6	After cooler			
7	Misc. pipe and fittings			
8	Inlet air cooler			
9	Discharge check valve			
10	Discharge isolation valve			
11	Enclosure doors or panel openings			
12	Estimated system inlet press. drop			
13	Blow-off valve			
14	Blow-off silencer			
15	Additional components not listed shall be included as forming the PAC package.			

2. Electric Power Related Components:

No.	Component	Included in Performance Boundary		
		Included in Test	Determine by Calculation	Not Applicable
1	Drive Motor			
2	Motor Cooling Fan(s)			

No.	Component	Included in Performance Boundary		
		Included in Test	Determine by Calculation	Not Applicable
3	Magnetic Bearing and Controller			
4	Bearing cooling fan(s)			
5	Coolant Pumps			
6	Lubrication Pumps and Accessories			
7	Heat Exchanger Fans			
8	Package Cooling Fan			
9	VFD			
10	VFD Line Side Power Conditioning Equipment			
11	VFD Load Side Power Conditioning Equipment			
12	Eddy Current or Variable Speed Clutch			
13	Operation Control Panel(s)			
14	Power/Isolation Transformers and Power Supplies			
15	Power Conditioner			
16	PAC and Motor Cooling			
17	VFD Cooling			
18	Electronics compartment A/C			
19	Additional components not listed shall be included as forming the PAC package.			