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Sanford Underground Research Facility WWTP

PREPARED FOR

South Dakota Science and Technology Authority
Lead, South Dakota

PREPARED BY

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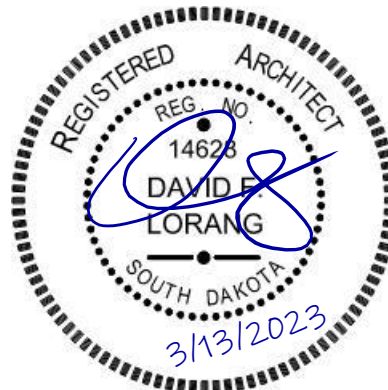
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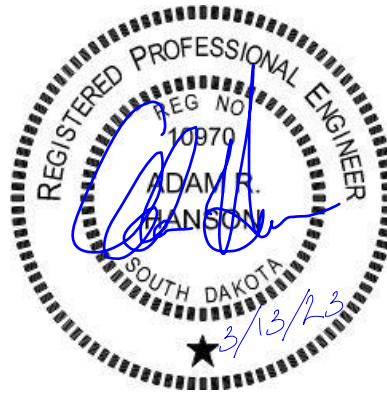
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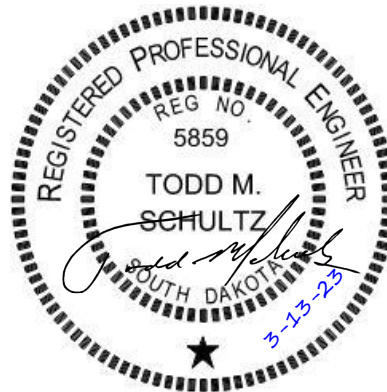
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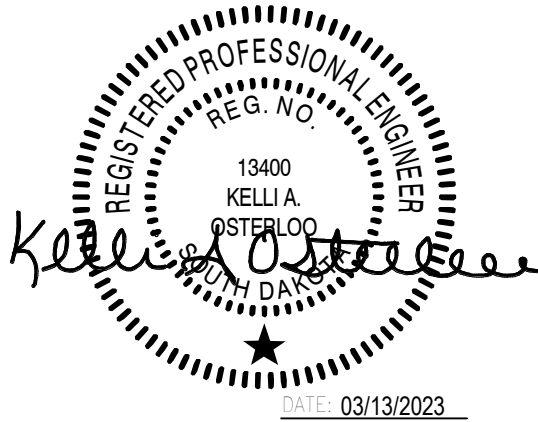
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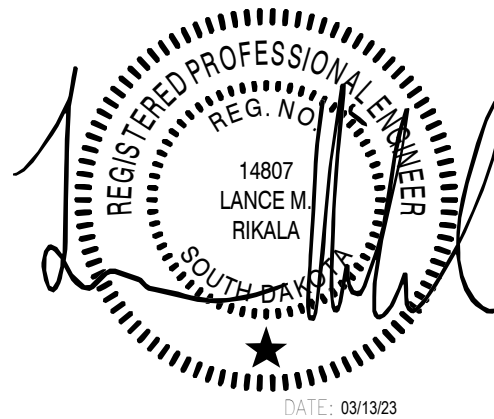


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**SECTION 01 0001
SUMMARY OF WORK**

PART 1 GENERAL

1.1 WORK COVERED BY CONTRACT DOCUMENTS

A. Project Description

1. The work includes the following major milestones:
 - a. Demolition of a portion of the existing RBC units and basins.
 - b. Construction of new MBBR aeration basins.
 - c. Construction of new Blower Building
 - d. Installation of blowers and coarse bubble aeration system.
 - e. Installation of air piping connections.
 - f. Installation of process water piping.
 - g. Installation of associated electrical system.
 - h. Installation of associated Instrumentation & Control system.
 - i. Any incidental related work.

B. Location

1. The work is located at the Sanford Underground Research Facility, approximately as indicated: All work will take place at the Wastewater Treatment Facility, approximately 1 mile east of Yates Complex. Work will be within the existing RBC location.

1.2 OCCUPANCY OF PREMISES

- A. Building/location of work will be occupied during performance of work under this Contract. Occupancy notifications will be posted in a prominent location in the work area.
- B. Before work is started, arrange with the Project Manager a sequence of procedure, means of access, space for storage of materials and equipment, and use of approaches, corridors, and stairways.
- C. WWTP will continue to operate during the entire duration of this contract.

1.3 EXISTING WORK

- A. Remove or alter existing work in such a manner as to prevent injury or damage to any portions of the existing work which remain. Repair or replace portions of existing work which have been

altered during construction operations to match existing or adjoining work, as approved by the Project Manager. At the completion of operations, existing work must be in a condition equal to or better than that which existed before new work started.

1.4 LOCATION OF EXISTING UTILITIES

- A. Obtain digging permits prior to start of excavation and comply with Facility requirements for locating and marking underground utilities. Contact local utility locating service (Jim's Private Utility Locating Service) a minimum of 72 hours prior to excavating, to mark utilities, and within sufficient time required if work occurs on a Monday or after a Holiday. Verify existing utility locations indicated on contract drawings, within area of work. Jim's Private Locating Services performs all locating work on SURF property.

1.5 NOTIFICATION PRIOR TO EXCAVATION

- A. Notify the Project Manager at least 48 hours prior to starting excavation work.

END OF SECTION 01 0001

**SECTION 01 0002
ADMINISTRATIVE REQUIREMENTS**

PART 1 GENERAL

1.1 PROGRESS AND COMPLETION PICTURES

- A. Photographically document site conditions prior to start of construction operations. Provide monthly digital photographs showing the sequence and progress of work to clearly capture the work performed during that period, in particular areas that will be covered as part of the scope of work. Submit with the monthly invoice. Aerial photographs, if they can be done easily, would be beneficial to document the construction. Photographs provided are for unrestricted use by the SDSTA.

1.2 SUPERVISION

- A. Minimum Requirements
 - 1. Have at least one qualified superintendent, or competent alternate, capable of reading, writing, and conversing fluently in the English language, on the jobsite at all times during the performance of contract work. The Quality Control (QC) representative must also have fluent English communication skills.
- B. Superintendent Qualifications
 - 1. The project superintendent must have a minimum of 10 years' experience in construction with at least 2 of those years as a superintendent on projects similar in size and complexity. The individual must have experience in the areas of hazard identification and safety compliance. The individual must be capable of interpreting a critical path schedule and construction drawings. The qualification requirements for the alternate superintendent are the same as for the project superintendent. The Contracting Officer may request proof of the superintendent's qualifications at any point in the project if the performance of the superintendent is in question.
 - 2. For routine projects where the superintendent is permitted to also serve as the Quality Control (QC) Manager as established in Section QUALITY CONTROL, the superintendent must have qualifications in accordance with that section.
 - 3. Duties
 - a. The project superintendent is primarily responsible for managing and coordinating day-to-day production and schedule adherence on the project. The superintendent is required to attend partnering meetings, and quality control meetings if applicable. The superintendent or qualified alternate must be on-site at all times during the performance of this contract until the work is completed and accepted.
- C. Non-Compliance Actions

1. The Project Superintendent is subject to removal by the Contracting Officer for non-compliance with requirements specified in the contract and for failure to manage the project to insure timely completion. Furthermore, the Contracting Officer may issue an order stopping all or
2. part of the work until satisfactory corrective action has been taken. No part of the time lost due to such stop orders is acceptable as the subject of claim for extension of time for excess costs or damages by the Contractor.

1.3 PRECONSTRUCTION

- A. After award of the contract but prior to commencement of any work at the site, meet with the Project Manager to discuss and develop a mutual understanding relative to the administration of the quality control, safety program, preparation of the schedule of prices, shop drawings, and other submittals, scheduling programming, and prosecution of the work. Major subcontractors who will engage in the work must also attend.

END OF SECTION 01 0002

**SECTION 01 0003
PROJECT CONSTRUCTION PROGRESS SCHEDULES**

PART 1 GENERAL

1.1 SUBMITTALS

- A. Construction Schedule
- B. Monthly Schedule Updates

1.2 ACCEPTANCE

- A. Prior to the start of work, prepare and submit to the Project Manager for acceptance a construction schedule in the form of a Bar Chart Schedule to the Project Manager for acceptance.
- B. The acceptance of a Baseline Construction Schedule is a condition precedent to:
 - 1. The Contractor starting work on the demolition or construction stage(s) of the contract.
 - 2. Processing Contractor's invoice(s) for construction activities.
 - 3. Review of any schedule updates.
- C. Submittal of the Baseline Schedule, and subsequent schedule updates, is understood to be the Contractor's certification that the submitted schedule meets all of the requirements of the Contract Documents, represents the Contractor's plan on how the work will be accomplished, and accurately reflects the work that has been accomplished and how it was sequenced.

1.3 SCHEDULE FORMAT

- A. Bar Chart Schedule
 - 1. The Bar Chart must, as a minimum, show work activities, major material/equipment delivery, on-site construction, key inspections, and closeout activities. The Bar Chart must be time scaled and generated using an electronic spreadsheet program.
- B. Schedule Submittals and Procedures
 - 1. Submit a Bar Chart Schedule and updates in hard copy and on electronic media that is acceptable to the Project Manager.

1.4 SCHEDULE MONTHLY UPDATES

- A. Update the Construction Schedule at monthly intervals or when the schedule has been revised. The updated schedule must be kept current, reflecting actual progress and plan for completing the remaining work.

1.5 CONTRACT MODIFICATION

- A. Submit a schedule analysis with each cost and time proposal for a proposed change. The analysis must illustrate the influence of each change or delay on the Contract Completion Date or milestones. No time extensions will be granted nor delay damages paid unless a delay occurs which consumes all available Project Float and extends the Projected Finish beyond the Contract Completion Date. Identify types of delays as follows:
 - 1. Excusable Delay: Force-Majeure (e.g. unusual weather) - Contractor may receive time extension, but time will not be compensable.
 - 2. Inexcusable Delay: Contractor Responsibility - Contractor will not receive time extension.
 - 3. Compensable Delay: SDSTA Responsibility - Contractor may receive compensable time extension.
- B. If a combination of any of the delay types outlined above occurs, it is considered a Concurrent Delay, which will require an analysis of the facts to determine compensability and entitlement to any time extension under the applicable contract clauses.

1.6 WEEKLY PROJECT STATUS MEETING AND 3-WEEK LOOK AHEAD SCHEDULE

- A. Each week during the active construction period, a Weekly Status Meeting will be held. At a minimum, the project superintendent and QC Manager should attend representing the contractor. The superintendent or other designated rep will take meeting minutes to capture the discussions. As part of the process, the contractor will prepare and issue a 3-Week Look Ahead schedule to provide a more detailed day-to-day plan of upcoming work identified on the Construction Schedule. Additionally, include upcoming outages, closures, etc. The detailed work plans are to be bar chart type schedules, separate from the Construction Schedule on an electronic spreadsheet program and printed on (8-1/2 by 11 inch) sheets as directed by the Project Manager. In addition to schedule discussions, the Weekly Status meeting should discuss status of submittal reviews and approvals, Requests For Information (RFI), outstanding change orders, and other relevant project coordination issues.

END OF SECTION 01 0003

**SECTION 01 0004
SUBMITTAL PROCEDURES**

PART 1 GENERAL

1.1 DEFINITIONS

A. Submittal Descriptions (SD)

1. Submittal requirements in addition to those noted below may be specified in the technical spec sections and drawings.
2. Preconstruction Submittals
 - a. Submittals which are required prior to start of construction (work). (See definition below).
 - 1) -List of Proposed Subcontractors
 - 2) -Construction Progress Schedule
 - 3) -Submittal Register
 - 4) -Schedule of Prices
 - 5) -Health and Safety Plan
 - 6) -Quality Control (QC) Plan
 - 7) -Environmental Protection Plan
3. Shop Drawings
4. Drawings, diagrams, and schedules specifically prepared to illustrate some portion of the work.
 - a. Diagrams and instructions from a manufacturer or fabricator for use in producing the product and as aids to the Contractor for integrating the product or system into the project.
5. Drawings prepared by or for the Contractor to show how multiple systems and interdisciplinary work will be coordinated.
6. Product Data
 - a. Catalog cuts, illustrations, schedules, diagrams, performance charts, instructions and brochures illustrating size, physical appearance and other characteristics of materials, systems, or equipment for some portion of the work.

- b. Samples of warranty language when the contract requires extended product warranties.
- 7. Samples
 - a. Fabricated or unfabricated physical examples of materials, equipment or workmanship that illustrate functional and aesthetic characteristics of a material or product and establish standards by which the work can be judged.
 - b. Color samples from the manufacturer's standard line (or custom color samples if specified) to be used in selecting or approving colors for the project.
 - c. Field samples and mock-ups constructed on the project site establish standards by which the ensuring work can be judged. Includes assemblies or portions of assemblies which are to be incorporated into the project and those which will be removed at conclusion of the work.
- 8. Test Reports
 - a. Report signed by authorized official of testing laboratory that a material, product, or system identical to the material, product, or system to be provided has been tested in accord with specified requirements. Unless specified in another section, testing must have been within three years of date of contract award for the project.
 - b. Report which includes findings of a test required to be performed by the Contractor on an actual portion of the work or prototype prepared for the project before shipment to job site.
 - c. Report which includes finding of a test made at the job site or on sample taken from the job site, on portion of work during or after installation.
- 9. Certificates
 - a. Statements printed on the manufacturer's letterhead and signed by responsible officials of manufacturer of product, system or material attesting that the product, system, or material meets specification requirements. Must be dated after award of project contract and clearly name the project.
- 10. Operation and Maintenance Data
 - a. Data that is furnished by the manufacturer, or the system provider, to the equipment operating and maintenance personnel, including manufacturer's help and product line documentation necessary to maintain and install equipment. This data is needed by operating and maintenance personnel for the safe and efficient operation, maintenance, and repair of the item.

- b. This data is intended to be incorporated in an operations and maintenance manual or control system.
- 11. Closeout Submittals
 - a. Documentation to record compliance with technical or administrative requirements or to establish an administrative mechanism.
 - b. Special requirements necessary to properly close out a construction contract. For example, as-built drawings. Also, submittal requirements necessary to properly close out a major phase of construction on a multi-phase contract.

1.2 SUBMITTAL REGISTER

A. Use of Submittal Register

1. Submit a register of submittals, arranged in chronological order by dates required by construction schedule. Use of Submittal Exchange is required. Include time required for review, ordering, manufacturing, fabrication, and delivery when establishing dates. Include additional time required for making corrections or revisions to submittals noted by Architect and additional time for handling and reviewing submittals required by those corrections.
2. Coordinate submittal register with list of subcontracts, the schedule of values, and Contractor's construction schedule.
3. Initial Submittal. Submit concurrently with startup construction schedule. Include submittals required during the first 60 days of construction. List those submittals required to maintain orderly progress of the Work and those required early because of long lead time for manufacture or fabrication.
4. Submit revised submittal schedule to reflect changes in current status and timing for submittals.
5. Format. Arrange the following information in a tabular format. (As applicable)
 - a. Scheduled date for first submittal.
 - b. Specification/RFP Section number and title.
 - c. Name of subcontractor.
 - d. Description of the Work covered.
 - e. Scheduled date for final release or approval.
 - f. Scheduled date of fabrication.
 - g. Scheduled dates for purchasing.

6. Scheduled dates for installation.
 - a. Activity or event number.

1.3 VARIATIONS

- A. Variations from contract requirements require both A/E and SDSTA approval and will be considered where advantageous to SDSTA.
 1. Considering Variations
 - a. Discussion with Project Manager and A/E (if applicable) prior to submission will help ensure functional and quality requirements are met and minimize rejections and re-submittals.
 - b. Specifically point out variations from contract requirements in transmittal letters. Failure to point out deviations may result in the rejection and removal of such work at no additional cost to the SDSTA.
- B. Proposing Variations
 - a. When proposing variation, deliver written request to the Project Manager, with documentation of the nature and features of the variation and why the variation is desirable and beneficial to SDSTA. If lower cost is a benefit, also include an estimate of the cost savings. In addition to documentation required for variation, include the submittals required for the item. Clearly mark the proposed variation in all documentation.
2. Warranting that Variations are Compatible
 - a. When delivering a variation for approval, Contractor, including its Designer(s) of Record (if applicable), warrants that this contract has been reviewed to establish that the variation, if incorporated, will be compatible with other elements of work.
3. Review Schedule Extension
 - a. In addition to normal submittal review period, a period of 10 working days will be allowed for consideration by the A/E and SDSTA of submittals with variations.

1.4 SCHEDULING

- A. Schedule and submit concurrently submittals covering component items forming a system or items that are interrelated. Include certifications to be submitted with the pertinent drawings at the same time. No delay damages or time extensions will be allowed for time lost in late submittals.
 1. Coordinate scheduling, sequencing, preparing, and processing of submittals with performance of work so that work will not be delayed by submittal processing. Allow for

potential resubmittal of requirements.

2. Re-submit register and annotate monthly by the Contractor with actual submission and approval dates. When all items on the register have been fully approved, no further re-submittal is required.
3. Carefully control procurement operations to ensure that each individual submittal is made on or before the Contractor scheduled submittal date shown on the approved "Submittal Register."

B. Review Notations

1. Submittals will be returned to the Contractor with the following notations:
 - a. Submittals marked "accepted" authorize the Contractor to proceed with the work covered.
 - b. Submittals marked "accepted as noted" or "accepted as noted, resubmittal not required," authorize the Contractor to proceed with the work covered provided he takes no exception to the corrections.
 - c. Submittals marked "revise and resubmit," indicate noncompliance with the contract requirements or design concept, or that submittal is incomplete. Resubmit with appropriate changes. No work shall proceed for this item until resubmittal is approved.
 - d. Submittals marked "not reviewed" will indicate submittal has been previously reviewed and accepted, is not required, does not have evidence of being reviewed and approved by Contractor, or is not complete. A submittal marked "not reviewed" will be returned with an explanation of the reason it is not reviewed. Resubmit submittals returned for lack of review by Contractor or for being incomplete, with appropriate action, coordination, or change.

1.5 REJECTED SUBMITTALS

- A. If the Contractor considers any correction or notation on the returned submittals to constitute a change to the contract drawings or specifications; notice as required under the contract is to be given to the Contracting Officer. Contractor is responsible for the dimensions and design of connection details and construction of work. Failure to point out deviations may result in the SDSTA requiring rejection and removal of such work at the Contractor's expense.
- B. If changes are necessary to submittals, make such revisions and submission of the submittals in accordance with the procedures above. No item of work requiring a submittal change is to be accomplished until the changed submittals are approved.

1.6 ACCEPTED SUBMITTALS

- A. The acceptance of submittals is not to be construed as a complete check, and indicates only that acceptance will not relieve the Contractor of the responsibility for any error which may exist, as the Contractor under the Contractor Quality Control (CQC) requirements of this contract is responsible for dimensions, the design of adequate connections and details, and the satisfactory construction of all work.
- B. After submittals have been accepted, no resubmittal for the purpose of substituting materials or equipment will be considered unless accompanied by an explanation of why a substitution is necessary.

1.7 APPROVED SAMPLES

- A. Approval of a sample is only for the characteristics or use named in such approval and is not to be construed to change or modify any contract requirements. Before submitting samples, the Contractor to assure that the materials or equipment will be available in quantities required in the project. No change or substitution will be permitted after a sample has been approved.
- B. Match the approved samples for materials and equipment incorporated in the work. If requested, approved samples, including those which may be damaged in testing, will be returned to the Contractor, at his expense, upon completion of the contract.
- C. Samples of various materials or equipment delivered on the site or in place may be taken by the SDSTA for testing. Samples failing to meet contract requirements will automatically void previous approvals. Contractor to replace such materials or equipment to meet contract requirements.
- D. Approval of the Contractor's samples does not relieve the Contractor of his responsibilities under the contract.

END OF SECTION 01 0004

**SECTION 01 0005
QUALITY CONTROL FOR CONSTRUCTION**

PART 1 GENERAL

1.1 SUBMITTALS

- A. Submit the following in accordance with Section 01 0004 SUBMITTAL PROCEDURES:
- B. SD-01 Preconstruction Submittals
- C. QC Plan;
- D. Submit a QC plan within 15 calendar days after receipt of Notice of Award.

1.2 INFORMATION REQUIREMENTS

- A. Prior to commencing work on construction, the Contractor can obtain a single copy set of the current report forms from the Project Manager. The report forms will consist of the Contractor DAILY Report, Contractor DAILY Report (Continuation Sheet), Rework Items List, and Testing Plan and Log.
- B. Deliver the following to the Project Manager and the designated SDSTA QA Rep:
 - 1. DAILY Report: By 10:00 AM the next working day after each day that work is performed;
 - 2. Field Test Reports: One copy, within one week after the test is performed, attached to the CQC Report;
 - 3. QC Certifications: As required by the paragraph entitled "QC Certifications."

1.3 QC PROGRAM REQUIREMENTS

- A. Establish and maintain a QC program as described in this section. The QC program consists of a QC Manager, a QC plan, a Project Pre-Construction Conference, Weekly Status Meeting, submittal review, testing, and QC certifications and documentation necessary to provide materials, equipment, workmanship, fabrication, construction, and operations which comply with the requirements of this contract. The QC program shall cover on-site and off-site work and shall be keyed to the work sequence. No work or testing may be performed unless the QC Manager is on the work site.
 - 1. Preliminary Work Authorized Prior to Acceptance
 - a. The only work that is authorized to proceed prior to the acceptance of the QC plan is mobilization of storage and office trailers, temporary utilities, and surveying.
 - 2. Acceptance

- a. Acceptance of the QC plan is required prior to the start of construction. The SDSTA reserves the right to require changes in the QC plan and operations as necessary, including removal of personnel, to ensure the specified quality of work.
- 3. Notification of Changes
 - a. Notify the contracting officer, in writing, of any proposed change, including changes in the QC organization personnel, a minimum of seven calendar days prior to a proposed change. Proposed changes shall be subject to the acceptance by the contracting officer.

1.4 QC ORGANIZATION

A. QC Manager

- 1. Duties
 - a. Provide a QC Manager at the work site to implement and manage the QC program. In addition to implementing and managing the QC program, the QC Manager may perform the duties of project superintendent. The QC Manager is required to attend the Project Preconstruction Meeting, conduct the QC meetings (If separate from the Weekly Status meeting), perform submittal review, ensure testing is performed and provide QC certifications and documentation required in this contract. The QC Manager is responsible for managing and coordinating documentation performed by others.
- 2. Qualifications
 - a. An individual with a minimum of 10 years combined experience as a superintendent, inspector, QC Manager, project manager, or construction manager on similar size and type construction contracts which included the major trades that are part of this contract. The individual must be familiar with and have experience in the areas of hazard identification and safety compliance.

B. Alternate QC Manager Duties and Qualifications

- 1. Designate an alternate for the QC Manager to serve in the event of the designated QC Manager's absence. The period of absence may not exceed two weeks at one time, and not more than 30 workdays during a calendar year. The qualification requirements for the Alternate QC Manager shall be the same as for the QC Manager.

1.5 QC PLAN

A. Requirements

- 1. Provide, for acceptance by the contracting officer, a QC plan that covers both on-site and off-site work and includes the following with a table of contents listing the major sections

identified with tabs.

- a. QC ORGANIZATION: A chart showing the QC organizational structure and its relationship to the production side of the organization.
- b. NAMES AND QUALIFICATIONS: In resume format, for each person in the QC organization.
- c. DUTIES, RESPONSIBILITY AND AUTHORITY OF QC PERSONNEL: Of each person in the QC organization.
- d. OUTSIDE ORGANIZATIONS: A listing of outside organizations such as architectural and consulting engineering firms that will be employed by the Contractor and a description of the services these firms will provide.
- e. APPOINTMENT LETTERS: Letters signed by an officer of the firm appointing the QC Manager and Alternate QC Manager and stating that they are responsible for managing and implementing the QC program as described in this contract. Include in this letter the QC Manager's authority to direct the removal and replacement of non-conforming work.
- f. SUBMITTAL PROCEDURES AND INITIAL SUBMITTAL REGISTER: Procedures for reviewing and managing submittals. Provide the name(s) of the person(s) in the QC organization authorized to review and certify submittals prior to approval.
- g. TESTING LABORATORY INFORMATION: Testing laboratory information required by the paragraphs "Accredited Laboratories" or "Testing Laboratory Requirements", as applicable.
- h. TESTING PLAN AND LOG: A Testing Plan and Log that includes the tests required, referenced by the specification paragraph number requiring the test, the frequency, and the person responsible for each test.
- i. PROCEDURES TO COMPLETE REWORK ITEMS: Procedures to identify, record, track, and complete rework items.
- j. DOCUMENTATION PROCEDURES: Use SDSTA formats or agreed upon formats with SDSTA QA Manager and Contractor.
- k. PROCEDURES FOR COMPLETION INSPECTION: See the paragraph entitled "COMPLETION INSPECTIONS".

1.6 PROJECT PRECONSTRUCTION CONFERENCE

- A. During the Pre-Construction conference and prior to the start of construction, discuss the QC program required by this contract. The purpose is to develop a mutual understanding of the QC

details, including documentation, administration for on-site and off-site work, and the coordination of the Contractor's management, production, and the QC personnel. At the meeting, the Contractor will be required to explain how quality control will be implemented for key features of work. Contractor's personnel required to attend shall include the QC Manager, project manager, and superintendent. Minutes of the meeting will be prepared by the QC Manager and signed by both the Contractor and the Project Manager. The Contractor shall provide a copy of the signed minutes to all attendees.

1.7 TESTING

- A. Except as stated otherwise in the specification sections, perform sampling and testing required under this contract.
 - 1. Test Results
 - a. Cite applicable Contract requirements, tests or analytical procedures used. Provide actual results and include a statement that the item tested or analyzed conforms or fails to conform to specified requirements. If the item fails to conform, notify the contracting officer immediately. Conspicuously stamp the cover sheet for each report in large red letters "CONFORMS" or "DOES NOT CONFORM" to the specification requirements, whichever is applicable. Test results shall be signed by a testing laboratory representative authorized to sign certified test reports. Furnish the signed reports, certifications, and other documentation to the Project Manager.

1.8 QC CERTIFICATIONS

- A. Invoice Certification
 - 1. Furnish a certificate with each payment request, signed by the QC Manager, attesting that as-built drawings are current and attesting that the work for which payment is requested, including stored material is in compliance with contract requirements.
- B. Completion Certification
 - 1. Upon completion of work under this contract, the QC Manager shall furnish a certificate attesting that "the work has been completed, inspected, tested and is in compliance with the contract."

1.9 COMPLETION INSPECTIONS

- A. Punch-Out Inspection
 - 1. Near the completion of all work or stated elsewhere in the specifications, the QC Manager shall conduct an inspection of the work and develop a punch list of items which do not conform to the approved drawings and specifications. Include in the punch list any remaining items of the "Rework Items List", which were not corrected prior to the Punch-Out inspection. The punch list shall include the estimated date by which the deficiencies

will be corrected. A copy of the punch list shall be provided to the Project Manager. The QC Manager or staff shall make follow-on inspections to ascertain that all deficiencies have been corrected. Once this is accomplished, the Contractor shall notify the SDSTA that the facility is ready for the SDSTA "Pre-Final Inspection".

B. Pre-Final Inspection

1. The SDSTA and QC manager will perform this inspection to verify that the facility is complete and ready to be occupied. A SDSTA pre-final punch list may be developed as a result of this inspection. The QC Manager shall ensure that all items on this list are corrected prior to notifying the SDSTA that a "Final" inspection with the customer can be scheduled. Any items noted on the "Pre-Final" inspection shall be corrected in a timely manner and shall be accomplished before the contract completion date for the work or any particular increment thereof if the project is divided into increments by separate completion dates.

C. Final Acceptance Inspection

1. The QC Manager, the superintendent, or other Contractor management personnel and the Project Manager and SDSTA QA Rep will be in attendance at this inspection. The final acceptance inspection will be formally scheduled based upon results of the "Pre-Final Inspection".

1.10 DOCUMENTATION

- A. Maintain current and complete records of on-site and off-site QC program operations and activities. Reports are required for each day work is performed. Account for each calendar day throughout the life of the contract. The superintendent and the QC Manager (If separate) must prepare and sign the Contractor DAILY Report. The reporting of work shall be identified by terminology consistent with the construction schedule. In the "remarks" section in this report which will contain pertinent information including directions received, problems encountered during construction, work progress and delays, conflicts or errors in the drawings or specifications, field changes, safety hazards encountered, instructions given, and corrective actions taken, delays encountered and a record of visitors to the work site.

1. As-Built Drawings

- a. The QC Manager is required to review the as-built drawings and ensure they are kept current on a regular basis and marked to show deviations, which have been made from the Contract drawings. Ensure each deviation has been identified with the appropriate modifying documentation, e.g. modification number, RFI number, etc. The QC Manager shall initial each deviation or revision. Upon completion of work, the QC Manager shall submit a certificate attesting to the accuracy of the as-built drawings prior to submission to the SDSTA.

1.11 NOTIFICATION ON NON-COMPLIANCE

- A. The Project Manager or QA Rep will notify the Contractor of any detected non-compliance with the foregoing requirements. The Contractor shall take immediate corrective action. If the contractor fails or refuses to correct the non-compliant work, the contracting officer will issue a non-compliance notice. Such notice, when delivered to the Contractor at the work site, shall be deemed sufficient for the purpose of notification. If the Contractor fails or refuses to comply promptly, the contracting officer may issue an order stopping all or part of the work until satisfactory corrective action has been taken. The Contractor shall make no part of the time lost due to such stop orders the subject of claim for extension of time, for excess costs, or damages.

END OF SECTION 01 0005

SECTION 01 0006
TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS

PART 1 GENERAL

1.1 REFERENCES

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.
- B. AMERICAN WATER WORKS ASSOCIATION (AWWA)
- C. AWWA – All standards applicable to the design & construction of this project
- D. NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
- E. (2015) Standard for Safeguarding Construction, Alteration, and Demolition Operations
- F. (2017) National Electrical Code

1.2 SUBMITTALS

- A. Submit the following in accordance with Section SUBMITTAL PROCEDURES:
- B. Construction Site Plan
- C. Traffic Control Plan

1.3 CONSTRUCTION SITE PLAN

- A. Prior to the start of work, submit a site plan showing the locations and dimensions of temporary facilities (including layouts and details, equipment, and material storage area (onsite and offsite), and access and haul routes, avenues of ingress/egress to the fenced area and details of the fence installation. Identify any areas which may have to be graveled to prevent the tracking of mud. Indicate if the use of a supplemental or other staging area is desired. Show locations of safety and construction fences, site trailers, construction entrances, trash dumpsters, temporary sanitary facilities, and worker parking areas.

PART 2 PRODUCTS

2.1 TEMPORARY TRAFFIC CONTROL

- A. Barricades
 - 1. Erect and maintain temporary barricades to limit public access to hazardous areas. Whenever safe public access to paved areas such as roads, parking areas or sidewalks is prevented by construction activities or as otherwise necessary to ensure the safety of both pedestrian and vehicular traffic barricades will be required. Securely place barricades clearly visible with adequate illumination to provide sufficient visual warning of the hazard during both day and night.

B. Fencing

1. Provide fencing along the construction site at all open excavations and tunnels to control access by unauthorized people.
2. The safety fencing must be a high visibility orange colored, high density polyethylene grid or approved equal, a minimum of 1.2 m (48 inches) high and maximum mesh size of 50 mm (2 inches), supported and tightly secured to steel posts located on maximum 3 m (10 foot) centers, constructed at the approved location. Install fencing to be able to restrain a force of at least 114.00 kg (250 pounds) against it.

2.2 TEMPORARY WIRING

- A. Provide temporary wiring in accordance with NFPA 241 and NFPA 70. The contractor is required to conduct frequent inspections of all installed equipment and apparatus and report this on the daily report.

PART 3 EXECUTION

3.1 EMPLOYEE PARKING

- A. Contractor employees will park privately owned vehicles in an area designated by the Project Manager. This area will be within reasonable walking distance of the construction site. Contractor employee parking must not interfere with existing and established parking requirements of the SDSTA installation.

3.2 AVAILABILITY AND USE OF UTILITY SERVICES

A. Temporary Utilities

1. Provide temporary utilities required for construction. Materials may be new or used, must be adequate for the required usage, not create unsafe conditions, and not violate applicable codes and standards.

B. Sanitation

1. Provide and maintain within the construction area minimum field-type sanitary facilities approved by the Project Manager and periodically empty wastes into a municipal, district, or station sanitary sewage system, or remove waste to a commercial facility. Obtain approval from the system owner prior to discharge into any district or commercial sanitary sewer system. Any penalties and/or fines associated with improper discharge will be the responsibility of the Contractor. Coordinate with the Project Manager and follow sanitary district regulations and procedures when discharging into the sanitary sewer system. Maintain these conveniences at all times without nuisance. Include provisions for pest control and elimination of odors. SDSTA toilet facilities will not be available to Contractor's personnel.

C. Fire Protection

1. Provide temporary fire protection equipment for the protection of personnel and property during construction. Remove debris and flammable materials daily to minimize potential hazards.

3.3 TRAFFIC PROVISIONS

A. Maintenance of Traffic

1. Conduct operations in a manner that will not close any thoroughfare or interfere in any way with traffic except with written permission of the Project Manager at least 15 calendar days prior to the proposed modification date and provide a Traffic Control Plan detailing the proposed controls to traffic movement for approval. Contractor may move oversized and slow-moving vehicles to the worksite provided requirements of the highway authority have been met.
2. Conduct work so as to minimize obstruction of traffic and maintain traffic on at least half of the roadway width at all times. Obtain approval from the Contracting Officer prior to starting any activity that will obstruct traffic.

B. Protection of Traffic

1. Maintain and protect traffic on all affected roads during the construction period except as otherwise specifically directed by the Project Manager. Measures for the protection and diversion of traffic, including the provision of watchmen and flagmen, erection of barricades, placing of lights around and in front of equipment the work, and the erection and maintenance of adequate warning, danger, and direction signs, will be as required by the State and local authorities having jurisdiction. Protect the traveling public from damage to person and property. Minimize the interference with public traffic on roads selected for hauling material to and from the site. Investigate the adequacy of existing roads and their allowable load limit. Contractor is responsible for the repair of any damage to roads caused by construction operations.

C. Dust Control

1. Dust control methods and procedures must be approved by the Project Manager. Treat dust abatement on access roads with applications of calcium chloride, water sprinklers, or similar methods or treatment.

3.4 CONTRACTOR'S TEMPORARY FACILITIES

A. Administrative Field Offices

1. Provide and maintain administrative field office facilities within the construction area at the designated site. SDSTA office and Wastewater Treatment Facilities will not be available to the Contractor's personnel.

B. Storage Area

1. Construct a temporary 1.8 m (6 foot) high chain link fence around trailers and materials. Include colored plastic strip inserts so that visibility through the fence is obstructed. Fence posts may be driven, in lieu of concrete bases, where soil conditions permit. Do not place or store Trailers, materials, or equipment outside the fenced area unless such trailers, materials, or equipment are assigned a separate and distinct storage area by the Project Manager away from the vicinity of the construction site but within SURF boundaries. Do not stockpile materials outside the fence in preparation for the next day's work. Park mobile equipment, such as tractors, wheeled lifting equipment, cranes, trucks, and like equipment within the fenced area at the end of each workday.

C. Appearance of Temporary Facilities

1. Trailers utilized by the Contractor for administrative or material storage purposes must present a clean and neat exterior appearance and be in a state of good repair.
2. Keep fencing in a state of good repair and proper alignment. Grassed or unpaved areas, which are not established roadways, will be covered with a layer of gravel as necessary to prevent rutting and the tracking of mud onto paved or established roadways, should the Contractor elect to traverse them with construction equipment or other vehicles; gravel gradation will be at the Contractor's discretion. Mow and maintain grass located within the boundaries of the construction site for the duration of the project.

D. Security Provisions

1. Provide adequate outside security lighting at the Contractor's temporary facilities. The Contractor will be responsible for the security of its own equipment.

3.5 CLEANUP

- A. Remove construction debris, waste materials, packaging material and the like from the work site daily. Any dirt or mud which is tracked onto paved or surfaced roadways must be cleaned away. Store any salvageable materials resulting from demolition activities within the fenced area described above or at the supplemental storage area. Neatly stack stored materials not in trailers, whether new or salvaged.

3.6 RESTORATION OF STORAGE AREA

- A. Upon completion of the project remove the bulletin board, signs, barricades, haul roads, and any other temporary products from the site. After removal of trailers, materials, and equipment from within the fenced area, remove the fence that will become the property of the Contractor. Restore areas used by the Contractor for the storage of equipment or material, or other use to the original or better condition. Remove gravel used to traverse grassed areas and restore the area to its original condition, including topsoil and seeding as necessary.

END OF SECTION 01 0006

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**SECTION 01 0007
CLOSEOUT SUBMITTALS**

PART 1 GENERAL

1.1 DEFINITIONS

A. As-Built Drawings

1. As-built drawings are developed and maintained by the Contractor and depict actual conditions, including deviations from the Contract Documents. These deviations and additions may result from coordination required by, but not limited to: contract modifications; official responses to Contractor submitted Requests for Information; direction from the Contracting Officer; designs which are the responsibility of the Contractor, and differing site conditions. Maintain the as-builts throughout construction as red-lined hard copies on site. These files serve as the basis for the creation of the record drawings.

B. Record Drawings

1. The record drawings are the final compilation of actual conditions reflected in the as-built drawings.

1.2 SUBMITTALS

A. Submit the following in accordance with Section 01 0004 SUBMITTAL PROCEDURES:

1. Product Data
2. Spare Parts Data
3. Manufacturer's Instructions
4. Posted Instructions
5. As-Built Drawings
6. Final Approved Shop Drawings

1.3 AS-BUILT DRAWINGS

A. Markup Guidelines

- B. Make comments and markup the drawings complete without reference to letters, memos, or materials that are not part of the As-Built drawing. Show what was changed, how it was changed, where item(s) were relocated and change related details. These working as-built markup prints must be neat, legible, and accurate as follows:

1. Use base colors of red, green, and blue. Color code for changes as follows:

- a. Special (Blue) - Items requiring special information, coordination, or special detailing or detailing notes.
- b. Deletions (Red) - Over-strike deleted graphic items (lines), lettering in notes and leaders.
- c. Additions (Green) - Added items, lettering in notes and leaders.

C. As-Built Drawings Content

- 1. Show on the as-built drawings, but not limited to, the following information:
 - a. The actual location, kinds, and sizes of all sub-surface utility lines. In order that the location of these lines and appurtenances may be determined in the event the surface openings or indicators become covered over or obscured, show by offset dimensions to two permanently fixed surface features the end of each run including each change in direction on the record drawings. Locate valves, splice boxes and similar appurtenances by dimensioning along the utility run from a reference point. Also record the average depth below the surface of each run.
 - b. The location and dimensions of any changes within the building structure.
 - c. Layout and schematic drawings of electrical circuits and piping.
 - d. Correct grade, elevations, cross section, or alignment of roads, earthwork, structures, or utilities if any changes were made from contract plans.
 - e. Changes in details of design or additional information obtained from working drawings specified to be prepared and/or furnished by the Contractor; including but not limited to shop drawings, fabrication, erection, installation plans and placing details, pipe sizes, insulation material, dimensions of equipment foundations, etc.
 - f. The topography, invert elevations and grades of drainage installed or affected as part of the project construction.
 - g. Where contract drawings or specifications present options, show only the option selected for construction on the working as-built markup drawings.
 - h. Systems designed or enhanced by the Contractor, such as HVAC controls, fire alarm, fire sprinkler, and irrigation systems.
 - i. Actual location of anchors, construction, and control joints, etc., in concrete.
- 2. Unusual or uncharted obstructions that are encountered in the contract work area during construction.

1.4 CLEANUP

- A. Leave premises "broom clean." Clean interior and exterior glass surfaces exposed to view; remove temporary labels, stains, and foreign substances; polish transparent and glossy surfaces; vacuum carpeted and soft surfaces. Clean equipment and fixtures to a sanitary condition. Replace filters of operating equipment. Clean debris from roofs, gutters, downspouts, and drainage systems. Sweep paved areas and rake clean landscaped areas. Remove waste and surplus materials, rubbish, and construction facilities from the site.

END OF SECTION 01 0007

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**SECTION 01 0008
OPERATION AND MAINTENANCE DATA**

PART 1 GENERAL

1.1 SUBMITTALS

- A. Submit the following in accordance with Section 01 0004 SUBMITTAL PROCEDURES:
- B. Operation and Maintenance Data
- C. Training Plan

1.2 OPERATION AND MAINTENANCE DATA

- A. Submit Operation and Maintenance (O&M) Data for the provided equipment, product, or system, defining the importance of system interactions, troubleshooting, and long-term preventive operation and maintenance. Compile, prepare, and aggregate O&M data to include clarifying and updating the original sequences of operation to as-built conditions. Organize and present information in sufficient detail to clearly explain O&M requirements at the system, equipment, component, and subassembly level. Include an index preceding each submittal.
- B. Package Quality
 - 1. Documents must be fully legible. Operation and Maintenance data must be consistent with the manufacturer's standard brochures, schematics, printed instructions, general operating procedures, and safety precautions.
 - 2. Commissioning Authority Review and Approval, If commissioning services are part of the contract.
 - a. Submit the commissioned systems and equipment submittals to the Commissioning Authority (CxA) to review for completeness and applicability. Obtain validation from the CxA that the systems and equipment provided meet the requirements of the Contract documents and design intent, particularly as they relate to functionality, energy performance, water performance, maintainability, sustainability, system cost, indoor environmental quality, and local environmental impacts. The CxA communicates deficiencies to the Contracting Officer. Submit the O&M manuals to the Contracting Officer upon a successful review of the corrections, and with the CxA recommendation for approval and acceptance of these O&M manuals. This work is in addition to the normal review procedures for O&M data.

1.3 OPERATION AND MAINTENANCE MANUAL FILE FORMAT

- A. Assemble data packages into electronic Operation and Maintenance Manuals. Assemble each manual into a composite electronically indexed file using the most current version of Adobe Acrobat or similar software capable of producing PDF file format. Include a complete

electronically linked operation and maintenance directory.

1. O&M MANUAL LABEL REQUIREMENTS
2. Provide the following information on the label:
 - a. Building Number
 - b. Project Title
 - c. Activity and Location
 - d. Construction Contract Number
 - e. Prepared By: (Name, title, phone number and email address)
 - f. Date

**1.4 TYPES OF INFORMATION REQUIRED IN O&M DATA PACKAGES. THE
FOLLOWING ARE A DETAILED DESCRIPTION OF THE DATA PACKAGE ITEMS
REQUIRED.**

A. Operating Instructions

1. Provide specific instructions, procedures, and illustrations for the following phases of operation for the installed model and features of each system:
 - a. Safety Precautions and Hazards
 - 1) List personnel hazards and equipment or product safety precautions for operating conditions. List all residual hazards identified in the Activity Hazard Analysis provided under Section 01 35 26 SDSTA SAFETY REQUIREMENTS. Provide recommended safeguards for each identified hazard.
 - b. Operator Prestart
 - 1) Provide procedures required to install, set up, and prepare each system for use.
 - c. Startup, Shutdown and Post-Shutdown Procedures
 - 1) Provide narrative description for Startup, Shutdown and Post-shutdown operating procedures including the control sequence for each procedure.
 - d. Normal Operations

- 1) Provide Control Diagrams with data to explain operation and control of systems and specific equipment. Provide narrative description of Normal Operating Procedures.

e. Emergency Operations

- 1) Provide Emergency Procedures for equipment malfunctions to permit a short period of continued operation or to shut down the equipment to prevent further damage to systems and equipment. Provide Emergency Shutdown Instructions for fire, explosion, spills, or other foreseeable contingencies. Provide guidance and procedures for emergency operation of utility systems including required valve positions, valve locations and zones or portions of systems controlled.

f. Operator Service Requirements

- 1) Provide instructions for services to be performed by the operator such as lubrication, adjustment, inspection, and recording gauge readings.

g. Environmental Conditions

- 1) Provide a list of Environmental Conditions (temperature, humidity, and other relevant data) that are best suited for the operation of each product, component, or system. Describe conditions under which the item equipment should not be allowed to run.

B. Preventive Maintenance

1. Provide the following information for preventive and scheduled maintenance to minimize repairs for the installed model and features of each system. Include potential environmental and indoor air quality impacts of recommended maintenance procedures and materials.

a. Lubrication Data

- 1) Include the following preventive maintenance lubrication data, in addition to instructions for lubrication required under paragraph OPERATOR SERVICE REQUIREMENTS:
 - a) A table showing recommended lubricants for specific temperature ranges and applications.
 - b) Charts with a schematic diagram of the equipment showing lubrication points, recommended types and grades of lubricants, and capacities.
 - c) A Lubrication Schedule showing service interval frequency.

b. Preventive Maintenance Plan, Schedule, and Procedures

- 1) Provide manufacturer's schedule for routine preventive maintenance, inspections, condition monitoring (predictive tests) and adjustments required to ensure proper and economical operation and to minimize repairs. Provide instructions stating when the systems should be retested. Provide manufacturer's projection of preventive maintenance work-hours on a daily, weekly, monthly, and annual basis including craft requirements by type of craft. For periodic calibrations, provide manufacturer's specified frequency and procedures for each separate operation.
 - a) Define the anticipated time required to perform each test (work-hours), test apparatus, number of personnel identified by responsibility, and a testing validation procedure permitting the record operation capability requirements within the schedule. Provide a remarks column for the testing validation procedure referencing operating limits of time, pressure, temperature, volume, voltage, current, acceleration, velocity, alignment, calibration, adjustments, cleaning, or special system notes. Delineate procedures for preventive maintenance, inspection, adjustment, lubrication, and cleaning necessary to minimize repairs.
 - b) Repair requirements must inform operators how to check out, troubleshoot, repair, and replace components of the system. Include electrical and mechanical schematics and diagrams and diagnostic techniques necessary to enable operation and troubleshooting of the system after acceptance.

C. Appendices

- D. Provide information required below and information not specified in the preceding paragraphs but pertinent to the maintenance or operation of the product or equipment. Include the following:

a. Parts Identification

- 1) Provide identification and coverage for the parts of each component, assembly, subassembly, and accessory of the end items subject to replacement.

b. Warranty Information

- 1) List and explain the various warranties and clearly identify the servicing and technical precautions prescribed by the manufacturers or contract documents in order to keep warranties in force. Include warranty information for primary components of the system.

- c. Personnel Training Requirements
 - 1) Provide information available from the manufacturers that is needed for use in training designated personnel to properly operate and maintain the equipment and systems.
- d. Testing Equipment and Special Tool Information
 - 1) Include information on test equipment required to perform specified tests and on special tools needed for the operation, maintenance, and repair of components. Provide final set points.

PART 2 PRODUCTS

2.1 NOT USED

PART 3 EXECUTION

3.1 TRAINING

- A. Prior to acceptance of the facility for Beneficial Occupancy, provide comprehensive training for the systems and equipment specified in the technical specifications. The training must be targeted for the Wastewater Treatment Operators. Training must include field lectures based on the system operating requirements.
 - 1. Training Plan
 - a. Submit a written training plan to the Project Manager for approval. Training plan must be approved by the Quality Control Manager prior to forwarding to the SDSTA. Also, coordinate the training schedule with the Contracting Officer and QC. Include within the plan the following elements:
 - 2. Training Content
 - a. The core of this training must be based on manufacturer's recommendations and the operation and maintenance information. The QC Manager is responsible for overseeing and approving the content and adequacy of the training. Include the following for each system training presentation:
 - b. Start-up, normal operation, shutdown, unoccupied operation, seasonal changeover, manual operation, controls set-up and programming, troubleshooting, and alarms.
 - 1) Relevant health and safety issues.
 - 2) Discussion of how the feature or system is environmentally responsive. Advise adjustments and optimizing methods for energy conservation.
 - 3) Design intent.

- 4) Use of O&M Manual Files.
- 5) Review of control drawings and schematics.
- 6) Interactions with other systems.
- 7) Special maintenance and replacement sources.
- 8) Tenant interaction issues.

END OF SECTION 01 0008

**SECTION 02 4100
DEMOLITION**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Building demolition excluding removal of hazardous materials and toxic substances.
- B. Selective demolition of built site elements.
- C. Selective demolition of building elements for alteration purposes.
- D. Abandonment and removal of existing utilities and utility structures.

1.2 RELATED REQUIREMENTS

- A. SDSTA Division 1 - Summary of Work: Limitations on Contractor's use of site and premises.
- B. SDSTA Division 1 - Administrative Requirements
- C. SDSTA Division 1 - Project Construction Progress Schedules
SDSTA Division 1 - Quality Control for Construction
- D. SDSTA Division 1 - Temporary Construction Facilities and Controls: Site fences, security, protective barriers, and waste removal.
- E. Section 31 1000 - Site Clearing: Vegetation and existing debris removal.
- F. Section 31 2200 - Grading: Topsoil removal.
- G. Section 31 2200 - Grading: Fill material for filling holes, pits, and excavations generated as a result of removal operations.
- H. Section 31 2323 - Fill: Filling holes, pits, and excavations generated as a result of removal operations.

1.3 DEFINITIONS

- A. Demolition: Dismantle, raze, destroy or wreck any building or structure or any part thereof.
- B. Remove: Detach or dismantle items from existing construction and dispose of them off site, unless items are indicated to be salvaged or reinstalled.
- C. Remove and Reinstall: Detach or dismantle items from existing construction in a manner to prevent damage. Clean and prepare for reuse and reinstall where indicated.
- D. Existing to Remain: Designation for existing items that are not to be removed and that are not otherwise indicated to be salvaged or reinstalled.

1.4 REFERENCE STANDARDS

- A. 29 CFR 1926 - Safety and Health Regulations for Construction Current Edition.
- B. NFPA 241 - Standard for Safeguarding Construction, Alteration, and Demolition Operations 2022, with Errata (2021).

1.5 SUBMITTALS

- A. See SDSTA Division 1 - Submittal Procedures for submittal procedures.
- B. Site Plan: Indicate:
 - 1. Areas for temporary construction and field offices.
 - 2. Areas for temporary and permanent placement of removed materials.
- C. Demolition Plan: Submit demolition plan as required by OSHA and local AHJs.
 - 1. Indicate extent of demolition, removal sequencing, bracing and shoring, and location and construction of barricades and fences.
 - 2. Summary of safety procedures.
- D. Demolition firm qualifications.
- E. Project Record Documents: Accurately record actual locations of capped and active utilities and subsurface construction.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Fill Material: See Section 31 2323.

PART 3 EXECUTION

3.1 DEMOLITION

- A. Remove the designated Existing RBCs, Basins, and Appurtenant Equipment and Concrete Channels, and Designated Drainage Pipe and Appurtenances as show in the Plans..
- B. Remove portions of existing buildings in the following sequence in accordance with Construction Sequence in Plans:
 - 1. Designated Existing RBCs (Area 3).
 - 2. Designated Appurtenant Equipment (Area 3).
 - 3. Designated Concrete Channels (Area 3).

4. Designated Drainage Pipe and Appurtenances (Area 3)
 5. Designated Process Piping and Valves in Influent Filter Building (Area 2)
 6. Designated Process Piping and Valves in Influent Building (Area 1)
- C. Remove paving and curbs required to accomplish new work.
- D. Remove other items indicated, for salvage and relocation.

3.2 GENERAL PROCEDURES AND PROJECT CONDITIONS

- A. Comply with applicable codes and regulations for demolition operations and safety of adjacent structures and the public.
1. Obtain required permits.
 2. Take precautions to prevent catastrophic or uncontrolled collapse of structures to be removed; do not allow worker or public access within range of potential collapse of unstable structures.
 3. Provide, erect, and maintain temporary barriers and security devices.
 4. Conduct operations to minimize effects on and interference with adjacent structures and occupants.
 5. Do not close or obstruct roadways or sidewalks without permits from authority having jurisdiction.
 6. Conduct operations to minimize obstruction of public and private entrances and exits. Do not obstruct required exits at any time. Protect persons using entrances and exits from removal operations.
 7. Obtain written permission from owners of adjacent properties when demolition equipment will traverse, infringe upon, or limit access to their property.
- B. Do not begin removal until receipt of notification to proceed from Owner.
- C. Protect existing structures and other elements to remain in place and not removed.
1. Provide bracing and shoring.
 2. Prevent movement or settlement of adjacent structures.
 3. Stop work immediately if adjacent structures appear to be in danger.
- D. Minimize production of dust due to demolition operations. Do not use water if that will result in ice, flooding, sedimentation of public waterways or storm sewers, or other pollution.

E. Hazardous Materials:

1. If hazardous materials are discovered during removal operations, stop work and notify Owner; hazardous materials include regulated asbestos containing materials, lead, PCBs, and mercury.

F. Partial Removal of Paving and Curbs: Neatly saw cut at right angle to surface.

3.3 EXISTING UTILITIES

- A. Coordinate work with utility companies. Notify utilities before starting work, comply with their requirements, and obtain required permits.
- B. Protect existing utilities to remain from damage.
- C. Do not disrupt public utilities without permit from authority having jurisdiction.
- D. Do not close, shut off, or disrupt existing life safety systems that are in use without at least 7 days prior written notification to Owner.
- E. Do not close, shut off, or disrupt existing utility branches or take-offs that are in use without at least 3 days prior written notification to Owner.
- F. Locate and mark utilities to remain; mark using highly visible tags or flags, with identification of utility type; protect from damage due to subsequent construction, using substantial barricades if necessary.
- G. Remove exposed piping, valves, meters, equipment, supports, and foundations of disconnected and abandoned utilities.
- H. Prepare building demolition areas by disconnecting and capping utilities outside the demolition zone. Identify and mark, in same manner as other utilities to remain, utilities to be reconnected.

3.4 SELECTIVE DEMOLITION FOR ALTERATIONS

- A. Existing construction and utilities indicated on drawings are based on casual field observation and existing record documents only.
 1. Verify construction and utility arrangements are as indicated.
 2. Report discrepancies to Owner before disturbing existing installation.
 3. Beginning of demolition work constitutes acceptance of existing conditions that would be apparent upon examination prior to starting demolition.
- B. Remove existing work as indicated and required to accomplish new work.
 1. Remove items indicated on drawings.

- C. Services including, but not limited to, HVAC, Plumbing, Fire Protection, Electrical, and Telecommunications: Remove existing systems and equipment as indicated.
 - 1. Maintain existing active systems to remain in operation, and maintain access to equipment and operational components.
 - 2. Where existing active systems serve occupied facilities but are to be replaced with new services, maintain existing systems in service until new systems are complete and ready for service.
 - 3. Verify that abandoned services serve only abandoned facilities before removal.
 - 4. Remove abandoned pipe, ducts, conduits, and equipment including those in RBC tunnels where demolition is to occur. Remove back to source of supply where possible, otherwise cap stub and tag with identification.
- D. Protect existing work to remain.
 - 1. Prevent movement of structure. Provide shoring and bracing as required.
 - 2. Perform cutting to accomplish removal work neatly and as specified for cutting new work.
 - 3. Repair adjacent construction and finishes damaged during removal work.
 - 4. Patch to match new work.

3.5 DEBRIS AND WASTE REMOVAL

- A. Remove debris, junk, and trash from site.
- B. Leave site in clean condition, ready for subsequent work.
- C. Clean up spillage and wind-blown debris from public and private lands.

END OF SECTION 02 4100

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**SECTION 03 1000
CONCRETE FORMING AND ACCESSORIES**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Formwork for cast-in-place concrete, with shoring, bracing and anchorage.
- B. Openings for other work.
- C. Form accessories.
- D. Form stripping.

1.2 RELATED REQUIREMENTS

- A. Section 03 2000 - Concrete Reinforcing.
- B. Section 03 3000 - Cast-in-Place Concrete.

1.3 REFERENCE STANDARDS

- A. ACI 117 - Specification for Tolerances for Concrete Construction and Materials 2010 (Reapproved 2015).
- B. ACI 301 - Specifications for Concrete Construction 2020.
- C. ACI 318 - Building Code Requirements for Structural Concrete 2019 (Reapproved 2022).
- D. ACI 347R - Guide to Formwork for Concrete 2014 (Reapproved 2021).
- E. COE CRD-C 572 - Handbook for Concrete and Cement Corps of Engineers Specifications for Polyvinylchloride Waterstop 1974.

1.4 SUBMITTALS

- A. See Section 01 0004 Submittal Procedures, for submittal procedures.
- B. Product Data: Provide data on void form materials and installation requirements.
- C. Shop Drawings: Indicate pertinent dimensions, materials, bracing, and arrangement of joints and ties.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver prefabricated forms and installation instructions in manufacturer's packaging.
- B. Store prefabricated forms off ground in ventilated and protected manner to prevent deterioration from moisture.

- C. Protect plastic foam products from damage and exposure to sunlight.

PART 2 PRODUCTS

2.1 FORMWORK - GENERAL

- A. Provide concrete forms, accessories, shoring, and bracing as required to accomplish cast-in-place concrete work.
- B. Design and construct concrete that complies with design with respect to shape, lines, and dimensions.
- C. Chamfer outside corners of beams, joists, columns, and walls.
- D. Comply with applicable state and local codes with respect to design, fabrication, erection, and removal of formwork.
- E. Comply with relevant portions of ACI 347R, ACI 301, and ACI 318.

2.2 WOOD FORM MATERIALS

- A. As-Cast Surface Form-Facing Material:
 - 1. Provide continuous, true, and smooth concrete surfaces.
 - 2. Furnish in largest practicable sizes to minimize number of joints.
 - 3. Acceptable Materials: As required to comply with Surface Finish designations specified in Section 03 30 00 "Cast-In-Place Concrete, and as follows:
 - a. Plywood, metal, or other approved panel materials
 - b. Exterior-grade plywood panels, suitable for concrete forms, complying with DOC PS 1.

2.3 FORMWORK ACCESSORIES

- A. Form Ties: Snap-off type, galvanized metal, fixed length, with waterproofing washer, 1 inch back break dimension, (25 mm back break dimension,) free of defects that could leave holes larger than 1 inch (25 mm) in concrete surface.
- B. Form Release Agent: Capable of releasing forms from hardened concrete without staining or discoloring concrete or forming bugholes and other surface defects, compatible with concrete and form materials, and not requiring removal for satisfactory bonding of coatings to be applied.
 - 1. Do not use materials containing diesel oil or petroleum-based compounds.
 - 2. Composition: Colorless, reactive, water-based compound.

- C. Filler Strips for Chamfered Corners: Wood, metal, PVC, or rubber strips type; 3/4 x 3/4 inch (19 x 19 mm) size; maximum possible lengths.
- D. Nails, Spikes, Lag Bolts, Through Bolts, Anchorages: Sized as required, of sufficient strength and character to maintain formwork in place while placing concrete.
- E. Waterstops: PVC, complying with COE CRD-C 572.
 - 1. Configuration: As indicated on drawings.
 - 2. Size: As indicated on drawings.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify lines, levels and centers before proceeding with formwork. Ensure that dimensions agree with drawings.

3.2 EARTH FORMS

- A. Earth forms are not permitted.
- B. Hand trim sides and bottom of earth forms. Remove loose soil prior to placing concrete.

3.3 ERECTION - FORMWORK

- A. Erect formwork, shoring and bracing to achieve design requirements, in accordance with requirements of ACI 301.
- B. Provide bracing to ensure stability of formwork. Shore or strengthen formwork subject to overstressing by construction loads.
- C. Arrange and assemble formwork to permit dismantling and stripping. Do not damage concrete during stripping. Permit removal of remaining principal shores.
- D. Align joints and make watertight. Keep form joints to a minimum.
- E. Obtain approval before framing openings in structural members that are not indicated on drawings.
- F. Coordinate this section with other sections of work that require attachment of components to formwork.
- G. If formwork is placed after reinforcement, resulting in insufficient concrete cover over reinforcement, request instructions from Architect before proceeding.

3.4 APPLICATION - FORM RELEASE AGENT

- A. Apply form release agent on formwork in accordance with manufacturer's recommendations.
- B. Apply prior to placement of reinforcing steel, anchoring devices, and embedded items.

3.5 INSERTS, EMBEDDED PARTS, AND OPENINGS

- A. Provide formed openings where required for items to be embedded in passing through concrete work.
- B. Locate and set in place items that will be cast directly into concrete.
- C. Coordinate with work of other sections in forming and placing openings, slots, reglets, recesses, sleeves, bolts, anchors, other inserts, and components of other work.
- D. Install accessories in accordance with manufacturer's instructions, so they are straight, level, and plumb. Ensure items are not disturbed during concrete placement.
- E. Install waterstops in accordance with manufacturer's instructions, so they are continuous without displacing reinforcement. Heat seal joints so they are watertight.

3.6 FORM CLEANING

- A. Clean forms as erection proceeds, to remove foreign matter within forms.
- B. Clean formed cavities of debris prior to placing concrete.

3.7 FORMWORK TOLERANCES

- A. Construct formwork to maintain tolerances required by ACI 117, unless otherwise indicated.

3.8 FIELD QUALITY CONTROL

- A. Special Inspections: Engage a qualified testing and inspecting agency to perform tests and inspections and to submit reports.
- B. Inspections:
 - 1. Inspect formwork for shape, location, and dimensions of the concrete member being formed.
 - 2. Inspect insulating concrete forms for shape, location, and dimensions of the concrete member being formed

3.9 FORM REMOVAL

- A. Do not remove forms or bracing until concrete has gained sufficient strength to carry its own weight and imposed loads.

END OF SECTION 03 1000

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**SECTION 03 2000
CONCRETE REINFORCING**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Reinforcing steel for cast-in-place concrete.
- B. Supports and accessories for steel reinforcement.

1.2 RELATED REQUIREMENTS

- A. Section 03 1000 - Concrete Forming and Accessories.
- B. Section 03 3000 - Cast-in-Place Concrete.

1.3 REFERENCE STANDARDS

- A. ACI 301 - Specifications for Concrete Construction 2020.
- B. ACI 318 - Building Code Requirements for Structural Concrete 2019 (Reapproved 2022).
- C. ACI SP-66 - ACI Detailing Manual 2004.
- D. ASTM A615/A615M - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement 2022.
- E. ASTM A1064/A1064M - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete 2022.
- F. CRSI (DA4) - Manual of Standard Practice 2018, with Errata (2019).

1.4 SUBMITTALS

- A. See Section 01 0004 Submittal Procedures, for submittal procedures.
- B. Shop Drawings: Comply with requirements of ACI SP-66. Include bar schedules, shapes of bent bars, spacing of bars, and location of splices.
- C. Manufacturer's Certificate: Certify that reinforcing steel and accessories supplied for this project meet or exceed specified requirements.
- D. Reports: Submit certified copies of mill test report of reinforcement materials analysis.

PART 2 PRODUCTS

2.1 REINFORCEMENT

- A. Reinforcing Steel: ASTM A615/A615M, Grade 60 (60,000 psi) (420 MPa).

- B. Steel Welded Wire Reinforcement (WWR): Galvanized, deformed type; ASTM A1064/A1064M.
- C. Reinforcement Accessories:
 - 1. Tie Wire: Annealed, minimum 16 gauge, 0.0508 inch (1.29 mm).
 - 2. Chairs, Bolsters, Bar Supports, Spacers: Sized and shaped for adequate support of reinforcement during concrete placement.

2.2 RE-BAR SPLICING:

- A. Coupler Systems: Mechanical devices for splicing reinforcing bars; capable of developing full steel reinforcing design strength in tension and compression.
- B. Dowel Bar Splicer with Dowel-Ins: Mechanical devices for connecting dowels; capable of developing full steel reinforcing design strength in tension and compression.

2.3 FABRICATION

- A. Fabricate concrete reinforcing in accordance with CRSI (DA4) - Manual of Standard Practice.
- B. Welding of reinforcement is not permitted.
- C. Locate reinforcing splices not indicated on drawings at point of minimum stress.

PART 3 EXECUTION

3.1 PLACEMENT

- A. Place, support and secure reinforcement against displacement. Do not deviate from required position.
- B. Do not displace or damage vapor barrier.
- C. Accommodate placement of formed openings.
- D. Comply with applicable code for concrete cover over reinforcement.

3.2 FIELD QUALITY CONTROL

- A. Special Inspections: Engage a special inspector to perform tests and inspections and to submit reports.
- B. Inspections:
 - 1. Steel-reinforcement placement.

2. Steel-reinforcement mechanical splice couplers.

END OF SECTION 03 2000

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**SECTION 03 3000
CAST-IN-PLACE CONCRETE**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Concrete formwork.
- B. Floors and slabs on grade.
- C. Concrete foundation walls.
- D. Joint devices associated with concrete work.
- E. Miscellaneous concrete elements, including equipment pads and thrust blocks.
- F. Concrete curing.

1.2 RELATED REQUIREMENTS

- A. Section 03 1000 - Concrete Forming and Accessories: Forms and accessories for formwork.
- B. Section 03 2000 - Concrete Reinforcing.
- C. Section 07 9200 - Joint Sealants: Products and installation for sealants and joint fillers for saw cut joints and isolation joints in slabs.

1.3 REFERENCE STANDARDS

- A. ACI 211.1 - Selecting Proportions for Normal-Density and High Density-Concrete - Guide 2022.
- B. ACI 301 - Specifications for Concrete Construction 2020.
- C. ACI 302.1R - Guide to Concrete Floor and Slab Construction 2015.
- D. ACI 304R - Guide for Measuring, Mixing, Transporting, and Placing Concrete 2000 (Reapproved 2009).
- E. ACI 308R - Guide to External Curing of Concrete 2016.
- F. ACI 318 - Building Code Requirements for Structural Concrete 2019 (Reapproved 2022).
- G. ASTM C33/C33M - Standard Specification for Concrete Aggregates 2018.
- H. ASTM C39/C39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens 2021.
- I. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete 2022a.

- J. ASTM C109/C109M - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50 mm] Cube Specimens) 2021.
- K. ASTM C171 - Standard Specification for Sheet Materials for Curing Concrete 2020.
- L. ASTM C173/C173M - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method 2016.
- M. ASTM C260/C260M - Standard Specification for Air-Entraining Admixtures for Concrete 2010a (Reapproved 2016).
- N. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete 2019, with Editorial Revision (2022).
- O. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete 2022.
- P. ASTM C881/C881M - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete 2020a.
- Q. ASTM C1059/C1059M - Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete 2021.
- R. ASTM C1107/C1107M - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink) 2020.
- S. ASTM C1602/C1602M - Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete 2018.
- T. ASTM C1708/C1708M - Standard Test Methods for Self-leveling Mortars Containing Hydraulic Cements 2019.
- U. ASTM D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types) 2018.
- V. ASTM E1643 - Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs 2018a.
- W. ASTM E1745 - Standard Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill Under Concrete Slabs 2017.
- X. COE CRD-C 48 - Handbook for Concrete and Cement Standard Test Method for Water Permeability of Concrete 1992.
- Y. COE CRD-C 572 - Handbook for Concrete and Cement Corps of Engineers Specifications for Polyvinylchloride Waterstop 1974.

1.4 SUBMITTALS

- A. See Section 01 0004 Submittal Procedures for submittal procedures.
- B. Product Data: Submit manufacturers' data on manufactured products showing compliance with specified requirements and installation instructions.
- C. Mix Design: Submit proposed concrete mix design.
 - 1. Indicate proposed mix design complies with fiber reinforcing manufacturer's written recommendations.
- D. Samples: Submit samples of underslab vapor retarder to be used.
- E. Test Reports: Submit report for each test or series of tests specified.

1.5 QUALITY ASSURANCE

- A. Perform work of this section in accordance with ACI 301 and ACI 318.

PART 2 PRODUCTS

2.1 FORMWORK

- A. Comply with requirements of Section 03 1000.

2.2 REINFORCEMENT MATERIALS

- A. Comply with requirements of Section 03 2000.

2.3 CONCRETE MATERIALS

- A. Cement: ASTM C150/C150M, Type I - Normal Portland type.
 - 1. Acquire cement for entire project from same source.
- B. Fine and Coarse Aggregates: ASTM C33/C33M.
 - 1. Acquire aggregates for entire project from same source.
- C. Fly Ash: ASTM C618, Class C or F.
- D. Water: ASTM C1602/C1602M; clean, potable, and not detrimental to concrete.

2.4 ADMIXTURES

- A. Do not use chemicals that will result in soluble chloride ions in excess of 0.1 percent by weight of cement.
- B. Air Entrainment Admixture: ASTM C260/C260M.

- C. High Range Water Reducing Admixture: ASTM C494/C494M Type F.
- D. Water Reducing and Retarding Admixture: ASTM C494/C494M Type D.
- E. Water Reducing Admixture: ASTM C494/C494M Type A.
- F. Waterproofing Admixture: Admixture formulated to reduce permeability to liquid water, with no adverse effect on concrete properties.
 - 1. Admixture Composition: Crystalline, functioning by growth of crystals in capillary pores.
 - 2. Permeability of Cured Concrete: No measurable leakage when tested in accordance with COE CRD-C 48 at 200 psi (1.38 MPa); provide test reports.
 - 3. Products: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Xypex Chemical Corporation; XYPEX Admix C-500: www.xypex.com/#sle.

2.5 ACCESSORY MATERIALS

- A. Underslab Vapor Retarder:
 - 1. Sheet Material: ASTM E1745, Class A, except with a maximum water-vapor permeance of 0.01 and a minimum thickness of 15 mils; stated by manufacturer as suitable for installation in contact with soil or granular fill under concrete slabs. Single-ply polyethylene is prohibited.
 - 2. Accessory Products: Vapor retarder manufacturer's recommended tape, adhesive, mastic, prefabricated boots, etc., for sealing seams and penetrations.
 - 3. Products:
 - a. Stego Industries, LLC: www.stegoindustries.com/#sle.
 - b. Raven Industries, Inc..
- B. Non-Shrink Cementitious Grout: Premixed compound consisting of non-metallic aggregate, cement, water reducing and plasticizing agents.
 - 1. Grout: Comply with ASTM C1107/C1107M.
- C. Self-Leveling Cementitious Concrete Floor Topping:
 - 1. Minimum Compressive Strength at 28 Days, ASTM C1708/C1708M: 5000 pounds per square inch (34.5 MPa).

2.6 LIQUID FLOOR TREATMENTS

- A. Penetrating Liquid Floor Treatment: Clear, chemically reactive, waterborne solution of inorganic silicate or silicate materials and proprietary components; odorless; that penetrates, hardens, and densifies concrete surfaces.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Dayton Superior: Sure Hard (J17)
 - a. Laticrete International, Inc.: Seal Hard

2.7 BONDING AND JOINTING PRODUCTS

- A. Latex Bonding Agent: Non-redispersable acrylic latex, complying with ASTM C1059/C1059M, Type II.
- B. Epoxy Bonding System:
 - 1. Complying with ASTM C881/C881M and of Type required for specific application.
- C. Waterstops: PVC, complying with COE CRD-C 572.
 - 1. Configuration: As indicated on drawings.
 - 2. Size: As indicated on drawings.
- D. Slab Isolation Joint Filler: 1/2 inch (13 mm) thick, height equal to slab thickness, with removable top section that will form 1/2 inch (13 mm) deep sealant pocket after removal.
 - 1. Material: ASTM D1751, cellulose fiber.
- E. Slab Construction Joint Devices: Combination keyed joint form and screed, galvanized steel, with rectangular or round knockout holes for conduit or rebar to pass through joint form at 6 inches (150 mm) on center; ribbed steel stakes for setting.

2.8 CURING MATERIALS

- A. Absorptive Cover: AASHTO M182, Class 2.
 - 1. Burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. when dry.
- B. Moisture-Retaining Sheet: ASTM C171.
 - 1. Polyethylene film, white opaque, minimum nominal thickness of 4 mil, 0.004 inch (0.102 mm).

- C. Water: Potable, not detrimental to concrete.

2.9 CONCRETE MIX DESIGN, GENERAL

- A. Concrete Strength: Establish required average strength for each type of concrete on the basis of field experience or trial mixtures, as specified in ACI 301.
 - 1. For trial mixtures method, employ independent testing agency acceptable to Architect for preparing and reporting proposed mix designs.
- B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:
 - 1. Fly Ash: 25 percent.
- C. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.
- D. Admixtures: Add acceptable admixtures as recommended in ACI 211.1 and at rates recommended or required by manufacturer.
 - 1. Use high-range, water-reducing admixture in concrete, as required, for placement and workability.
 - 2. Use water-reducing and -retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
 - 3. Use water-reducing admixture in pumped concrete, concrete for heavy-use industrial slabs and parking structure slabs, concrete required to be watertight, and concrete with a w/c ratio below 0.50.
 - 4. Use permeability-reducing admixture in concrete mixtures in all tank walls, slabs, below-grade gallery walls and where indicated.

2.10 CONCRETE MIXTURES FOR BUILDING ELEMENTS

- A. Normal Weight Concrete for Tank Slabs or Footings:
 - 1. Compressive Strength, when tested in accordance with ASTM C39/C39M at 28 days: As indicated on drawings.
 - 2. Water-Cement Ratio: Maximum 45 percent by weight.
 - 3. Total Air Content: 6 percent, determined in accordance with ASTM C173/C173M, plus or minus 1.5 percent at point of delivery for 1-inch nominal maximum aggregate size.
 - 4. Maximum Slump: 4 inches (100 mm) or 8 inches for concrete with verified slump of 2 to 4 inches before adding high-range water-reducing admixture or plasticizing admixture,

plus or minus 1 inch.

5. Maximum Aggregate Size: 1 inch (25 mm).

B. Normal Weight Concrete for Walls:

1. Compressive Strength, when tested in accordance with ASTM C39/C39M at 28 days: As indicated on drawings.
2. Water-Cement Ratio: Maximum 45 percent by weight.
3. Total Air Content: 6 percent, determined in accordance with ASTM C173/C173M, plus or minus 1.5 percent at point of delivery for 1-inch nominal maximum aggregate size.
4. Maximum Slump: 4 inches (100 mm) or 8 inches for concrete with verified slump of 2 to 4 inches before adding high-range water-reducing admixture or plasticizing admixture, plus or minus 1 inch.
5. Maximum Aggregate Size: 1 inch (25 mm).

C. Normal Weight Concrete for Slab-on-Grade:

1. Compressive Strength, when tested in accordance with ASTM C39/C39M at 28 days: As indicated on drawings.
2. Minimum Cementitious Materials Content: 520 lb/cu. yd..
3. Total Air Content: 6 percent, determined in accordance with ASTM C173/C173M, plus or minus 1.5 percent at point of delivery for 1-inch nominal maximum aggregate size. Do not allow air content of trowel-finished floors to exceed 3 percent.
4. Maximum Slump: 4 inches (100 mm), plus or minus 1 inch.
5. Maximum Aggregate Size: 1 inch (25 mm).

2.11 MIXING

- A. Transit Mixers: Comply with ASTM C94/C94M.
- B. Adding Water: If concrete arrives on-site with slump less than suitable for placement, do not add water that exceeds the maximum water-cement ratio or exceeds the maximum permissible slump.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify lines, levels, and dimensions before proceeding with work of this section.

3.2 PREPARATION

- A. Formwork: Comply with requirements of ACI 301. Design and fabricate forms to support all applied loads until concrete is cured, and for easy removal without damage to concrete.
- B. Verify that forms are clean and free of rust before applying release agent.
- C. Coordinate placement of embedded items with erection of concrete formwork and placement of form accessories.
- D. Where new concrete is to be bonded to previously placed concrete, prepare existing surface by cleaning and applying bonding agent in according to bonding agent manufacturer's instructions.
 - 1. Use epoxy bonding system for bonding to damp surfaces, for structural load-bearing applications, and where curing under humid conditions is required.
 - 2. Use latex bonding agent only for non-load-bearing applications.
- E. Interior Slabs on Grade: Install vapor retarder under interior slabs on grade. Comply with ASTM E1643. Lap joints minimum 6 inches (150 mm). Seal joints, seams and penetrations watertight with manufacturer's recommended products and follow manufacturer's written instructions. Repair damaged vapor retarder before covering.

3.3 INSTALLING REINFORCEMENT AND OTHER EMBEDDED ITEMS

- A. Comply with requirements of ACI 301. Clean reinforcement of loose rust and mill scale, and accurately position, support, and secure in place to achieve not less than minimum concrete coverage required for protection.
- B. Install welded wire reinforcement in maximum possible lengths, and offset end laps in both directions. Splice laps with tie wire.
- C. Verify that anchors, seats, plates, reinforcement and other items to be cast into concrete are accurately placed, positioned securely, and will not interfere with concrete placement.

3.4 PLACING CONCRETE

- A. Place concrete in accordance with ACI 304R.
- B. Place concrete for floor slabs in accordance with ACI 302.1R.
- C. Ensure reinforcement, inserts, waterstops, embedded parts, and formed construction joint devices will not be disturbed during concrete placement.
- D. Place concrete continuously without construction (cold) joints wherever possible; where construction joints are necessary, before next placement prepare joint surface by removing laitance and exposing the sand and sound surface mortar, by sandblasting or high-pressure water jetting.

- E. Finish floors level and flat, unless otherwise indicated, within the tolerances specified below.

3.5 SLAB JOINTING

- A. Locate joints as indicated on drawings.
- B. Anchor joint fillers and devices to prevent movement during concrete placement.
- C. Isolation Joints: Use preformed joint filler with removable top section for joint sealant, total height equal to thickness of slab, set flush with top of slab.
 - 1. Install wherever necessary to separate slab from other building members, including columns, walls, equipment foundations, footings, stairs, manholes, sumps, and drains.
- D. Saw Cut Contraction Joints: Saw cut joints before concrete begins to cool, within 4 to 12 hours after placing; use 3/16 inch (5 mm) thick blade and cut at least 1 inch (25 mm) deep but not less than one quarter (1/4) the depth of the slab.
- E. Construction Joints: Where not otherwise indicated, use metal combination screed and key form, with removable top section for joint sealant.

3.6 FLOOR FLATNESS AND LEVELNESS TOLERANCES

- A. Correct defects by grinding or by removal and replacement of the defective work. Areas requiring corrective work will be identified. Re-measure corrected areas by the same process.

3.7 CONCRETE FINISHING, FORMED SURFACES

- A. As-Cast Surface Finishes:
 - 1. ACI 301 Surface Finish SF-1.0: As-cast concrete texture imparted by form-facing material.
 - a. Patch voids larger than 1-1/2 inches wide or 1/2 inch deep.
 - b. Remove projections larger than 1 inch.
 - c. Tie holes do not require patching.
 - d. Surface Tolerance: ACI 117 Class D.
 - e. Apply to concrete surfaces not exposed to view.
 - 2. ACI 301 Surface Finish SF-2.0: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams.
 - a. Patch voids larger than 3/4 inch wide or 1/2 inch deep.
 - b. Remove projections larger than 1/4 inch.

- c. Patch tie holes.
- d. Surface Tolerance: ACI 117 Class B.
- e. Locations: Apply to concrete surfaces exposed to view.

B. Related Unformed Surfaces:

- 1. At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a color and texture matching adjacent formed surfaces.
- 2. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces unless otherwise indicated.

3.8 CONCRETE FINISHING, UNFORMED SURFACES

A. Concrete Slabs: Finish to requirements of ACI 302.1R, and as follows:

- 1. Other Surfaces to Be Left Exposed: Trowel as described in ACI 302.1R, minimizing burnish marks and other appearance defects.

B. Scratch Finish:

- 1. While still plastic, texture concrete surface that has been screeded and bull-floated or darbied.
- 2. Use stiff brushes, brooms, or rakes to produce a profile depth of 1/4 inch in one direction.
- 3. Apply scratch finish to surfaces to receive concrete floor toppings.

C. Float Finish:

- 1. When bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operation of specific float apparatus, consolidate concrete surface with power-driven floats or by hand floating if area is small or inaccessible to power-driven floats.
- 2. Repeat float passes and restraightening until surface is left with a uniform, smooth, granular texture and complies with ACI 117 tolerances for conventional concrete.
- 3. Apply float finish to surfaces to receive trowel finish and to be covered with fluid-applied or sheet waterproofing, built-up or membrane roofing, or sand-bed terrazzo.

D. Trowel Finish:

- 1. After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel.

2. Continue troweling passes and restraighten until surface is free of trowel marks and uniform in texture and appearance.
 3. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.
 4. Do not add water to concrete surface.
 5. Do not apply hard-troweled finish to concrete, which has a total air content greater than 3 percent.
 6. Apply a trowel finish to surfaces exposed to view or to be covered with resilient flooring, carpet, ceramic or quarry tile set over a cleavage membrane, paint, or another thin-film-finish coating system.
 7. Finish surfaces to the following tolerances, in accordance with ASTM E1155, for a randomly trafficked floor surface:
 - a. Slabs on Ground:
 - 1) Specified overall values of flatness, FF 25; and of levelness, FL 20; with minimum local values of flatness, FF 17; and of levelness, FL 15.
- E. Broom Finish: Apply a broom finish to exterior concrete platforms, steps, ramps, and locations indicated on Drawings.
1. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route.
 2. Coordinate required final finish with Architect before application.

3.9 CURING AND PROTECTION

- A. Comply with requirements of ACI 308R. Immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures, and mechanical injury.
- B. Maintain concrete with minimal moisture loss at relatively constant temperature for period necessary for hydration of cement and hardening of concrete.
 1. Normal concrete: Not less than seven days.
 2. High early strength concrete: Not less than four days.
- C. Formed Surfaces: Cure by moist curing with forms in place for full curing period.
- D. Surfaces Not in Contact with Forms:
 1. Initial Curing: Start as soon as free water has disappeared and before surface is dry. Keep continuously moist for not less than three days by water ponding, water-saturated

sand, water-fog spray, or saturated burlap.

- a. Ponding: Maintain 100 percent coverage of water over floor slab areas, continuously for 4 days.
 - b. Spraying: Spray water over floor slab areas and maintain wet.
 - c. Saturated Burlap: Saturate burlap-polyethylene and place burlap-side down over floor slab areas, lapping ends and sides; maintain in place.
2. Final Curing: Begin after initial curing but before surface is dry.
 - a. Moisture-Retaining Sheet: Lap strips not less than 3 inches (75 mm) and seal with waterproof tape or adhesive; secure at edges.
 - b. Curing Compound: Apply in two coats at right angles, using application rate recommended by manufacturer.

3.10 APPLICATION OF LIQUID FLOOR TREATMENTS

- A. Penetrating Liquid Floor Treatment: Prepare, apply, and finish penetrating liquid floor treatment in accordance with manufacturer's written instructions.
 1. Remove curing compounds, sealers, oil, dirt, laitance, and other contaminants and complete surface repairs.
 2. Do not apply to concrete that is less than 28 days' old.
 3. Apply liquid until surface is saturated, scrubbing into surface until a gel forms; rewet; and repeat brooming or scrubbing.
 4. Rinse with water; remove excess material until surface is dry.
 5. Apply a second coat in a similar manner if surface is rough or porous.

3.11 FIELD QUALITY CONTROL

- A. Special Inspections: Engage a special inspector to perform field tests and inspections and prepare testing and inspection reports.
- B. Batch Tickets: For each load delivered, submit three copies of batch delivery ticket to testing agency, indicating quantity, mix identification, admixtures, design strength, aggregate size, design air content, design slump at time of batching, and amount of water that can be added at Project site.
- C. Inspections:
 1. Headed bolts and studs.

2. Verification of use of required design mixture.
 3. Concrete placement, including conveying and depositing.
 4. Curing procedures and maintenance of curing temperature.
 5. Verification of concrete strength before removal of shores and forms from beams and slabs.
 6. Batch Plant Inspections: On a random basis, as determined by Architect.
- D. Concrete Tests: Testing of composite samples of fresh concrete obtained in accordance with ASTM C 172/C 172M to be performed in accordance with the following requirements:
1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 5 cu. yd., but less than 25 cu. yd., plus one set for each additional 50 cu. yd. or fraction thereof.
 - a. When frequency of testing provides fewer than five compressive-strength tests for each concrete mixture, testing to be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
 2. Slump: ASTM C143/C143M:
 - a. One test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 - b. Perform additional tests when concrete consistency appears to change.
 3. Slump Flow: ASTM C1611/C1611M:
 - a. One test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 - b. Perform additional tests when concrete consistency appears to change.
 4. Air Content: ASTM C231/C231M pressure method, for normal-weight concrete.
 - a. One test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 5. Concrete Temperature: ASTM C1064/C1064M:
 - a. One test hourly when air temperature is 40 deg F and below or 80 deg F and above, and one test for each composite sample.
 6. Unit Weight: ASTM C567/C567M fresh unit weight of structural lightweight concrete.

- a. One test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
- 7. Compression Test Specimens: ASTM C31/C31M:
 - a. Cast and laboratory cure one sets of four 6-inch by 12-inch or 4-inch by 8-inch cylinder specimens for each composite sample.
- 8. Compressive-Strength Tests: ASTM C39/C39M.
 - a. Test one laboratory-cured specimens at seven days and two specimens at 28 days.
 - b. A compressive-strength test to be the average compressive strength from a set of two specimens obtained from same composite sample and tested at age indicated.
- 9. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor to evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
- 10. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength, and no compressive-strength test value falls below specified compressive strength by more than 500 psi if specified compressive strength is 5000 psi, or no compressive strength test value is less than 10 percent of specified compressive strength if specified compressive strength is greater than 5000 psi.
- 11. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Engineer but will not be used as sole basis for approval or rejection of concrete.
- 12. Additional Tests:
 - a. Testing and inspecting agency to make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Engineer.
 - b. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C42/C42M or by other methods as directed by Engineer.
 - 1) Acceptance criteria for concrete strength to be in accordance with ACI 301, Section 1.6.6.3.
- 13. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- 14. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.

- E. Measure floor and slab flatness and levelness in accordance with ASTM E1155 within 48 hours of completion of floor finishing and promptly report test results to Engineer.

3.12 DEFECTIVE CONCRETE

- A. Test Results: The testing agency shall report test results in writing to Architect and Contractor within 24 hours of test.
- B. Defective Concrete: Concrete not complying with required lines, details, dimensions, tolerances or specified requirements.
- C. Repair or replacement of defective concrete will be determined by the Architect. The cost of additional testing shall be borne by Contractor when defective concrete is identified.
- D. Do not patch, fill, touch-up, repair, or replace exposed concrete except upon express direction of Architect for each individual area.

3.13 PROTECTION

- A. Do not permit traffic over unprotected concrete floor surface until fully cured.

END OF SECTION 03 3000

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**SECTION 05 5000
METAL FABRICATIONS**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Shop fabricated steel and aluminum items.

1.2 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete: Placement of metal fabrications in concrete.
- B. Section 05 5100 - Metal Stairs.
- C. Section 05 5213 - Pipe and Tube Railings.

1.3 REFERENCE STANDARDS

- A. ASTM A36/A36M - Standard Specification for Carbon Structural Steel 2019.
- B. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless 2022.
- C. ASTM A283/A283M - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates 2018.
- D. ASTM A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength 2021.
- E. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar 2015.
- F. ASTM B211/B211M - Standard Specification for Aluminum and Aluminum-Alloy Rolled or Cold Finished Bar, Rod, and Wire 2019.
- G. ASTM B209/B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate 2021a.
- H. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes 2021.
- I. AWS B2.1/B2.1M - Specification for Welding Procedure and Performance Qualification 2021.
- J. AWS D1.1/D1.1M - Structural Welding Code - Steel 2020, with Errata (2022).
- K. AWS D1.2/D1.2M - Structural Welding Code - Aluminum 2014, with Errata (2020).
- L. IAS AC172 - Accreditation Criteria for Fabricator Inspection Programs for Structural Steel AC172 2019.

- M. SSPC-Paint 15 - Steel Joist Shop Primer/Metal Building Primer 2004.
- N. SSPC-Paint 20 - Zinc-Rich Coating (Type I - Inorganic, and Type II - Organic) 2019.
- O. SSPC-SP 2 - Hand Tool Cleaning 2018.

1.4 SUBMITTALS

- A. See Section 01 0004 Submittal Procedures, for submittal procedures.
- B. Shop Drawings: Indicate profiles, sizes, connection attachments, reinforcing, anchorage, size and type of fasteners, and accessories. Include erection drawings, elevations, and details where applicable.
- C. Welders' Qualification Statement: Welders' certificates in accordance with AWS B2.1/B2.1M and dated no more than 12 months before start of scheduled welding work.
- D. Fabricator's Qualification Statement: Provide documentation showing steel fabricator is accredited under IAS AC172.

1.5 QUALITY ASSURANCE

- A. Design under direct supervision of a Professional Structural Engineer experienced in design of this work and licensed in the State in which the Project is located.
- B. Welder Qualifications: Welding processes and welding operators qualified in accordance with AWS D1.1/D1.1M and AWS D1.2/D1.2M and dated no more than 12 months before start of scheduled welding work.

PART 2 PRODUCTS

2.1 MATERIALS - STEEL

- A. Steel Sections: ASTM A36/A36M.
- B. Plates: ASTM A283/A283M.
- C. Pipe: ASTM A53/A53M, Grade B Schedule 40, black finish.
- D. Stainless Steel, General: ASTM A666, Type 304.
- E. Mechanical Fasteners: Same material as or compatible with materials being fastened; type consistent with design and specified quality level.
- F. Bolts, Nuts, and Washers: ASTM A307, Grade A, plain.
- G. Shop and Touch-Up Primer: SSPC-Paint 15, complying with VOC limitations of authorities having jurisdiction.

- H. Touch-Up Primer for Galvanized Surfaces: SSPC-Paint 20, Type I - Inorganic, complying with VOC limitations of authorities having jurisdiction.

2.2 MATERIALS - ALUMINUM

- A. Extruded Aluminum: ASTM B221 (ASTM B221M), 6063 alloy, T6 temper.
- B. Sheet and Plate Aluminum: ASTM B209/B209M, 6061-T6 alloy
- C. Structural Shapes Aluminum: ASTM B211/B211M, 6061-T6 alloy

2.3 FASTENERS

- A. Bolts, Nuts, and Washers, General: Unless otherwise indicated, provide Type 304 stainless-steel fasteners for exterior use. Select fasteners for type, grade, and class required.
 - 1. Provide stainless-steel fasteners for fastening to aluminum
- B. Bolts, Nuts, and Washers: Stainless steel
 - 1. Regular hexagon-head annealed stainless-steel bolts, ASTM F593/F593M; with hex nuts ASTM 594/594M; and, where indicated, flat washers; Alloy Group 1.
- C. Anchors, General: Anchors capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM 488/488M, conducted by a qualified independent testing agency
- D. Post-Installed Anchors: Torque-controlled expansion anchors or chemical anchors.
 - 1. Material for Exterior Locations and where Stainless-Steel is indicated: Alloy Group 1 stainless-steel bolts, ASTM F593/F593M, and nuts, ASTM F594/F594M
- E. Welding Materials: AWS D1.2/D1.2M; type required for materials being welded.

2.4 FABRICATION

- A. Fit and shop assemble items in largest practical sections, for delivery to site.
- B. Fabricate items with joints tightly fitted and secured.
- C. Grind exposed joints flush and smooth with adjacent finish surface. Make exposed joints butt tight, flush, and hairline. Ease exposed edges to small uniform radius.
- D. Furnish components required for anchorage of fabrications. Fabricate anchors and related components of same material and finish as fabrication, except where specifically noted otherwise.

2.5 FABRICATED ITEMS

- A. Ledge Angles, Shelf Angles, Channels, and Plates Not Attached to Structural Framing: For support of metal decking; prime paint finish.
- B. Lintels: As detailed; prime paint finish.
- C. Wall Openings: Channel and Angle sections; prime paint finish.

2.6 FINISHES - STEEL

- A. Prime paint steel items.
 - 1. Exceptions: Galvanize items to be embedded in concrete.
- B. Prepare surfaces to be primed in accordance with SSPC-SP2.
- C. Clean surfaces of rust, scale, grease, and foreign matter prior to finishing.
- D. Prime Painting: One coat.

2.7 FINISHES - ALUMINUM

- A. Exterior Aluminum Surfaces: Mill Finish.
- B. Apply one coat of bituminous paint to concealed aluminum surfaces in contact with cementitious or dissimilar materials or coat per 09 9600.

2.8 FABRICATION TOLERANCES

- A. Squareness: 1/8 inch (3 mm) maximum difference in diagonal measurements.
- B. Maximum Offset Between Faces: 1/16 inch (1.5 mm).
- C. Maximum Misalignment of Adjacent Members: 1/16 inch (1.5 mm).
- D. Maximum Bow: 1/8 inch (3 mm) in 48 inches (1.2 m).
- E. Maximum Deviation From Plane: 1/16 inch (1.5 mm) in 48 inches (1.2 m).

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field conditions are acceptable and are ready to receive work.

3.2 PREPARATION

- A. Furnish setting templates to the appropriate entities for steel items required to be cast into concrete or embedded in masonry.

3.3 INSTALLATION

- A. Install items plumb and level, accurately fitted, free from distortion or defects.
- B. Provide for erection loads, and for sufficient temporary bracing to maintain true alignment until completion of erection and installation of permanent attachments.
- C. Perform field welding in accordance with AWS D1.1/D1.1M.
- D. Obtain approval prior to site cutting or making adjustments not scheduled.
- E. After erection, prime welds, abrasions, and surfaces not shop primed , except surfaces to be in contact with concrete.

END OF SECTION 05 5000

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**SECTION 05 5100
METAL STAIRS**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Stairs with grating treads.
- B. Structural steel stair framing and supports.
- C. Handrails and guards.

1.2 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete: Placement of metal anchors in concrete.
- B. Section 04 2000 - Unit Masonry: Placement of metal fabrications in masonry.
- C. Section 05 5000 - Metal Fabrications.
- D. Section 05 5213 - Pipe and Tube Railings: Metal handrails for the stairs specified in this section.
- E. Section 09 9600 - High-Performance Coatings

1.3 REFERENCE STANDARDS

- A. AISC 201 - AISC Certification Program for Structural Steel Fabricators, Standard for Steel Building Structures 2006.
- B. AWS A2.4 - Standard Symbols for Welding, Brazing, and Nondestructive Examination 2020.
- C. AWS B2.1/B2.1M - Specification for Welding Procedure and Performance Qualification 2021.
- D. AWS D1.1/D1.1M - Structural Welding Code - Steel 2020, with Errata (2022).
- E. IAS AC172 - Accreditation Criteria for Fabricator Inspection Programs for Structural Steel AC172 2019.
- F. NAAMM AMP 510 - Metal Stairs Manual 1992.
- G. NAAMM MBG 531 - Metal Bar Grating Manual 2017.
- H. NAAMM MBG 532 - Heavy Duty Metal Bar Grating Manual 2019.

1.4 SUBMITTALS

- A. See Section 01 0004 Submittal Procedures, for submittal procedures.

- B. Shop Drawings: Indicate profiles, sizes, connection attachments, reinforcing, anchorage, size and type of fasteners, and accessories.
 - 1. Indicate welded connections using standard AWS A2.4 welding symbols. Indicate net weld lengths.
- C. Welders' Qualification Statement: Welders' certificates in accordance with AWS B2.1/B2.1M and dated no more than 12 months before start of scheduled welding work.
- D. Fabricator's Qualification Statement: Provide documentation showing steel fabricator is certified under AISC 201.
- E. Fabricator's Qualification Statement: Provide documentation showing steel fabricator is accredited under IAS AC172.

1.5 QUALITY ASSURANCE

- A. Structural Designer Qualifications: Professional Structural Engineer experienced in design of this work and licensed in the State in which the Project is located, or personnel under direct supervision of such an engineer.
- B. Welder Qualifications: Welding processes and welding operators qualified in accordance with AWS D1.1/D1.1M and dated no more than 12 months before start of scheduled welding work.
- C. Fabricator Qualifications:

PART 2 PRODUCTS

2.1 METAL STAIRS - GENERAL

- A. Metal Stairs: Provide stairs of the design specified, complete with landing platforms, vertical and horizontal supports, railings, and guards, fabricated accurately for anchorage to each other and to building structure.
 - 1. Regulatory Requirements: Provide stairs and railings that comply with most stringent requirements of local, state, and federal regulations; where requirements of Contract Documents exceed those of regulations, comply with Contract Documents.
 - 2. Handrails: Comply with applicable accessibility requirements of ADA Standards.
 - 3. Dimensions: As indicated on drawings.
 - 4. Shop assemble components; disassemble into largest practical sections suitable for transport and access to site.
 - 5. No sharp or rough areas on exposed travel surfaces and surfaces accessible to touch.
 - 6. Separate dissimilar metals using paint or permanent tape.

B. Metal Jointing and Finish Quality Levels:

1. Architectural: All joints as inconspicuous as possible, whether welded or mechanical.
 - a. Welded Joints: Continuously welded and ground smooth and flush.
 - b. Mechanical Joints: Butted tight, flush, and hairline; concealed fastenings only.
 - c. Exposed Edges and Corners: Eased to small uniform radius.
 - d. Metal Surfaces to be Painted: Sanded or ground smooth, suitable for highest quality gloss finish.
2. Industrial: All joints made neatly.
 - a. Welded Joints: Welded on back side wherever possible.
 - b. Welds Exposed to Touch: Ground smooth.
 - c. Bolts Exposed to Touch in Travel Area: No nuts or screw threads exposed to touch.

- C. Fasteners: Same material or compatible with materials being fastened; type consistent with design and specified quality level.
- D. Anchors and Related Components: Same material and finish as item to be anchored, except where specifically indicated otherwise; provide all anchors and fasteners required.

2.2 METAL STAIRS WITH GRATING TREADS

- A. Jointing and Finish Quality Level: Industrial, as defined above.
- B. Risers: Open.
- C. Treads: Aluminum bar grating.
 1. Grating Type: Pressure locked.
 2. Bearing Bar Depth: 1-1/2 inch (37 mm), minimum.
 3. Top Surface: Serrated.
 4. Nosing: Abrasive cast aluminum.
 5. Nosing Width: 1-1/4 inch (32 mm), minimum.
 6. Anchorage to Stringers: End plates welded to grating, bolted to stringers.
- D. Stringers: Aluminum Channel.

1. Stringer Depth: 10 inches (250 mm).

- E. Railings: Aluminum Pipe Railing.

2.3 HANDRAILS AND GUARDS

- A. Wall-Mounted Rails: See Section 05 5213.

2.4 MATERIALS

- A. Aluminum Plate and Sheet: ASTM B209/B209M, Alloy 6061-T6
- B. Aluminum-Alloy Rolled Tread Plate: ASTM B632/B632M, Alloy 6061-T6.
- C. Gratings: Bar gratings that comply with NAAMM MBG 531 or NAAMM MBG 532, whichever applies based on bar sizes.

2.5 ACCESSORIES

- A. Stainless Steel Bolts, Nuts, and Washers: Type 304 Regular hexagin-head annealed stainless steel bolts, nuts, and, where indicated, flat washers; ASTM F593/F593M for bolts and ASTM F594/F594M for nuts, Alloy Group 1 Group 2.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field conditions are acceptable and are ready to receive work.

3.2 PREPARATION

- A. When field welding is required, clean and strip primed steel items to bare metal.
- B. Supply items required to be cast into concrete and embedded in masonry with setting templates.

3.3 INSTALLATION

- A. Install components plumb and level, accurately fitted, free from distortion or defects.
- B. Provide anchors, plates, angles, hangers, and struts required for connecting stairs to structure.
- C. Allow for erection loads, and for sufficient temporary bracing to maintain true alignment until completion of erection and installation of permanent attachments.
- D. Provide welded field joints where specifically indicated on drawings. Perform field welding in accordance with AWS D1.1/D1.1M.
- E. Other field joints may be either welded or bolted provided the result complies with the limitations specified for jointing quality levels.

- F. Obtain approval prior to site cutting or creating adjustments not scheduled.

END OF SECTION 05 5100

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**SECTION 05 5213
PIPE AND TUBE RAILINGS**

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Aluminum pipe and tube railings.
- B. Related Sections:
 - 1. Division 05 Section "Metal Stairs" for metal stairs.

1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design railings, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. General: In engineering railings to withstand structural loads indicated, determine allowable design working stresses of railing materials based on the following:
 - 1. Aluminum: The lesser of minimum yield strength divided by 1.65 or minimum ultimate tensile strength divided by 1.95.
- C. Structural Performance: Railings shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
 - 1. Handrails and Top Rails of Guards:
 - a. Uniform load of 50 lbf/ ft. applied in any direction.
 - b. Concentrated load of 200 lbf applied in any direction.
 - c. Uniform and concentrated loads need not be assumed to act concurrently.
 - 2. Infill of Guards:
 - a. Concentrated load of 50 lbf applied horizontally on an area of 1 sq. ft..
 - b. Infill load and other loads need not be assumed to act concurrently.
- D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes acting on exterior metal fabrications by preventing buckling, opening of joints,

overstressing of components, failure of connections, and other detrimental effects.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.
- E. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

1.4 SUBMITTALS

- A. Product Data: For the following:
1. Manufacturer's product lines of mechanically connected railings.
 2. Post-installed anchors.
 3. Railing brackets.
 4. Bituminous paint.
 5. Grout, anchoring cement, and paint products.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
- C. Delegated-Design Submittal: For installed products indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- D. Qualification Data: For qualified professional engineer.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain each type of railing from single source from single manufacturer.
- B. Welding Qualifications: Qualify procedures and personnel in accordance with the following:
1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."

1.6 PROJECT CONDITIONS

- A. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Protect mechanical finishes on exposed surfaces of railings from damage by applying a strippable, temporary protective covering before shipping.

1.8 COORDINATION AND SCHEDULING

- A. Coordinate installation of anchorages for railings. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.
- B. Schedule installation so wall attachments are made only to completed walls. Do not support railings temporarily by any means that do not satisfy structural performance requirements.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Aluminum Pipe and Tube Railings:
 - a. Blum, Julius & Co., Inc.
 - b. Braun, J. G., Company; a division of the Wagner Companies.
 - c. Hollaender Manufacturing Company.
 - d. Kee Industrial Products, Inc.
 - e. Superior Aluminum Products, Inc.
 - f. Wagner, R & B, Inc.; a division of the Wagner Companies.
 - g. Or equal.

2.2 METALS, GENERAL

- A. Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.
- B. Brackets, Flanges, and Anchors: Cast or formed metal of same type of material and finish as supported rails unless otherwise indicated.
 - 1. Provide type of bracket with predrilled hole for exposed bolt anchorage and that provides 1-1/2-inch clearance from inside face of handrail to finished wall surface.

2.3 ALUMINUM

- A. Aluminum, General: Provide alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than the strength and durability properties of alloy and temper designated below for each aluminum form required.

- B. Extruded Bars and Tubing: ASTM B 221, Alloy 6063-T5/T52.
- C. Extruded Structural Pipe and Round Tubing: ASTM B 429/B 429M, Alloy 6063-T6.
 - 1. Provide Standard Weight (Schedule 40) pipe, unless otherwise indicated.
- D. Drawn Seamless Tubing: ASTM B 210, Alloy 6063-T832.
- E. Plate and Sheet: ASTM B 209, Alloy 6061-T6.
- F. Die and Hand Forgings: ASTM B 247, Alloy 6061-T6.
- G. Castings: ASTM B 26/B 26M, Alloy A356.0-T6.

2.4 FASTENERS

- A. General: Provide the following:
 - 1. Aluminum Railings: Type 316 stainless-steel fasteners.
- B. Fasteners for Anchoring Railings to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings to other types of construction indicated and capable of withstanding design loads.
- C. Fasteners for Interconnecting Railing Components:
 - 1. Provide concealed fasteners for interconnecting railing components and for attaching them to other work, unless otherwise indicated.
 - 2. Provide concealed fasteners for interconnecting railing components and for attaching them to other work, unless exposed fasteners are unavoidable or are the standard fastening method for railings indicated.
 - 3. Provide Phillips tamper-resistant, square or hex socket, flat-head machine screws for exposed fasteners unless otherwise indicated.
- D. Post-Installed Anchors: Torque-controlled expansion anchors or chemical anchors capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E 488, conducted by a qualified independent testing agency.
 - 1. Alloy Group 1 (A1) stainless-steel bolts, ASTM F 593, and nuts, ASTM F 594.

2.5 MISCELLANEOUS MATERIALS

- A. Handrail Brackets: Cast aluminum, center of handrail 2-1/2 inches from face of railing or wall.
- B. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

1. For aluminum railings, provide type and alloy as recommended by producer of metal to be welded and as required for color match, strength, and compatibility in fabricated items.
- C. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.
- D. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout specifically recommended by manufacturer for interior and exterior applications.

2.6 FABRICATION

- A. General: Fabricate railings to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage, but not less than that required to support structural loads.
 1. Provide 2.4" O.D posts.
 2. Provide 2.4" O.D top rails.
 3. Provide 2.4" O.D intermediate rails
 4. Provide 1.7" O.D. handrails
- B. Assemble railings in the shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.
 1. Clearly mark units for reassembly and coordinated installation.
 2. Use connections that maintain structural value of joined pieces.
- C. Cut, drill, and punch metals cleanly and accurately.
 1. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated.
 2. Remove sharp or rough areas on exposed surfaces.
- D. Form work true to line and level with accurate angles and surfaces.
- E. Fabricate connections that will be exposed to weather in a manner to exclude water.
 1. Provide weep holes where water may accumulate.
 2. Locate weep holes in inconspicuous locations.
- F. Cut, reinforce, drill, and tap as indicated to receive finish hardware, screws, and similar items.

- G. Connections: Fabricate railings with nonwelded connections unless otherwise indicated.
- H. Nonwelded Connections: Connect members with concealed mechanical fasteners and fittings. Fabricate members and fittings to produce flush, smooth, rigid, hairline joints.
 - 1. Fabricate splice joints for field connection using an epoxy structural adhesive if this is manufacturer's standard splicing method.
- I. Form changes in direction as follows:
 - 1. By inserting prefabricated flush-elbow fittings.
- J. Bend members in jigs to produce uniform curvature for each configuration required; maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.
- K. Close exposed ends of railing members with prefabricated end fittings.
- L. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated. Close ends of returns unless clearance between end of rail and wall is 1/4 inch (6 mm) or less.
- M. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect railing members to other work unless otherwise indicated.
 - 1. At brackets and fittings fastened to plaster or gypsum board partitions, provide crush-resistant fillers, or other means to transfer loads through wall finishes to structural supports and prevent bracket or fitting rotation and crushing of substrate.
- N. Provide inserts and other anchorage devices for connecting railings to concrete or masonry work. Fabricate anchorage devices capable of withstanding loads imposed by railings. Coordinate anchorage devices with supporting structure.
- O. Toe Boards: Provide toe boards at railings around openings and at edge of open-sided floors and platforms. Fabricate to dimensions and details indicated.

2.7 FINISHES, GENERAL

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- C. Provide exposed fasteners with finish matching appearance, including color and texture, of railings.

2.8 ALUMINUM FINISHES

- A. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are unacceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- B. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm or thicker.

PART 3 EXECUTION

3.1 INSTALLATION, GENERAL

- A. Fit exposed connections together to form tight, hairline joints.
- B. Perform cutting, drilling, and fitting required for installing railings. Set railings accurately in location, alignment, and elevation; measured from established lines and levels and free of rack.
 - 1. Do not weld, cut, or abrade surfaces of railing components that have been coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.
 - 2. Set posts plumb within a tolerance of 1/16 inch in 3 feet.
 - 3. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet.
- C. Corrosion Protection: Coat concealed surfaces of aluminum that will be in contact with grout, concrete, masonry, wood, or dissimilar metals, with a heavy coat of bituminous paint.
- D. Adjust railings before anchoring to ensure matching alignment at abutting joints.
- E. Fastening to In-Place Construction: Use anchorage devices and fasteners where necessary for securing railings and for properly transferring loads to in-place construction.

3.2 RAILING CONNECTIONS

- A. Nonwelded Connections: Use mechanical or adhesive joints for permanently connecting railing components. Seal recessed holes of exposed locking screws using plastic cement filler colored to match finish of railings.
- B. Expansion Joints: Install expansion joints at locations indicated but not farther apart than required to accommodate thermal movement. Provide slip-joint internal sleeve extending 2 inches beyond joint on either side, fasten internal sleeve securely to one side, and locate joint within 6 inches of post.

3.3 ANCHORING POSTS

- A. Anchor posts to metal surfaces with oval flanges, angle type, or floor type as required by conditions, connected to posts and to metal supporting members as follows:
 - 1. For aluminum pipe railings, attach posts using fittings designed and engineered for this purpose.

3.4 ATTACHING RAILINGS

- A. Anchor railing ends at walls with round flanges anchored to wall construction and connected to railing ends using nonwelded connections.
- B. Anchor railing ends to metal surfaces with flanges bolted to metal surfaces and connected to railing ends using nonwelded connections.
- C. Attach railings to wall with wall brackets, except where end flanges are used. Provide brackets with 1-1/2-inch (38-mm) clearance from inside face of handrail and finished wall surface. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.
 - 1. Use type of bracket with predrilled hole for exposed bolt anchorage.
 - 2. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.
- D. Secure wall brackets and railing end flanges to building construction as follows:
 - 1. For concrete and solid masonry anchorage, use drilled-in expansion shields and hanger or lag bolts.

3.5 ADJUSTING AND CLEANING

- A. Clean aluminum by washing thoroughly with clean water and soap and rinsing with clean water.

3.6 PROTECTION

- A. Protect finishes of railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of Substantial Completion.
- B. Restore finishes damaged during installation and construction period, so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit, or provide new units.

END OF SECTION 05 5213

**SECTION 05 5305
METAL GRATINGS AND FLOOR PLATES**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Formed metal floor and stair tread gratings.
- B. Flat surface floor and stair tread plating.
- C. Perimeter closure.

1.2 RELATED REQUIREMENTS

- A. Section 05 5000 - Metal Fabrications.
- B. Section 05 5100 - Metal Stairs: Framing for grating and stair treads.

1.3 REFERENCE STANDARDS

- A. ASTM A786/A786M - Standard Specification for Hot-Rolled Carbon, Low-Alloy, High-Strength Low-Alloy, and Alloy Steel Floor Plates 2015 (Reapproved 2021).
- B. ASTM B211/B211M - Standard Specification for Aluminum and Aluminum-Alloy Rolled or Cold Finished Bar, Rod, and Wire 2019.
- C. AWS D1.1/D1.1M - Structural Welding Code - Steel 2020, with Errata (2022).
- D. NAAMM MBG 531 - Metal Bar Grating Manual 2017.

1.4 SUBMITTALS

- A. See Section 01 0004 Submittal Procedures, for submittal procedures.
- B. Product Data: Provide span and deflection tables.
- C. Shop Drawings: Indicate details of component supports, openings, perimeter construction details, and tolerances.
 - 1. Include the design engineer's seal and signature on each sheet of shop drawings.

1.5 QUALITY ASSURANCE

- A. Welder Qualifications: Welding processes and welding operators qualified within previous 12 months in accordance with AWS D1.1/D1.1M.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Steel Floor Plate: ASTM A786/A786M; manufacturer's standard pattern.
- B. Aluminum For Lock Forming: ASTM B211/B211M bars, shapes as indicated.
- C. Cross Bars: ASTM B211/B211M solid bars.
- D. Welding Materials: AWS D1.1/D1.1M; type required for materials being welded.

2.2 ACCESSORIES

- A. Fasteners and Saddle Clips: Stainless steel:
 - 1. Stainless Steel Bolts: Type 304 Regular hexagin-head annealed stainless steel bolts, nuts, and, where indicated, flat washers; ASTM F593 for bolts and ASTM F594 for nuts, Alloy Group 1 Group 2..
 - 2. Post-Installed Anchors: Torque-controlled expansion anchors capable of sustaining, without failure, a load of four times the load imposed when installed in concrete, as determined by testing in accordance with ASTM E488/E488M conducted by a qualified independent testing agency. Alloy Group 1 Alloy Group 2 stainless steel bolts, ASTM F593.
- B. Perimeter Closure: Of same material as grating.

2.3 FABRICATION

- A. Grating Type: NAAMM MBG 531, Pressure Locked Type.
- B. Fabricate grates and plates to accommodate design loads.
- C. Mechanically fasten joints of intersecting metal sections.
- D. Fabricate support framing for openings.
- E. Top Surface: Serrated.
- F. Bearing Bar: 1-3/4 by 3/16 inch (45 by 5 mm) size, spaced 1-3/16 inches (30 mm) on center.
- G. Cross Bar: spaced 4 inches (102 mm) on center.

2.4 FINISHES

- A. Aluminum: Mill finish.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated on drawings.
- B. Verify that opening sizes and dimensional tolerances are acceptable.
- C. Verify that supports are correctly positioned.

3.2 INSTALLATION

- A. Install components in accordance with manufacturer's instructions.
- B. Place frames in correct position, plumb and level.
- C. Set perimeter closure flush with top of grating and surrounding construction.
- D. Secure to prevent movement.

3.3 TOLERANCES

- A. Comply with NAAMM MBG 531.

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**SECTION 06 1000
ROUGH CARPENTRY**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Structural dimension lumber framing.
- B. Rough opening framing for doors, windows, and roof openings.
- C. Sheathing.
- D. Miscellaneous framing and sheathing.
- E. Concealed wood blocking, nailers, and supports.
- F. FRP Panels.

1.2 RELATED REQUIREMENTS

- A. Section 05 5000 - Metal Fabrications: Miscellaneous steel connectors and support angles for wood framing.
- B. Section 06 1753 - Shop-Fabricated Wood Trusses.
- C. Section 07 6200 - Sheet Metal Flashing and Trim: Sill flashings.

1.3 REFERENCE STANDARDS

- A. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware 2016a.
- B. AWC (WFCM) - Wood Frame Construction Manual for One- and Two-Family Dwellings 2018, with Errata (2019).
- C. PS 2 - Performance Standard for Wood Structural Panels 2018.
- D. PS 20 - American Softwood Lumber Standard 2021.

1.4 SUBMITTALS

- A. See Section 01 0004 Submittal Procedures, for submittal procedures.
- B. Product Data: Provide technical data on insulated sheathing, wood preservative materials, and application instructions.
- C. Manufacturer's Certificate: Certify that wood products supplied for rough carpentry meet or exceed specified requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. General: Cover wood products to protect against moisture. Support stacked products to prevent deformation and to allow air circulation.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Dimension Lumber: Comply with PS 20 and requirements of specified grading agencies.
 - 1. If no species is specified, provide species graded by the agency specified; if no grading agency is specified, provide lumber graded by grading agency meeting the specified requirements.
 - 2. Grading Agency: Grading agency whose rules are approved by the Board of Review, American Lumber Standard Committee at www.alsc.org, and who provides grading service for the species and grade specified; provide lumber stamped with grade mark unless otherwise indicated.
 - 3. Lumber of other species or grades is acceptable provided structural and appearance characteristics are equivalent to or better than products specified.

2.2 DIMENSION LUMBER FOR CONCEALED APPLICATIONS

- A. Sizes: Nominal sizes as indicated on drawings, S4S.
- B. Moisture Content: S-dry or MC19.
- C. Stud Framing (2 by 2 through 2 by 10 (50 by 50 mm through 50 by 250 mm)):
 - 1. Species: Spruce-Pine-Fir.
 - 2. Grade: No. 1/No. 2.
- D. Miscellaneous Framing, Blocking, Nailers, Grounds, and Furring:
 - 1. Lumber: S4S, No. 2 or Standard Grade.
 - 2. Boards: Standard or No. 3.

2.3 CONSTRUCTION PANELS

- A. Roof Sheathing: PS 2 type, rated Sheathing.
 - 1. Bond Classification: Exposure 1.
 - 2. Span Rating: 40.

3. Performance Category: 5/8 PERF CAT.
- B. Wall Sheathing: PS 2 type.
1. Bond Classification: Exposure 1.
 2. Grade: Sheathing.
 3. Span Rating: 24.
 4. Performance Category: 7/16 PERF CAT.
 5. Edge Profile: Square edge.

2.4 FRP PANELS (INTERIOR WALLS AND CEILING)

- A. Fiberglass Reinforced Plastic (FRP) Panel Thickness: 3/4" Total Thickness
1. FRP: .09" Thickness
 2. Plywood: 5/8" Thickness – Fire Rated
 3. Texture: Embossed
 4. Fully adhered panels in factory.
 5. Class A rating for flame spread and smoke development when tested per ASTM E-84.
- B. FRP Panel Trim: Aluminum Fored batten strips, inside-outside angles, and end caps.
1. Color: Prefinished White
 2. Ceiling Perimeter Trim: 4" PVC wood-grain textured board
- C. Fasteners: Aluminum fasteners (prefinished white). Coordinate with manufacturer for proper length fastener.
- D. Basis of Design: NUDO - NuFiber Wall Panels or equal.

2.5 MISCELLANEOUS MATERIALS

- A. Adhesives for Field Gluing Panels to Wood Framing: Formulation complying with APA AFG-01 that is approved for use with type of construction panel indicated by manufacturers of both adhesives and panels.

2.6 ACCESSORIES

- A. Fasteners and Anchors:

1. Metal and Finish: Hot-dipped galvanized steel complying with ASTM A153/A153M for high humidity and preservative-treated wood locations, unfinished steel elsewhere.
2. Drywall Screws: Bugle head, hardened steel, power driven type, length three times thickness of sheathing.

B. Sill Flashing: See Section 07 6200.

PART 3 EXECUTION

3.1 PREPARATION

- A. Where wood framing bears on cementitious foundations, install full width sill flashing continuous over top of foundation, lap ends of flashing minimum of 4 inches (100 mm) and seal.
- B. Coordinate installation of rough carpentry members specified in other sections.

3.2 INSTALLATION - GENERAL

- A. Select material sizes to minimize waste.
- B. Reuse scrap to the greatest extent possible; clearly separate scrap for use on site as accessory components, including: shims, bracing, and blocking.

3.3 FRAMING INSTALLATION

- A. Set structural members level, plumb, and true to line. Discard pieces with defects that would lower required strength or result in unacceptable appearance of exposed members.
- B. Make provisions for temporary construction loads, and provide temporary bracing sufficient to maintain structure in true alignment and safe condition until completion of erection and installation of permanent bracing.
- C. Install structural members full length without splices unless otherwise specifically detailed.
- D. Comply with member sizes, spacing, and configurations indicated, and fastener size and spacing indicated, but not less than required by applicable codes and AWC (WFCM) Wood Frame Construction Manual.
- E. Construct double joist headers at floor and ceiling openings and under wall stud partitions that are parallel to floor joists; use metal joist hangers unless otherwise detailed.
- F. Frame wall openings with two or more studs at each jamb; support headers on cripple studs.

3.4 BLOCKING, NAILERS, AND SUPPORTS

- A. Provide framing and blocking members as indicated or as required to support finishes, fixtures, specialty items, and trim.

3.5 ROOF-RELATED CARPENTRY

- A. Coordinate installation of roofing carpentry with deck construction, framing of roof openings, and roofing assembly installation.

3.6 INSTALLATION OF CONSTRUCTION PANELS

- A. Roof Sheathing: Secure panels with long dimension perpendicular to framing members, with ends staggered and over firm bearing.
 - 1. Nail panels to framing; staples are not permitted.
- B. Wall Sheathing: Secure with long dimension perpendicular to wall studs, with ends over firm bearing and staggered, using nails, screws, or staples.

END OF SECTION 06 1000

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**SECTION 06 1753
SHOP-FABRICATED WOOD TRUSSES**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Shop-fabricated wood trusses.
- B. Truss bridging.

1.2 REFERENCE STANDARDS

- A. ANSI/TPI 1 - National Design Standard for Metal-Plate-Connected Wood Truss Construction 2014.
- B. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process 2022.
- C. SBCA (BCSI) - Building Component Safety Information: Guide to Good Practice for Handling, Installing, Restraining & Bracing of Metal Plate Connected Wood Trusses 2018 (Updated 2020).

1.3 SUBMITTALS

- A. See Section 01 0004 Submittal Procedures, for submittal procedures.
- B. Product Data: Manufacturer's data sheets on plate connectors, bearing plates, and metal bracing components.
- C. Shop Drawings: Show truss configurations, sizes, spacing, size and type of plate connectors, cambers, framed openings, bearing and anchor details, and bridging and bracing.
 - 1. Include identification of engineering software used for design.
 - 2. Provide shop drawings stamped or sealed by design engineer.
 - 3. Submit design calculations.

1.4 QUALITY ASSURANCE

- A. Designer Qualifications: Perform design by or under direct supervision of a Professional Engineer experienced in design of this Work and licensed in the State in which the Project is located.
- B. Metal Connector- Plate Manufacturer Qualifications: A manufacturer that is a member of TPI and that complies with quality-control procedures in TPI 1 for manufacture of connector plates.
- C. Fabricator Qualifications: Shop that participates in a recognized quality-assurance program that complies with quality-control procedures in TPI 1 and that involves third-party inspection by an

independent testing and inspecting agency acceptable to Architect and authorities having jurisdiction.

- D. Source Limitations for Connector Plates: Obtain metal connector plates from a single manufacturer.
- E. Comply with applicable requirements and recommendations of the following publications:
 - 1. TPI 1, "National Design Standard for Metal Plate Connected Wood Truss Construction."
 - 2. TPI DSB, "Recommended Design Specification for Temporary Bracing of Metal Plate Connected Wood Trusses."
 - 3. TPI HIB, "Commentary and Recommendations for Handling, Installing & Bracing Metal Plate Connected Wood Trusses."
- F. Wood Structural Design Standard: Comply with applicable requirements in AF&PA's "National Design Specifications for Wood Construction" and its "Supplement."

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Handle trusses in accordance with SBCA (BCSI).
- B. Store trusses in vertical position resting on bearing ends.

PART 2 PRODUCTS

2.1 TRUSSES

- A. Wood Trusses: Design and fabricate trusses in accordance with ANSI/TPI 1 and to achieve specified design requirements indicated.

2.2 MATERIALS

- A. Lumber:
 - 1. Moisture Content: Between 7 and 9 percent.
 - 2. Lumber fabricated from old growth timber is not permitted.
- B. Steel Connectors: Hot-dipped galvanized steel sheet, ASTM A653/A653M Structural Steel (SS) Grade 33/230, with G90/Z275 coating; die stamped with integral teeth; thickness as indicated.
- C. Truss Bridging: Type, size and spacing recommended by truss manufacturer.

2.3 ACCESSORIES

- A. Wood Blocking, Bridging, Plates, and Miscellaneous Framing: Softwood lumber, any species, construction grade, 19 percent maximum and 7 percent minimum moisture content.
- B. Wood Blocking, Bridging, Plates, and Miscellaneous Framing: As specified in Section 06 1000.
- C. Fasteners: Hot-dip galvanized steel, type to suit application.
- D. Bearing Plates: Hot-dip galvanized steel.

2.4 FABRICATION

- A. Cut truss members to accurate lengths, angles, and sizes to produce close-fitting joints.
- B. Fabricate metal connector plates to sizes, configurations, thicknesses, and anchorage details required to withstand design loads for types of joint designs indicated.
- C. Assemble truss members in design configuration indicated; use jigs or other means to ensure uniformity and accuracy of assembly with joints closely fitted to comply with tolerances in TPI 1.
 - 1. Position members to produce design camber indicated.
 - 1. Fabricate wood trusses within manufacturing tolerances in TPI 1.
- D. Connect truss members by metal connector plates located and securely embedded simultaneously in both sides of wood members by air or hydraulic press.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that supports and openings are ready to receive trusses.

3.2 ERECTION

- A. Install trusses in accordance with manufacturer's instructions, SBCA (BCSI); maintain a copy of applicable documents on site until installation is complete.
- B. Set members level and plumb, in correct position.
- C. Do not field-cut or alter structural members without approval of Architect.
- D. Install permanent bridging and bracing.

END OF SECTION 06 1753

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**SECTION 07 2100
THERMAL INSULATION**

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Extruded polystyrene foam-plastic board insulation.
 - 2. Thermal Insulation - blanket / batt insulation.
 - 3. Sound Control Insulation - blanket / batt insulation.
 - 4. Vapor retarders – walls and ceiling.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

1.4 QUALITY ASSURANCE

- A. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
- B. Fire-Test-Response Characteristics: Provide insulation and related materials with the fire-test-response characteristics indicated, as determined by testing identical products per test method indicated below by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify materials with appropriate markings of applicable testing and inspecting agency.
 - 1. Surface-Burning Characteristics: ASTM E 84.
 - 2. Fire-Resistance Ratings: ASTM E 119.
 - 3. Combustion Characteristics: ASTM E 136.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Protect insulation materials from physical damage and from deterioration due to moisture, soiling, and other sources. Store inside and in a dry location. Comply with manufacturer's written instructions for handling, storing, and protecting during installation.

- B. Protect foam-plastic board insulation as follows:
 - 1. Do not expose to sunlight except to necessary extent for period of installation and concealment.
 - 2. Protect against ignition at all times. Do not deliver foam-plastic board materials to Project site before installation time.
 - 3. Quickly complete installation and concealment of foam-plastic board insulation in each area of construction.

PART 2 PRODUCTS

2.1 FOAM-PLASTIC BOARD INSULATION

- A. Extruded Polystyrene Board Insulation, ASTM C578, Type IV, 25-psi minimum compressive strength; unfaced.
 - 1. Flame-Spread Index: Not more than 25 when tested in accordance with ASTM E84.
 - 2. Smoke-Developed Index: Not more than 450 when tested in accordance with ASTM E84.
 - 3. Fire Propagation Characteristics: Passes NFPA 285 testing as part of an approved assembly.
 - 4. Labeling: Provide identification of mark indicating R-value of each piece of insulation 12 inches and wider in width.
 - 5. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. DiversiFoam Products.
 - b. Dow Chemical Company (The).
 - c. Owens Corning.
- B. Adhesive for Bonding Insulation: Product with demonstrated capability to bond insulation securely to substrates without damaging insulation and substrates.
- C. Provided as Perimeter Insulation around entire building.

2.2 THERMAL BLANKET / BATT INSULATION

- A. Glass or other inorganic fibers and resinous binders formed into flexible blankets or batts.
- B. ASTM C665, Type I
- C. Thermal conductivity (k-value at 75 DegF): 0.27.

- D. Minimum thickness: R-19.
- E. Located in exterior walls.

2.3 VAPOR RETARDERS

- A. Fire – Rated, reinforced, 3 ply, class 1 material.
- B. Vapor-Retarder Tape: Pressure-sensitive tape of type recommended by vapor-retarder manufacturer for sealing joints and penetrations in vapor retarder.
- C. Single-Component Nonsag Urethane Sealant: ASTM C 920, Type I, Grade NS, Class 25, Use NT related to exposure, and Use O related to vapor-barrier-related substrates.
- D. Basis of Design: Griffolyn “TX-1200FR” – or equal.

2.4 ACCESSORIES

- A. Insulation for Miscellaneous Voids:
 - 1. Glass-Fiber Insulation: ASTM C764, Type II, loose fill; with maximum flame-spread and smoke-developed indexes of 5, per ASTM E84.
 - 2. Spray Polyurethane Foam Insulation: ASTM C1029, Type II, closed cell, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, per ASTM E84.

PART 3 EXECUTION

3.1 PREPARATION

- A. Clean substrates of substances that are harmful to insulation or vapor retarders, including removing projections capable of puncturing vapor retarders, or that interfere with insulation attachment.

3.2 INSTALLATION, GENERAL

- A. Comply with insulation manufacturer's written instructions applicable to products and applications indicated.
- B. Install insulation that is undamaged, dry, and unsoiled and that has not been left exposed to ice, rain, or snow at any time.
- C. Extend insulation to envelop entire area to be insulated. Cut and fit tightly around obstructions and fill voids with insulation. Remove projections that interfere with placement.
- D. Provide sizes to fit applications indicated and selected from manufacturer's standard thicknesses, widths, and lengths. Apply single layer of insulation units to produce thickness indicated unless multiple layers are otherwise shown or required to make up total thickness.

3.3 INSTALLATION OF BELOW-GRADE INSULATION

- A. Butt panels together for tight fit.
- B. On vertical footing and foundation wall surfaces, set insulation units using manufacturer's recommended adhesive according to manufacturer's written instructions.
- C. On horizontal surfaces under slabs, loosely lay insulation units according to manufacturer's written instructions. Stagger end joints and tightly abut insulation units.

3.4 INSTALLATION OF INSULATION FOR FRAMED CONSTRUCTION

- A. Apply insulation units to substrates by method indicated, complying with manufacturer's written instructions. If no specific method is indicated, bond units to substrate with adhesive or use mechanical anchorage to provide permanent placement and support of units.
- B. Blanket Insulation: Install in cavities formed by framing members according to the following requirements:
 - 1. Use insulation widths and lengths that fill the cavities formed by framing members. If more than one length is required to fill the cavities, provide lengths that will produce a snug fit between ends.
 - 2. Place insulation in cavities formed by framing members to produce a friction fit between edges of insulation and adjoining framing members.
 - 3. Maintain 3-inch clearance of insulation around recessed lighting fixtures not rated for or protected from contact with insulation.
 - 4. Attics: Install eave ventilation troughs between roof framing members in insulated attic spaces at vented eaves.
 - 5. For metal-framed wall cavities where cavity heights exceed 96 inches, support unfaced blankets mechanically and support faced blankets by taping flanges of insulation to flanges of metal studs.
- C. Miscellaneous Voids: Install insulation in miscellaneous voids and cavity spaces where required to prevent gaps in insulation using the following materials:
 - 1. Glass-Fiber Insulation: Compact to approximately 40 percent of normal maximum volume equaling a density of approximately 2.5 lb/cu. ft.
 - 2. Spray Polyurethane Insulation: Apply according to manufacturer's written instructions.

3.5 INSTALLATION OF VAPOR RETARDERS

- A. Place vapor retarders on side of construction indicated on Drawings. Extend vapor retarders to extremities of areas to protect from vapor transmission. Secure vapor retarders in place with

adhesives or other anchorage system as indicated. Extend vapor retarders to cover miscellaneous voids in insulated substrates, including those filled with loose-fiber insulation.

- B. Seal joints caused by pipes, conduits, electrical boxes, and similar items penetrating vapor retarders with vapor-retarder tape to create an airtight seal between penetrating objects and vapor retarders.
- C. Repair tears or punctures in vapor retarders immediately before concealment by other work. Cover with vapor-retarder tape or another layer of vapor retarders.

3.6 PROTECTION

- A. Protect installed insulation and vapor retarders from damage due to harmful weather exposures, physical abuse, and other causes. Provide temporary coverings or enclosures where insulation is subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.

END OF SECTION 07 2100

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**SECTION 07 2500
WEATHER BARRIER**

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Building wrap.
 - 2. Flexible flashing.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. For building wrap, include data on air and water-vapor permeance based on testing according to referenced standards.

PART 2 PRODUCTS

2.1 WATER-RESISTIVE BARRIER

- A. Building Wrap: ASTM E 1677, Type I air barrier; with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, when tested according to ASTM E 84; UV stabilized; and acceptable to authorities having jurisdiction.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Dow Chemical Company (The); Styrofoam Weathermate Plus Brand Housewrap.
 - b. DuPont (E. I. du Pont de Nemours and Company); Tyvek CommercialWrap.
 - c. Raven Industries Inc.; Fortress Pro Weather Protective Barrier.
 - 2. Water-Vapor Permeance: Not less than 20 perms per ASTM E 96/E 96M, Desiccant Method (Procedure A).
 - 3. Allowable UV Exposure Time: Not less than three months.
- B. Building-Wrap Tape: Pressure-sensitive plastic tape recommended by building-wrap manufacturer for sealing joints and penetrations in building wrap.

2.2 MISCELLANEOUS MATERIALS

- A. Flexible Flashing: Composite, self-adhesive, flashing product consisting of a pliable, butyl rubber compound, bonded to a high-density polyethylene film, aluminum foil, or spunbonded polyolefin to produce an overall thickness of not less than 0.040 inch.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
- B. Primer for Flexible Flashing: Product recommended by manufacturer of flexible flashing for substrate.
- C. Nails and Staples: ASTM F 1667.

PART 3 EXECUTION

3.1 WATER-RESISTIVE BARRIER INSTALLATION

- A. Cover exposed exterior surface of sheathing with water-resistive barrier securely fastened to framing immediately after sheathing is installed.
- B. Cover sheathing with water-resistive barrier as follows:
 - 1. Cut back barrier 1/2 inch on each side of the break in supporting members at expansion- or control-joint locations.
 - 2. Apply barrier to cover vertical flashing with a minimum 4-inch overlap unless otherwise indicated.
- C. Building Wrap: Comply with manufacturer's written instructions.
 - 1. Seal seams, edges, fasteners, and penetrations with tape.
 - 2. Extend into jambs of openings and seal corners with tape.

3.2 FLEXIBLE FLASHING INSTALLATION

- A. Apply flexible flashing where indicated to comply with manufacturer's written instructions.
 - 1. Prime substrates as recommended by flashing manufacturer.
 - 2. Lap seams and junctures with other materials at least 4 inches except that at flashing flanges of other construction, laps need not exceed flange width.
 - 3. Lap flashing over water-resistive barrier at bottom and sides of openings.
 - 4. Lap water-resistive barrier over flashing at heads of openings.

5. After flashing has been applied, roll surfaces with a hard rubber or metal roller to ensure that flashing is completely adhered to substrates.

END OF SECTION 07 2500

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**SECTION 07 4113
FORMED METAL PANELS**

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Exposed-fastener, lap-seam, metal roof panels.
 - 2. Exposed-fastener, lap-seam, metal wall panels.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type of panel and accessory.
- B. Shop Drawings:
 - 1. Include fabrication and installation layouts of metal panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, and accessories; and special details.
- C. Samples for Initial Selection: For each type of metal panel indicated with factory-applied color finishes.
 - 1. Include similar Samples of trim and accessories involving color selection.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Deliver components, metal panels, and other manufactured items so as not to be damaged or deformed. Package metal panels for protection during transportation and handling.
- B. Unload, store, and erect metal panels in a manner to prevent bending, warping, twisting, and surface damage.
- C. Stack metal panels horizontally on platforms or pallets, covered with suitable weathertight and ventilated covering. Store metal panels to ensure dryness, with positive slope for drainage of water. Do not store metal panels in contact with other materials that might cause staining, denting, or other surface damage.
- D. Retain strippable protective covering on metal panels during installation.

- E. Copper Panels: Wear gloves when handling to prevent fingerprints and soiling of surface.

1.5 FIELD CONDITIONS

- A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit assembly of metal panels to be performed according to manufacturers' written instructions and warranty requirements.

1.6 COORDINATION

- A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.
- B. Coordinate metal panel installation with rain drainage work, flashing, trim, construction of soffits, and other adjoining work to provide a leakproof, secure, and noncorrosive installation.

1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal panel systems that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures including rupturing, cracking, or puncturing.
 - b. Deterioration of metals and other materials beyond normal weathering.
 - 2. Warranty Period: Two years from date of Substantial Completion.
- B. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.
 - 1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:
 - a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
 - b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
 - c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
 - 2. Finish Warranty Period: 20 years from date of Substantial Completion.

PART 2 PRODUCTS

2.1 EXPOSED-FASTENER, LAP-SEAM, METAL ROOF PANELS

- A. General: Provide factory-formed metal panels designed to be installed by lapping side edges of adjacent panels and mechanically attaching panels to supports using exposed fasteners in side laps. Include accessories required for weathertight installation.
- B. Tapered-Rib-Profile, Exposed-Fastener Metal Panels: Formed with raised, trapezoidal major ribs and intermediate stiffening ribs symmetrically spaced between major ribs.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Berridge Manufacturing Company.
 - b. CENTRIA Architectural Systems.
 - c. Fabral.
 - d. Firestone Metal Products, LLC.
 - e. Petersen Aluminum Corporation.
 - 2. Metallic-Coated Steel Sheet: Zinc-coated (galvanized) steel sheet complying with ASTM A 653/A 653M, G90 (Z275) coating designation, or aluminum-zinc alloy-coated steel sheet complying with ASTM A 792/A 792M, Class AZ50 (Class AZM150) coating designation; structural quality. Prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
 - a. Nominal Thickness: 0.028 inch (24 ga.).
 - b. Exterior Finish: Two-coat fluoropolymer.
 - c. Color: As selected by Architect from manufacturer's full range.
 - 3. Major-Rib Spacing: 9 inches o.c.
 - 4. Panel Coverage: 36 inches.
 - 5. Panel Height: 0.75 inch.

2.2 EXPOSED-FASTENER, LAP-SEAM, METAL WALL PANELS

- A. General: Provide factory-formed metal panels designed to be installed by lapping side edges of adjacent panels and mechanically attaching panels to supports using exposed fasteners in side laps. Include accessories required for weathertight installation.

- B. Tapered-Rib-Profile, Exposed-Fastener Metal Panels: Formed with raised, trapezoidal major ribs and intermediate stiffening ribs symmetrically spaced between major ribs.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Berridge Manufacturing Company.
 - b. CENTRIA Architectural Systems.
 - c. Fabral.
 - d. Firestone Metal Products, LLC.
 - e. Petersen Aluminum Corporation.
 2. Metallic-Coated Steel Sheet: Zinc-coated (galvanized) steel sheet complying with ASTM A 653/A 653M, G90 (Z275) coating designation, or aluminum-zinc alloy-coated steel sheet complying with ASTM A 792/A 792M, Class AZ50 (Class AZM150) coating designation; structural quality. Prepainted by the coil-coating process to comply with ASTM A 755/A 755M.
 - a. Nominal Thickness: 0.022 inch (26 ga.).
 - b. Exterior Finish: Two-coat fluoropolymer.
 - c. Color: As selected by Architect from manufacturer's full range.
 3. Major-Rib Spacing: 9 inches o.c.
 4. Panel Coverage: 36 inches.
 5. Panel Height: 0.75 inch.

2.3 UNDERLAYMENT MATERIALS

- A. Self-Adhering, High-Temperature Underlayment: Provide self-adhering, cold-applied, sheet underlayment, a minimum of 30 mils thick, specifically designed to withstand high metal temperatures beneath metal roofing. Provide primer when recommended by underlayment manufacturer.
1. Thermal Stability: Stable after testing at 220 deg F; ASTM D 1970.
 2. Low-Temperature Flexibility: Passes after testing at minus 20 deg F; ASTM D 1970.
 3. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

- a. Carlisle Residential, a division of Carlisle Construction Materials; WIP 300HT.
 - b. Grace Construction Products, a unit of W. R. Grace & Co.; Grace Ice and Water Shield HT Ultra.
 - c. Owens Corning; WeatherLock Specialty Tile and Metal Underlayment.
- B. Slip Sheet: Manufacturer's recommended slip sheet, of type required for application.

2.4 MISCELLANEOUS MATERIALS

- A. Miscellaneous Metal Sub-framing and Furring: ASTM C 645; cold-formed, metallic-coated steel sheet, ASTM A 653/A 653M, G90 (Z275 hot-dip galvanized) coating designation or ASTM A 792/A 792M, Class AZ50 (Class AZM150) aluminum-zinc-alloy coating designation unless otherwise indicated. Provide manufacturer's standard sections as required for support and alignment of metal panel system.
- B. Panel Accessories: Provide components required for a complete, weathertight panel system including trim, copings, fasciae, mullions, sills, corner units, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal panels unless otherwise indicated.
- 1. Closures: Provide closures at eaves and ridges, fabricated of same metal as metal panels.
 - 2. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.
 - 3. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch thick, flexible closure strips; cut or pre-molded to match metal panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.
- C. Flashing and Trim: Provide flashing and trim formed from same material as metal panels as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, eaves, rakes, corners, bases, framed openings, ridges, fasciae, and fillers. Finish flashing and trim with same finish system as adjacent metal panels.
- D. Panel Fasteners: Self-tapping screws designed to withstand design loads. Provide exposed fasteners with heads matching color of metal panels by means of plastic caps or factory-applied coating. Provide EPDM or PVC sealing washers for exposed fasteners.
- E. Panel Sealants: Provide sealant types recommended by manufacturer that are compatible with panel materials, are non-staining, and do not damage panel finish.
- 1. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, non-sag, nontoxic, non-staining tape 1/2 inch wide and 1/8 inch thick.

2. Joint Sealant: ASTM C 920; elastomeric polyurethane or silicone sealant; of type, grade, class, and use classifications required to seal joints in metal panels and remain weathertight; and as recommended in writing by metal panel manufacturer.
3. Butyl-Rubber-Based, Solvent-Release Sealant: ASTM C 1311.

2.5 FABRICATION

- A. General: Fabricate and finish metal panels and accessories at the factory, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.
- B. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of panel.
- C. Fabricate metal panel joints with factory-installed captive gaskets or separator strips that provide a weathertight seal and prevent metal-to-metal contact, and that minimize noise from movements.
- D. Sheet Metal Flashing and Trim: Fabricate flashing and trim to comply with manufacturer's recommendations and recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of item indicated.
 1. Form exposed sheet metal accessories that are without excessive oil canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.
 2. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.
 3. Seams for Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.
 4. Sealed Joints: Form non-expansion, but movable, joints in metal to accommodate sealant and to comply with SMACNA standards.
 5. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of accessories exposed to view.
 6. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal recommended in writing by metal panel manufacturer.
 - a. Size: As recommended by SMACNA's "Architectural Sheet Metal Manual" or metal panel manufacturer for application, but not less than thickness of metal being secured.

2.6 FINISHES

- A. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in same piece are unacceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- C. Steel Panels and Accessories:
 - 1. Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, metal panel supports, and other conditions affecting performance of the Work.
 - 1. Examine primary and secondary roof framing to verify that rafters, purlins, angles, channels, and other structural panel support members and anchorages have been installed within alignment tolerances required by metal roof panel manufacturer.
 - 2. Examine solid roof sheathing to verify that sheathing joints are supported by framing or blocking and that installation is within flatness tolerances required by metal roof panel manufacturer.
 - a. Verify that air- or water-resistive barriers have been installed over sheathing or backing substrate to prevent air infiltration or water penetration.
- B. Examine roughing-in for components and systems penetrating metal panels to verify actual locations of penetrations relative to seam locations of metal panels before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Miscellaneous Supports: Install sub-framing, furring, and other miscellaneous panel support members and anchorages according to ASTM C 754 and metal panel manufacturer's written recommendations.

3.3 UNDERLAYMENT INSTALLATION

- A. Self-Adhering Sheet Underlayment: Apply primer if required by manufacturer. Comply with temperature restrictions of underlayment manufacturer for installation. Apply at locations indicated below, wrinkle free, in shingle fashion to shed water, and with end laps of not less than 6 inches staggered 24 inches between courses. Overlap side edges not less than 3-1/2 inches. Roll laps with roller. Cover underlayment within 14 days.
 - 1. Apply over the entire roof surface.
- B. Slip Sheet: Apply slip sheet over underlayment before installing metal roof panels.
- C. PART 55 Flashings: Install flashings to cover underlayment to comply with requirements specified in Section 076200 "Sheet Metal Flashing and Trim."

3.4 METAL PANEL INSTALLATION

- A. General: Install metal panels according to manufacturer's written instructions in orientation, sizes, and locations indicated. Install panels perpendicular to supports unless otherwise indicated. Anchor metal panels and other components of the Work securely in place, with provisions for thermal and structural movement.
 - 1. Shim or otherwise plumb substrates receiving metal panels.
 - 2. Flash and seal metal panels at perimeter of all openings. Fasten with self-tapping screws. Do not begin installation until air or water-resistive barriers and flashings that are concealed by metal panels are installed.
 - 3. Install screw fasteners in predrilled holes.
 - 4. Locate and space fastenings in uniform vertical and horizontal alignment.
 - 5. Install flashing and trim as metal panel work proceeds.
 - 6. Locate panel splices over, but not attached to, structural supports. Stagger panel splices and end laps to avoid a four-panel lap splice condition.
 - 7. Align bottoms of metal panels and fasten with blind rivets, bolts, or self-tapping screws. Fasten flashings and trim around openings and similar elements with self-tapping screws.
 - 8. Provide weathertight escutcheons for pipe- and conduit-penetrating panels.
- B. Fasteners:
 - 1. Steel Panels: Use stainless-steel fasteners for surfaces exposed to the exterior; use galvanized-steel fasteners for surfaces exposed to the interior.

- C. Metal Protection: Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action as recommended in writing by metal panel manufacturer.
- D. Lap-Seam Metal Panels: Fasten metal panels to supports with fasteners at each lapped joint at location and spacing recommended by manufacturer.
 - 1. Lap ribbed or fluted sheets one full rib. Apply panels and associated items true to line for neat and weathertight enclosure.
 - 2. Provide metal-backed washers under heads of exposed fasteners bearing on weather side of metal panels.
 - 3. Locate and space exposed fasteners in uniform vertical and horizontal alignment. Use proper tools to obtain controlled uniform compression for positive seal without rupture of washer.
 - 4. Install screw fasteners with power tools having controlled torque adjusted to compress washer tightly without damage to washer, screw threads, or panels. Install screws in predrilled holes.
 - 5. Flash and seal panels with weather closures at perimeter of all openings.
 - 6. Watertight Installation:
 - a. Apply a continuous ribbon of sealant or tape to seal lapped joints of metal panels, using sealant or tape as recommend by manufacturer on side laps of nesting-type panels and elsewhere as needed to make panels watertight.
 - b. Provide sealant or tape between panels and protruding equipment, vents, and accessories.
 - c. At panel splices, nest panels with minimum 6-inch (152-mm) end lap, sealed with sealant and fastened together by interlocking clamping plates.
- E. Accessory Installation: Install accessories with positive anchorage to building and weathertight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.
 - 1. Install components required for a complete metal panel system including trim, copings, corners, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items. Provide types indicated by metal panel manufacturer; or, if not indicated, provide types recommended in writing by metal panel manufacturer.
- F. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level. Install work with laps, joints, and seams that are permanently watertight.

1. Install exposed flashing and trim that is without buckling and tool marks, and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and achieve waterproof performance.
2. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet with no joints allowed within 24 inches of corner or intersection. Where lapped expansion provisions cannot be used or would not be sufficiently waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with mastic sealant (concealed within joints).

3.5 ERECTION TOLERANCES

- A. Installation Tolerances: Shim and align metal panel units within installed tolerance of 1/4 inch in 20 feet on slope and location lines and within 1/8-inch offset of adjoining faces and of alignment of matching profiles.

3.6 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect completed metal panel installation, including accessories. Report results in writing.
- B. Remove and replace applications where tests and inspections indicate that they do not comply with specified requirements.
- C. Additional tests and inspections, at Contractor's expense, are performed to determine compliance of replaced or additional work with specified requirements.
- D. Prepare test and inspection reports.

3.7 CLEANING AND PROTECTION

- A. Remove temporary protective coverings and strippable films, if any, as metal panels are installed, unless otherwise indicated in manufacturer's written installation instructions. On completion of metal panel installation, clean finished surfaces as recommended by metal panel manufacturer. Maintain in a clean condition during construction.
- B. Replace metal panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION 07 4113

SECTION 07 6200
SHEET METAL FLASHING AND TRIM

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Formed roof-drainage sheet metal fabrications.
 - a. Gutters and Downspouts.
 - 2. Formed low-slope roof sheet metal fabrications.
 - a. Fascia and Soffits
 - 3. Formed wall sheet metal fabrications.
- B. Related Requirements:
 - 1. Section 061000 "Rough Carpentry" for wood nailers, curbs, and blocking.

1.3 COORDINATION

- A. Coordinate sheet metal flashing and trim layout and seams with sizes and locations of penetrations to be flashed, and joints and seams in adjacent materials.
- B. Coordinate sheet metal flashing and trim installation with adjoining roofing and wall materials, joints, and seams to provide leakproof, secure, and noncorrosive installation.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each manufactured product and accessory.
- B. Shop Drawings: For sheet metal flashing and trim.
 - 1. Include identification of material, thickness, weight, and finish for each item and location in Project.
 - 2. Include details for forming, including profiles, shapes, seams, and dimensions.

3. Include details for joining, supporting, and securing, including layout and spacing of fasteners, cleats, clips, and other attachments. Include pattern of seams.
 4. Include details of termination points and assemblies.
 5. Include details of edge conditions, including eaves, ridges, valleys, rakes, crickets, and counterflashings as applicable.
 6. Include details of special conditions.
 7. Include details of connections to adjoining work.
- C. Samples for Verification: For each type of exposed finish.
1. Sheet Metal Flashing: Standard Color Selections.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For fabricator.
- B. Sample Warranty: For special warranty.

1.6 QUALITY ASSURANCE

- A. Fabricator Qualifications: Employs skilled workers who custom fabricates sheet metal flashing and trim similar to that required for this Project and whose products have a record of successful in-service performance.
 1. For copings and roof edge flashings that are ANSI/SPRI/FM 4435/ES-1 tested, shop shall be listed as able to fabricate required details as tested and approved.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Do not store sheet metal flashing and trim materials in contact with other materials that might cause staining, denting, or other surface damage. Store sheet metal flashing and trim materials away from uncured concrete and masonry.
- B. Protect strippable protective covering on sheet metal flashing and trim from exposure to sunlight and high humidity, except to extent necessary for period of sheet metal flashing and trim installation.

1.8 WARRANTY

- A. Special Warranty on Finishes: Manufacturer agrees to repair finish or replace sheet metal flashing and trim that shows evidence of deterioration of factory-applied finishes within specified warranty period.
 1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:

- a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
 - b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
 - c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
2. Finish Warranty Period: 20 years from date of Substantial Completion.

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General: Sheet metal flashing and trim assemblies shall withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Completed sheet metal flashing and trim shall not rattle, leak, or loosen, and shall remain watertight.
- B. Sheet Metal Standard for Flashing and Trim: Comply with NRCA's "The NRCA Roofing Manual" requirements for dimensions and profiles shown unless more stringent requirements are indicated.
- C. SPRI Wind Design Standard: Manufacture and install copings tested according to SPRI ES-1 and capable of resisting the following design pressure:
 1. Design Pressure: Resulting from Wind Speeds of 90 MPH.
- D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes to prevent buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 SHEET METALS

- A. General: Protect mechanical and other finishes on exposed surfaces from damage by applying strippable, temporary protective film before shipping.
- B. Metallic-Coated Steel Sheet: Provide zinc-coated (galvanized) steel sheet according to ASTM A 653/A 653M, G90 coating designation or aluminum-zinc alloy-coated steel sheet according to ASTM A 792/A 792M, Class AZ50 coating designation, Grade 40; prepainted by coil-coating process to comply with ASTM A 755/A 755M.
 1. Surface: Smooth, flat.
 2. Exposed Coil-Coated Finish:

- a. Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
3. Color: As selected by Architect from manufacturer's full range.
4. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with minimum total dry film thickness of 0.5 mil.

2.3 MISCELLANEOUS MATERIALS

- A. General: Provide materials and types of fasteners, protective coatings, sealants, and other miscellaneous items as required for complete sheet metal flashing and trim installation and as recommended by manufacturer of primary sheet metal or manufactured item
- B. Fasteners: Wood screws, annular threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners designed to withstand design loads and recommended by manufacturer of primary sheet metal or manufactured item.
 1. General: Blind fasteners or self-drilling screws, gasketed, with hex-washer head.
 - a. Exposed Fasteners: Heads matching color of sheet metal using plastic caps or factory-applied coating. Provide metal-backed EPDM or PVC sealing washers under heads of exposed fasteners bearing on weather side of metal.
 - b. Blind Fasteners: High-strength aluminum or stainless-steel rivets suitable for metal being fastened.
 - c. Spikes and Ferrules: Same material as gutter; with spike with ferrule matching internal gutter width.
 2. Fasteners for Zinc-Coated (Galvanized) Aluminum-Zinc Alloy-Coated Steel Sheet: Series 300 stainless steel or hot-dip galvanized steel according to ASTM A 153/A 153M or ASTM F 2329.
- C. Sealant Tape: Pressure-sensitive, 100 percent solids, polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch wide and 1/8 inch thick.
- D. Elastomeric Sealant: ASTM C 920, elastomeric polyurethane polymer sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.
- E. Bituminous Coating: Cold-applied asphalt emulsion according to ASTM D 1187.

2.4 FABRICATION, GENERAL

- A. Custom fabricate sheet metal flashing and trim to comply with details indicated and recommendations in cited sheet metal standard that apply to design, dimensions, geometry, metal thickness, and other characteristics of item required.
 - 1. Fabricate sheet metal flashing and trim in shop to greatest extent possible.
 - 2. 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.
 - 3. Verify shapes and dimensions of surfaces to be covered and obtain field measurements for accurate fit before shop fabrication.
 - 4. Form sheet metal flashing and trim to fit substrates without excessive oil-canning, buckling, and tool marks; true to line, levels, and slopes; and with exposed edges folded back to form hems.
 - 5. Conceal fasteners and expansion provisions where possible. Do not use exposed fasteners on faces exposed to view.
- B. Fabrication Tolerances: Fabricate sheet metal flashing and trim that is capable of installation to a tolerance of 1/4 inch in 20 feet on slope and location lines indicated on Drawings and within 1/8-inch offset of adjoining faces and of alignment of matching profiles.
 - 1. Form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with butyl sealant concealed within joints.
- C. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal.
- D. Fabricate cleats and attachment devices of sizes as recommended by cited sheet metal standard for application, but not less than thickness of metal being secured.
- E. Do not use graphite pencils to mark metal surfaces.

2.5 ROOF-DRAINAGE SHEET METAL FABRICATIONS

- A. Hanging Gutters: Fabricate to cross section required, complete with end pieces, outlet tubes, and other accessories as required. Fabricate / Install Seamless gutter system. Furnish flat-stock gutter brackets and flat-stock gutter spacers and straps fabricated from same metal as gutters, of size recommended by cited sheet metal standard but with thickness not less than twice the gutter thickness. Fabricate expansion joints, expansion-joint covers, gutter bead reinforcing bars, and gutter accessories from same metal as gutters. Shop fabricates interior and exterior corners.
 - 1. Expansion Joints: Lap type.
 - 2. Accessories: Wire-ball downspout strainer.

3. Large size Gutters with Girth up to 15 Inches: Fabricate from the following materials:
 - a. Zinc Coated - Galvanized Steel: 0.022 inch thick (26 ga.).
 4. Gutters shall slope to outlet for positive drainage – zero slope not allowed.
 5. Seamless System.
- B. Downspouts: Fabricate open-face downspouts to dimensions indicated, complete with mitered elbows. Furnish with metal hangers from same material as downspouts and anchors. Shop fabricate elbows.
1. Fabricate from the following materials:
 - a. Zinc coated - Galvanized Steel: 0.022 inch thick (26 ga.).
 2. Size: 4" Deep x 6" Wide.
 3. Provide stiffeners and wall mount brackets at top and bottom of vertical run and every 4'-0" max spacing between.

2.6 METAL SOFFIT PANELS

- A. General: Provide factory-formed metal soffit panels designed to be installed by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners and factory-applied sealant in side laps. Include accessories required for weathertight installation.
- B. Flush-Profile Metal Soffit Panels: Perforated / vented panels formed with vertical panel edges and intermediate stiffening ribs symmetrically spaced between panel edges; with flush joint between panels.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Berridge Manufacturing Company.
 - b. CENTRIA Architectural Systems.
 - c. Metal Sales Manufacturing Corporation.
 - d. Petersen Aluminum Corporation.
 2. Material: Zinc-coated (galvanized) steel sheet, 0.022-inch nominal thickness (26 ga.).
 - a. Exterior Finish: 2-coat fluoropolymer.
 - b. Color: As selected by Architect from Manufacturer's full range.

3. Panel Coverage: Refer to Drawings.
4. Panel Height: 1.0 inch.
5. Sealant: Factory applied within interlocking joint.

2.7 FASCIA

- A. General: Formed from 0.022 inch thick (26 ga.), zinc coated (galvanized) steel sheet prepainted with coil coating.
- B. Material: Zinc-coated (galvanized) steel sheet, 0.0209 inch thick.
 1. Exterior Finish: 2-coat Fluoropolymer.
 - a. Color: As selected by Architect from Manufacturer's full range.
 2. Fascia Panels shall provide breaks as necessary to avoid "oil-canning".

2.8 WALL SHEET METAL FABRICATIONS

- A. Through-Wall Flashing: Fabricate continuous flashings in minimum 96-inch long, but not exceeding 12-foot long, sections, and at shelf angles. Fabricate discontinuous lintel, sill, and similar flashings to extend 6 inches beyond each side of wall openings; and form with 2-inch high, end dams. Fabricate from the following materials:
 1. Zinc-Tin Alloy-Coated Copper: 16 oz./sq. ft. thick
- B. Opening Flashings in Frame Construction: Fabricate head, sill, jamb, and similar flashings to extend 4 inches beyond wall openings. Form head and sill flashing with 2-inch high, end dams. Fabricate from the following materials:
 1. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch thick.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, substrate, and other conditions affecting performance of the Work.
 1. Verify compliance with requirements for installation tolerances of substrates.
 2. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and securely anchored.
 3. Verify that air- or water-resistant barriers have been installed over sheathing or backing substrate to prevent air infiltration or water penetration.

- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. General: Anchor sheet metal flashing and trim and other components of the Work securely in place, with provisions for thermal and structural movement. Use fasteners, solder, protective coatings, separators, sealants, and other miscellaneous items as required to complete sheet metal flashing and trim system.
1. Install sheet metal flashing and trim true to line, levels, and slopes. Provide uniform, neat seams with minimum exposure of solder, welds, and sealant.
 2. Install sheet metal flashing and trim to fit substrates and to result in watertight performance. Verify shapes and dimensions of surfaces to be covered before fabricating sheet metal.
 3. Use continuous cleats.
 4. Install exposed sheet metal flashing and trim with limited oil canning, and free of buckling and tool marks.
 5. Torch cutting of sheet metal flashing and trim is not permitted.
 6. Do not use graphite pencils to mark metal surfaces.
- B. Metal Protection: Where dissimilar metals contact each other, or where metal contacts pressure-treated wood or other corrosive substrates, protect against galvanic action or corrosion by installing underlayment over corrosive substrates or dissimilar materials, prior to metal flashing installation, as recommended by sheet metal manufacturer.
1. Underlayment: Where installing sheet metal flashing and trim directly on cementitious or wood substrates or dissimilar metals, cover substrates or dissimilar metal with underlayment, prior to metal flashing installation.
- C. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at maximum of 10 feet with no joints within 24 inches of corner or intersection.
- D. Fasteners: Use fastener sizes that penetrate wood blocking or sheathing not less than 1-1/4 inches for nails and not less than 3/4 inch for wood screws.
- E. Conceal fasteners and expansion provisions where possible in exposed work and locate to minimize possibility of leakage. Cover and seal fasteners and anchors as required for a tight installation.
- F. Seal joints as required for watertight construction.

1. Prepare joints and apply sealants to comply with requirements in Section 079200 "Joint Sealants."

3.3 ROOF-DRAINAGE SYSTEM INSTALLATION

- A. General: Install sheet metal roof-drainage items to produce complete roof-drainage system according to cited sheet metal standard unless otherwise indicated. Coordinate installation of roof perimeter flashing with installation of roof-drainage system.
- B. Downspouts: Join sections with 1-1/2-inch telescoping joints.
 1. Provide hangers with fasteners designed to hold downspouts securely to walls. Locate hangers at top and bottom and at approximately 60 inches o.c.
 2. Connect downspouts to underground drainage system.

3.4 ROOF FLASHING INSTALLATION

- A. General: Install sheet metal flashing and trim to comply with performance requirements and cited sheet metal standard. Provide concealed fasteners where possible, and set units true to line, levels, and slopes. Install work with laps, joints, and seams that are permanently watertight and weather resistant.

3.5 INSTALLATION OF WALL FLASHINGS

- A. Install sheet metal wall flashing to intercept and exclude penetrating moisture in accordance with cited sheet metal standard unless otherwise indicated. Coordinate installation of wall flashing with installation of wall-opening components such as windows, doors, and louvers.
- B. Opening Flashings in Frame Construction: Install continuous head, sill, jamb, and similar flashings to extend 4 inches beyond wall openings.

3.6 METAL SOFFIT PANEL INSTALLATION

- A. In addition to complying with requirements in "Metal Roof Panel Installation, General" Article, install metal soffit panels to comply with requirements in this article.
- B. Metal Soffit Panels: Provide metal soffit panels full width of soffits. Install panels perpendicular to support framing.
 1. Flash and seal panels with weather closures where metal soffit panels meet walls and at perimeter of all openings.
- C. Metal Fascia Panels: Align bottom of panels and fasten with blind rivets, bolts, or self-tapping screws. Flash and seal panels with weather closures where fasciae meet soffits, along lower panel edges, and at perimeter of all openings.

3.7 ERECTION TOLERANCES

- A. Installation Tolerances: Shim and align sheet metal flashing and trim within installed tolerance of 1/4 inch in 20 feet on slope and location lines indicated on Drawings and within 1/8-inch offset of adjoining faces and of alignment of matching profiles.

3.8 CLEANING AND PROTECTION

- A. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.
- B. Clean off excess sealants.
- C. Remove temporary protective coverings and strippable films as sheet metal flashing and trim are installed unless otherwise indicated in manufacturer's written installation instructions. On completion of sheet metal flashing and trim installation, remove unused materials and clean finished surfaces as recommended by sheet metal flashing and trim manufacturer. Maintain sheet metal flashing and trim in 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 07 6200

**SECTION 07 9200
JOINT SEALANTS**

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 PERFORMANCE REQUIREMENTS

- A. Provide elastomeric joint sealants that establish and maintain watertight and airtight continuous joint seals without staining or deteriorating joint substrates.

1.3 SUBMITTALS

- A. Product Data: For each joint-sealant product indicated.
- B. Samples for Initial Selection: Manufacturer's color charts consisting of strips of cured sealants showing the full range of colors available for each product exposed to view.
- C. Product Certificates: For each type of joint sealant and accessory, signed by product manufacturer.
- D. Compatibility and Adhesion Test Reports: From sealant manufacturer, indicating the following:
 - 1. Materials forming joint substrates and joint-sealant backings have been tested for compatibility and adhesion with joint sealants.
 - 2. Interpretation of test results and written recommendations for primers and substrate preparation needed for adhesion.
- E. Product Test Reports: Based on comprehensive testing of product formulations performed by a qualified testing agency, indicating that sealants comply with requirements.
- F. Warranties: Special warranties specified in this Section.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized Installer who is approved or licensed for installation of elastomeric sealants required for this Project.
- B. Source Limitations: Obtain each type of joint sealant through one source from a single manufacturer.
- C. Product Testing: Obtain test results for "Product Test Reports" Paragraph in "Submittals" Article from a qualified testing agency based on testing current sealant formulations within a 36-month period preceding the commencement of the Work.

1. Testing Agency Qualifications: An independent testing agency qualified according to ASTM C 1021 to conduct the testing indicated, as documented according to ASTM E 548.
2. Test elastomeric joint sealants for compliance with requirements specified by reference to ASTM C 920, and where applicable, to other standard test methods.
3. Test elastomeric joint sealants according to SWRI's Sealant Validation Program for compliance with requirements specified by reference to ASTM C 920 for adhesion and cohesion under cyclic movement, adhesion-in-peel, and indentation hardness.
4. Test other joint sealants for compliance with requirements indicated by referencing standard specifications and test methods.

1.5 PROJECT CONDITIONS

- A. Do not proceed with installation of joint sealants under the following conditions:
 1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F.
 2. When joint substrates are wet.
 3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
 4. Contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

1.6 WARRANTY

- A. Special Installer's Warranty: Installer's standard form in which Installer agrees to repair or replace elastomeric joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.
 1. Warranty Period: Five years from date of Substantial Completion.
- B. Special Manufacturer's Warranty: Manufacturer's standard form in which elastomeric sealant manufacturer agrees to furnish elastomeric joint sealants to repair or replace those that do not comply with performance and other requirements specified in this Section within specified warranty period.
 1. Warranty Period: One year from date of Substantial Completion.
- C. Special warranties specified in this Article exclude deterioration or failure of elastomeric joint sealants from the following:

1. Movement of the structure resulting in stresses on the sealant exceeding sealant manufacturer's written specifications for sealant elongation and compression caused by structural settlement or errors attributable to design or construction.
2. Disintegration of joint substrates from natural causes exceeding design specifications.
3. Mechanical damage caused by individuals, tools, or other outside agents.
4. Changes in sealant appearance caused by accumulation of dirt or other atmospheric contaminants.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products listed in other Part 2 articles.

2.2 MATERIALS, GENERAL

- A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by sealant manufacturer, based on testing and field experience.

2.3 ELASTOMERIC JOINT SEALANTS

- A. Elastomeric Sealants: Comply with ASTM C 920 and other requirements indicated for each liquid-applied chemically curing sealant specified, including those referencing ASTM C 920 classifications for type, grade, class, and uses related to exposure and joint substrates.
- B. Stain-Test-Response Characteristics: Where elastomeric sealants are specified to be non-staining to porous substrates, provide products that have undergone testing according to ASTM C 1248 and have not stained porous joint substrates indicated for Project.
- C. Single-component Nonsag Polyurethane Sealant ES-1: CMU, Doors & Window frames, Gypsum Board, and most building components.
 1. Product:
 - a. Masterseal; NP1.
 2. Type and Grade: S (Single-component) and NS (nonsag).
 3. Class: 35.
 4. Use Related to Exposure: NT (nontraffic).
 5. Uses Related to Joint Substrates:

- a. Interior and exterior applications, above and below grade applications, immersed in water and expansion joints.
 - b. Precast Concrete Panels
 - c. Concrete Masonry;
 - d. Aluminum and Wood window frames
 - e. Roofing systems, fascia and soffits
- D. Single-Component Mildew-Resistant Silicone Sealant ES-2: Solid Surface sink counters and plumbing fixtures
- 1. Product:
 - a. Masterseal; 123NS
 - 2. Type and Grade: S (single component) and NS (non-sag).
 - 3. Non-staining.
 - 4. Class: 25.
 - 5. Use Related to Exposure: NT (nontraffic).
 - 6. Uses Related to Joint Substrates: G, A, and, as applicable to joint substrates indicated, O.
 - a. Plastic Laminate;
 - b. Porcelain Enamel (Plumbing Fixtures)
 - c. Natural Stone, CMU, Concrete and Brick
 - d. Wet Areas
 - e. Glazing Systems.
- E. Single-Component Mildew-Resistant Silicone Sealant ES-3: Shower areas
- 1. Product:
 - a. Masterseal; 121
 - 2. Type and Grade: S (single component) and NS (non-sag).
 - 3. Anti-Fungal – to keep wet areas hygienic
 - 4. Class: 25.
 - 5. Use Related to Exposure: NT (nontraffic).

6. Uses Related to Joint Substrates: G, A, and, as applicable to joint substrates indicated, O.
 - a. Kitchens and bathrooms
 - b. Window and door frames
- F. Multicomponent Pourable Urethane Sealant ES-3: Concrete floor joints
 1. Products:
 - a. Masterseal; SL-1
 2. Type and Grade: S (single-component) and P (pourable).
 3. Class: 35.
 4. Use Related to Exposure: T (traffic).
 5. Uses Related to Joint Substrates
 - a. Cast-In-Place Concrete
 - b. Sidewalks and decks
 - c. Floors - control joints and expansion joints

2.4 SOLVENT-RELEASE JOINT SEALANTS

- A. Butyl-Rubber-Based Solvent-Release Joint Sealant SRS-1: Comply with ASTM C 1085.
 1. Products:
 - a. Inner Bond 201 Butyl Rubber Sealant or Equal
 2. Uses related to joint substrates
 - a. Aluminum threshold bedding.

2.5 JOINT-SEALANT BACKING

- A. General: Provide sealant backings of material and type that are non-staining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.
- B. Elastomeric Tubing Sealant Backings: Neoprene, butyl, EPDM, or silicone tubing complying with ASTM D 1056, nonabsorbent to water and gas, and capable of remaining resilient at temperatures down to minus 26 deg F. Provide products with low compression set and of size and shape to provide a secondary seal, to control sealant depth, and to otherwise contribute to optimum sealant performance.

- C. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint where such adhesion would result in sealant failure. Provide self-adhesive tape where applicable.

2.6 MISCELLANEOUS MATERIALS

- A. Primer: Material recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.
- B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.
- C. Masking Tape: Non-staining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions and the following requirements:
 - 1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
 - 2. Clean, porous joint substrate surfaces by brushing, grinding, blast cleaning, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining after cleaning operations above by vacuuming or blowing out joints with oil-free compressed air. Porous joint substrates include the following:
 - a. Concrete.

- b. Masonry.
 - c. Unglazed surfaces of ceramic tile.
- 3. Remove laitance and form-release agents from concrete.
- 4. Clean nonporous surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants.
Nonporous joint substrates include the following:
 - a. Metal.
 - b. Glass.
 - c. Porcelain enamel.
 - d. Glazed surfaces of ceramic tile or structural glazed tile.
 - e. Plastic Laminate.
- B. Joint Priming: Prime joint substrates, where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.
- C. Masking Tape: Use masking tape where required to prevent contact of sealant with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.3 INSTALLATION OF JOINT SEALANTS

- A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.
- B. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
- C. Install sealant backings of type indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
 - 1. Do not leave gaps between ends of sealant backings.
 - 2. Do not stretch, twist, puncture, or tear sealant backings.
 - 3. Remove absorbent sealant backings that have become wet before sealant application and replace them with dry materials.

- D. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.
- E. Install sealants using proven techniques that comply with the following and at the same time backings are installed:
 - 1. Place sealants so they directly contact and fully wet joint substrates.
 - 2. Completely fill recesses in each joint configuration.
 - 3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- F. Tooling of Non-sag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants according to requirements specified below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.
 - 1. Remove excess sealant from surfaces adjacent to joints.
 - 2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.
 - 3. Provide concave joint configuration per Figure 5A in ASTM C 1193, unless otherwise indicated.
 - 4. Provide flush joint configuration where indicated per Figure 5B in ASTM C 1193.
 - 5. Provide recessed joint configuration of recess depth and at locations indicated per Figure 5C in ASTM C 1193.
 - a. Use masking tape to protect surfaces adjacent to recessed tooled joints.
- G. Installation of Preformed Foam Sealants: Install each length of sealant immediately after removing protective wrapping, taking care not to pull or stretch material, producing seal continuity at ends, turns, and intersections of joints. For applications at low ambient temperatures where expansion of sealant requires acceleration to produce seal, apply heat to sealant in compliance with sealant manufacturer's written instructions.

3.4 CLEANING

- A. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.5 PROTECTION

- A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from original work.

END OF SECTION 07 9200

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**SECTION 08 1113
HOLLOW METAL DOORS AND FRAMES**

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Standard hollow metal doors and frames.
- B. Related Sections:
 - 1. Division 08 Section "Door Hardware" for door hardware for hollow metal doors.
 - 2. Division 09 Sections "High Performance Coatings" for field painting hollow metal doors and frames.

1.3 DEFINITIONS

- A. Minimum Thickness: Minimum thickness of base metal without coatings.
- B. Standard Hollow Metal Work: Hollow metal work fabricated according to ANSI/SDI A250.8.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated. Include construction details, material descriptions, core descriptions, fire-resistance rating, temperature-rise ratings, and finishes.
- B. Shop Drawings: Include the following:
 - 1. Elevations of each door design.
 - 2. Details of doors, including vertical and horizontal edge details and metal thicknesses.
 - 3. Frame details for each frame type, including dimensioned profiles and metal thicknesses.
 - 4. Locations of reinforcement and preparations for hardware.
 - 5. Details of each different wall opening condition.
 - 6. Details of anchorages, joints, field splices, and connections.
 - 7. Details of accessories.
 - 8. Details of moldings, removable stops, and glazing.

9. Details of conduit and preparations for power, signal, and control systems.

C. Other Action Submittals:

1. Schedule: Provide a schedule of hollow metal work prepared by or under the supervision of supplier, using same reference numbers for details and openings as those on Drawings. Coordinate with door hardware schedule.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain hollow metal work from single source from single manufacturer.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver hollow metal work palletized, wrapped, or crated to provide protection during transit and Project-site storage. Do not use non-vented plastic.
1. Provide additional protection to prevent damage to finish of factory-finished units.
- B. Deliver welded frames with two removable spreader bars across bottom of frames, tack welded to jambs and mullions.
- C. Store hollow metal work under cover at Project site. Place in stacks of five units maximum in a vertical position with heads up, spaced by blocking, on minimum 4-inch- high wood blocking. Do not store in a manner that traps excess humidity.
1. Provide minimum 1/4-inch space between each stacked door to permit air circulation.

1.7 PROJECT CONDITIONS

- A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

1.8 COORDINATION

- A. Coordinate installation of anchorages for hollow metal frames. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors. Deliver such items to Project site in time for installation.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Ceco Door Products; an Assa Abloy Group company.

2. Curries Company; an Assa Abloy Group company.

2.2 MATERIALS

- A. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B; suitable for exposed applications.
- B. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS), Type B; with minimum G60 (Z180) or A60 (ZF180) metallic coating.
- C. Frame Anchors: ASTM A 591/A 591M, Commercial Steel (CS), 40Z coating designation; mill phosphatized.
 1. For anchors built into exterior walls, steel sheet complying with ASTM A 1008/A 1008M or ASTM A 1011/A 1011M, hot-dip galvanized according to ASTM A 153/A 153M, Class B.
- D. Inserts, Bolts, and Fasteners: Hot-dip galvanized according to ASTM A 153/A 153M.
- E. Grout: ASTM C 476, except with a maximum slump of 4 inches, as measured according to ASTM C 143/C 143M.
- F. Mineral-Fiber Insulation: ASTM C 665, Type I (blankets without membrane facing); consisting of fibers manufactured from slag or rock wool with 6- to 12-lb/cu. ft. density; with maximum flame-spread and smoke-development indexes of 25 and 50, respectively; passing ASTM E 136 for combustion characteristics.
- G. Glazing: Comply with requirements in Division 08 Section "Glazing."
- H. Bituminous Coating: Cold-applied asphalt mastic, SSPC-Paint 12, compounded for 15-mil dry film thickness per coat. Provide inert-type noncorrosive compound free of asbestos fibers, sulfur components, and other deleterious impurities.

2.3 HOLLOW METAL DOORS

- A. General: Provide doors of design indicated, not less than thickness indicated; fabricated with smooth surfaces, without visible joints or seams on exposed faces unless otherwise indicated. Comply with ANSI/SDI A250.8 or ANSL/NAAMM-HMMA 861.
 1. Design: Flush panel as indicated.
 2. Core Construction: Manufacturer's standard (insulated) polystyrene, polyurethane, or poly-isocyanate core.
 - a. Thermal-Rated (Insulated) Doors: Where indicated, provide doors fabricated with thermal-resistance value (R-value) of not less than 6.0 deg F x h x sq. ft./Btu when tested according to ASTM C 1363.

3. Vertical Edges for Single-Acting Doors: Manufacturer's standard.
 4. Top and Bottom Edges: Closed with flush or inverted 0.042-inch- thick, end closures or channels of same material as face sheets.
 5. Tolerances: Comply with SDI 117, "Manufacturing Tolerances for Standard Steel Doors and Frames."
- B. Exterior Doors: Face sheets fabricated from metallic-coated steel sheet. Provide doors complying with requirements indicated below by referencing ANSI/SDI A250.8 for level and model and ANSI/SDI A250.4 for physical performance level:
1. Level 3 and Physical Performance Level A (Extra Heavy Duty), Model 2 (Seamless).
- C. Interior Doors: Face sheets fabricated from cold-rolled steel sheet unless metallic-coated sheet is indicated. Provide doors complying with requirements indicated below by referencing ANSI/SDI A250.8 for level and model and ANSI/SDI A250.4 for physical performance level:
1. Level 2 and Physical Performance Level B (Heavy Duty), Model 2 (Seamless).
- D. Hardware Reinforcement: Fabricate according to ANSI/SDI A250.6 with reinforcing plates from same material as door face sheets.
- E. Fabricate concealed stiffeners and hardware reinforcement from either cold- or hot-rolled steel sheet.

2.4 HOLLOW METAL FRAMES

- A. General: Comply with ANSI/SDI A250.8 or ANSI/NAAMM-HMMA 861, and with details indicated for type and profile.
- B. Exterior Frames: Fabricated from metallic-coated steel sheet.
1. Fabricate frames with mitered or coped corners.
 2. Fabricate frames as full profile welded
 3. Frames for Level 3 Steel Doors: 0.053-inch- thick steel sheet.
- C. Interior Frames: Fabricated from metallic-coated sheet.
1. Fabricate frames with mitered or coped corners.
 2. Fabricate frames as full profile welded.
 3. Frames for Level 2 Steel Doors: 0.053-inch- thick steel sheet.
 4. Frames for Borrowed Lights: 0.053-inch- thick steel sheet.

- D. Hardware Reinforcement: Fabricate according to ANSI/SDI A250.6 with reinforcement plates from same material as frames.

2.5 FRAME ANCHORS

- A. Jamb Anchors:
 - 1. Type: Anchors of minimum size and type required by applicable door and frame standard, and suitable for performance level indicated.
 - 2. Quantity: Minimum of three anchors per jamb, with one additional anchor for frames with no floor anchor. Provide one additional anchor for each 24 inches of frame height above 7 feet.
 - 3. Post-installed Expansion Anchor: Minimum 3/8-inch-diameter bolts with expansion shields or inserts, with manufacturer's standard pipe spacer.
- B. Floor Anchors: Formed from same material as frames, not less than 0.042 inch thick, and as follows:
 - 1. Monolithic Concrete Slabs: Clip-type anchors, with two holes to receive fasteners.

2.6 STOPS AND MOLDINGS

- A. Moldings for Glazed Lites in Doors: Minimum 0.032 inch thick, fabricated from same material as door face sheet in which they are installed.
- B. Fixed Frame Moldings: Formed integral with hollow metal frames, a minimum of 5/8 inch high unless otherwise indicated.
- C. Loose Stops for Glazed Lites in Frames: Minimum 0.032 inch thick, fabricated from same material as frames in which they are installed.

2.7 GLAZING

- A. Insulating-Glass Units. Factory-assembled units consisting of sealed lites of glass separated by a dehydrated interspace, qualified according to ASTM E 2190, and complying with other requirements specified.
 - 1. Sealing System: Dual seal, with manufacturer's standard primary and secondary.
 - 2. Spacer: Manufacturer's standard spacer material and construction
- B. Insulating-Glass Types
 - 1. Glass Type GL-1: Clear insulating glass
 - a. Overall Unit Thickness: 1 inch.

- b. Thickness of Each Glass Lite: 6.0 mm.
- c. Outdoor Lite: Fully tempered float glass.
- d. Interspace Content: Argon
- e. Indoor Lite: Fully tempered float glass.
- f. Provide safety glazing labeling.

2.8 ACCESSORIES

- A. Mullions and Transom Bars: Join to adjacent members by welding or rigid mechanical anchors.
- B. Grout Guards: Formed from same material as frames, not less than 0.016 inch (0.4 mm) thick.

2.9 FABRICATION

- A. Fabricate hollow metal work to be rigid and free of defects, warp, or buckle. Accurately form metal to required sizes and profiles, with minimum radius for thickness of metal. Where practical, fit and assemble units in manufacturer's plant. To ensure proper assembly at Project site, clearly identify work that cannot be permanently factory assembled before shipment.
- B. Tolerances: Fabricate hollow metal work to tolerances indicated in SDI 117 and in ANSI/NAAMM-HMMA 861.
- C. Hollow Metal Doors:
 - 1. Exterior Doors: Provide weep-hole openings in bottom of exterior doors to permit moisture to escape. Seal joints in top edges of doors against water penetration.
 - 2. Glazed Lites: Factory cut openings in doors.
 - 3. Astragals: Provide overlapping astragal on one leaf of pairs of doors where required by NFPA 80 for fire-performance rating or where indicated. Extend minimum 3/4 inch beyond edge of door on which astragal is mounted.
- D. Hollow Metal Frames: Where frames are fabricated in sections due to shipping or handling limitations, provide alignment plates or angles at each joint, fabricated of same thickness metal as frames.
 - 1. Welded Frames: Weld flush face joints continuously; grind, fill, dress, and make smooth, flush, and invisible.
 - 2. Provide countersunk, flat- or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.
 - 3. Grout Guards: Weld guards to frame at back of hardware mortises in frames to be grouted.

4. Floor Anchors: Weld anchors to bottom of jambs and mullions with at least four spot welds per anchor.
5. Jamb Anchors: Provide number and spacing of anchors as follows:
 - a. Masonry Type: Locate anchors not more than 18 inches from top and bottom of frame. Space anchors not more than 32 inches o.c. and as follows:
 - 1) Two anchors per jamb up to 60 inches high.
 - 2) Three anchors per jamb from 60 to 90 inches high.
 - 3) Four anchors per jamb from 90 to 120 inches high.
 - 4) Four anchors per jamb plus 1 additional anchor per jamb for each 24 inches or fraction thereof above 120 inches high.
 - b. Post-installed Expansion Type: Locate anchors not more than 6 inches from top and bottom of frame. Space anchors not more than 26 inches o.c.
6. Door Silencers: Except on weather-stripped doors, drill stops to receive door silencers as follows. Keep holes clear during construction.
 - a. Single-Door Frames: Drill stop in strike jamb to receive three door silencers.
 - b. Double-Door Frames: Drill stop in head jamb to receive two door silencers.
- E. Fabricate concealed stiffeners, edge channels, and hardware reinforcement from either cold- or hot-rolled steel sheet.
- F. Hardware Preparation: Factory prepare hollow metal work to receive templated mortised hardware; include cutouts, reinforcement, mortising, drilling, and tapping according to the Door Hardware Schedule and templates furnished as specified in Division 08 Section "Door Hardware."
 1. Locate hardware as indicated, or if not indicated, according to ANSI/SDI A250.8 ANSI/NAAMM-HMMA 861.
 2. Reinforce doors and frames to receive non-templated, mortised and surface-mounted door hardware.
 3. Comply with applicable requirements in ANSI/SDI A250.6 and ANSI/DHI A115 Series specifications for preparation of hollow metal work for hardware.
- G. Stops and Moldings: Provide stops and moldings around glazed lites where indicated. Form corners of stops and moldings with butted or mitered hairline joints.
 1. Single Glazed Lites: Provide fixed stops and moldings welded on secure side of hollow metal work.

2. Provide fixed frame moldings on outside of exterior and on secure side of interior doors and frames.
3. Provide loose stops and moldings on inside of hollow metal work.
4. Coordinate rabbet width between fixed and removable stops with type of glazing and type of installation indicated.

2.10 STEEL FINISHES

- A. Prime Finish: Apply manufacturer's standard primer immediately after cleaning and pretreating.
 1. Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with ANSI/SDI A250.10 acceptance criteria; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for embedded and built-in anchors to verify actual locations before frame installation.
- C. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Remove welded-in shipping spreaders installed at factory. Restore exposed finish by grinding, filling, and dressing, as required to make repaired area smooth, flush, and invisible on exposed faces.
- B. Prior to installation, adjust and securely brace welded hollow metal frames for squareness, alignment, twist, and plumbness to the following tolerances:
 1. Squareness: Plus or minus 1/16 inch, measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
 2. Alignment: Plus or minus 1/16 inch, measured at jambs on a horizontal line parallel to plane of wall.

3. Twist: Plus or minus 1/16 inch, measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
 4. Plumbness: Plus or minus 1/16 inch, measured at jambs on a perpendicular line from head to floor.
- C. Drill and tap doors and frames to receive non-templated, mortised, and surface-mounted door hardware.

3.3 INSTALLATION

- A. General: Install hollow metal work plumb, rigid, properly aligned, and securely fastened in place; comply with Drawings and manufacturer's written instructions.
- B. Hollow Metal Frames: Install hollow metal frames of size and profile indicated. Comply with ANSI/SDI A250.11.
1. Set frames accurately in position, plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces, leaving surfaces smooth and undamaged.
 - a. At fire-protection-rated openings, install frames according to NFPA 80.
 - b. Where frames are fabricated in sections because of shipping or handling limitations, field splice at approved locations by welding face joint continuously; grind, fill, dress, and make splice smooth, flush, and invisible on exposed faces.
 - c. Install frames with removable glazing stops located on secure side of opening.
 - d. Install door silencers in frames before grouting.
 - e. Remove temporary braces necessary for installation only after frames have been properly set and secured.
 - f. Check plumbness, squareness, and twist of frames as walls are constructed. Shim as necessary to comply with installation tolerances.
 - g. Field apply bituminous coating to backs of frames that are filled with grout containing anti-freezing agents.
 2. Masonry Walls: Coordinate installation of frames to allow for solidly filling space between frames and masonry with grout.
 3. In-Place Concrete or Masonry Construction: Secure frames in place with post-installed expansion anchors. Countersink anchors, and fill and make smooth, flush, and invisible on exposed faces.

4. Installation Tolerances: Adjust hollow metal door frames for squareness, alignment, twist, and plumb to the following tolerances:
 - a. Squareness: Plus or minus 1/16 inch, measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
 - b. Alignment: Plus or minus 1/16 inch, measured at jambs on a horizontal line parallel to plane of wall.
 - c. Twist: Plus or minus 1/16 inch, measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
 - d. Plumbness: Plus or minus 1/16 inch, measured at jambs at floor.
- C. Hollow Metal Doors: Fit hollow metal doors accurately in frames, within clearances specified below. Shim as necessary.
 1. Non-Fire-Rated Standard Steel Doors:
 - a. Jambs and Head: 1/8 inch plus or minus 1/16 inch.
 - b. Between Edges of Pairs of Doors: 1/8 inch plus or minus 1/16 inch.
 - c. Between Bottom of Door and Top of Threshold: Maximum 3/8 inch.
 - d. Between Bottom of Door and Top of Finish Floor (No Threshold): Maximum 3/4 inch.
- D. Glazing: Comply with installation requirements in Division 08 Section "Glazing" and with hollow metal manufacturer's written instructions.
 1. Secure stops with countersunk flat- or oval-head machine screws spaced uniformly not more than 9 inches o.c. and not more than 2 inches o.c. from each corner.

3.4 ADJUSTING AND CLEANING

- A. Final Adjustments: Check and readjust operating hardware items immediately before final inspection. Leave work in complete and proper operating condition. Remove and replace defective work, including hollow metal work that is warped, bowed, or otherwise unacceptable.
- B. Remove grout and other bonding material from hollow metal work immediately after installation.
- C. Prime-Coat Touchup: Immediately after erection, sand smooth rusted or damaged areas of prime coat and apply touchup of compatible air-drying, rust-inhibitive primer.

END OF SECTION 08 1113

**SECTION 08 3613
SECTIONAL DOORS**

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes electrically operated sectional doors.
- B. Related Sections:
 - 1. Section 055000 "Metal Fabrications" for miscellaneous steel supports.

1.3 PERFORMANCE REQUIREMENTS

- A. General Performance: Sectional doors shall meet performance requirements specified without failure due to defective manufacture, fabrication, installation, or other defects in construction and without requiring temporary installation of reinforcing components.
- B. Delegated Design: Design sectional doors, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- C. Structural Performance: Exterior sectional doors shall withstand the effects of gravity loads, and the following loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - 1. Wind Loads: Uniform pressure (velocity pressure) resulting from wind speed indicated below, but not less than 20 lbf/sq. ft., acting inward and outward.
 - a. Basic Wind Speed: 90 mph.
 - b. Importance Factor: 1.
 - c. Exposure Category: C.
 - 2. Deflection Limits: Design sectional doors to withstand design wind loads without evidencing permanent deformation or disengagement of door components. Deflection of door in horizontal position (open) shall not exceed 1/120 of the door width.
- D. Air Infiltration: Maximum rate not more than indicated when tested according to ASTM E 283.
 - 1. Air Infiltration: Maximum rate of 0.08 cfm/sq. ft. at 15 and 25 mph.
- E. Operation Cycles: Provide sectional door components and operators capable of operating for not less than number of cycles indicated for each door. One operation cycle is complete when a

door is opened from the closed position to the fully open position and returned to the closed position.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type and size of sectional door and accessory. Include the following:
 - 1. Construction details, material descriptions, dimensions of individual components, profile door sections, and finishes.
 - 2. Rated capacities, operating characteristics, electrical characteristics, and furnished accessories.
- B. Shop Drawings: For each installation and for special components not dimensioned or detailed in manufacturer's product data. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.
- C. Delegated-Design Submittal: For sectional doors indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Summary of forces and loads on walls and jambs.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For sectional doors to include in maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for both installation and maintenance of units required for this Project.
- B. Source Limitations: Obtain sectional doors from single source from single manufacturer.
 - 1. Obtain operators and controls from sectional door manufacturer.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Standard for Sectional Doors: Fabricate sectional doors to comply with DASMA 102 unless otherwise indicated.

1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of sectional doors that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures including, but not limited to, excessive deflection.
 - b. Faulty operation of hardware.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use; rust through.
 - d. Delamination of exterior or interior facing materials.
 - 2. Warranty Period: Five years from date of Substantial Completion.
- B. Special Finish Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components that show evidence of deterioration of factory-applied finishes within specified warranty period.
 - 1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 PRODUCTS

2.1 STEEL DOOR SECTIONS

- A. Exterior Section Faces and Frames: Fabricate from zinc-coated (galvanized), cold-rolled, commercial steel (CS) sheet, complying with ASTM A 653/A 653M, with indicated zinc coating and thickness.
 - 1. Fabricate section faces from single sheets to provide sections not more than 24 inches high and of indicated thickness. Roll horizontal meeting edges to a continuous, interlocking, keyed, rabbeted, shiplap, or tongue-in-groove weathertight seal, with a reinforcing flange return.
 - 2. For insulated doors, provide sections with continuous thermal-break construction, separating the exterior and interior faces of door.
- B. Section Ends and Intermediate Stiles: Enclose open ends of sections with channel end stiles formed from galvanized-steel sheet not less than 0.064-inch- nominal coated thickness and welded to door section. Provide intermediate stiles formed from not less than 0.064-inch- thick galvanized-steel sheet, cut to door section profile, and welded in place. Space stiles not more than 48 inches apart.

- C. Reinforce bottom section with a continuous channel or angle conforming to bottom-section profile and allowing installation of astragal.
- D. Reinforce sections with continuous horizontal and diagonal reinforcement, as required to stiffen door and for wind loading. Provide galvanized-steel bars, struts, trusses, or strip steel, formed to depth and bolted or welded in place.
- E. Provide reinforcement for hardware attachment.
- F. Foamed-in-Place Thermal Insulation: Insulate interior of steel sections with door manufacturer's standard CFC-free polyurethane insulation, foamed in place to completely fill interior of section and pressure bonded to face sheets to prevent delamination under wind load, and with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, according to ASTM E 84. Enclose insulation completely within steel sections that incorporate the following interior facing material, with no exposed insulation:
 - 1. Interior Facing Material: Zinc-coated (galvanized), cold-rolled, commercial steel (CS) sheet, complying with ASTM A 653/A 653M, with indicated thickness.
- G. Fabricate sections so finished door assembly is rigid and aligned, with tight hairline joints and free of warp, twist, and deformation.

2.2 TRACKS, SUPPORTS, AND ACCESSORIES

- A. Tracks: Manufacturer's standard, galvanized-steel track system of configuration indicated, sized for door size and weight, designed for lift type indicated and clearances shown on Drawings, and complying with ASTM A 653/A 653M for minimum G60 zinc coating. Provide complete track assembly including brackets, bracing, and reinforcement for rigid support of ball-bearing roller guides for required door type and size. Slot vertical sections of track spaced 2 inches apart for door-drop safety device. Slope tracks at proper angle from vertical or design tracks to ensure tight closure at jambs when door unit is closed.
- B. Track Reinforcement and Supports: Galvanized-steel track reinforcement and support members, complying with ASTM A 36/A 36M and ASTM A 123/A 123M. Secure, reinforce, and support tracks as required for door size and weight to provide strength and rigidity without sag, sway, and vibration during opening and closing of doors. wall jamb brackets attached to track and attached to wall.
 - 1. Horizontal Track Assembly: Track with continuous reinforcing angle attached to track and supported at points from curve in track to end of track by laterally braced attachments to overhead structural members.
- C. Weatherseals: Replaceable, adjustable, continuous, compressible weather-stripping gaskets of flexible vinyl, rubber, or neoprene fitted to bottom and top of sectional door unless otherwise indicated.

2.3 HARDWARE

- A. General: Provide heavy-duty, corrosion-resistant hardware, with hot-dip galvanized, stainless-steel, or other corrosion-resistant fasteners, to suit door type.
- B. Hinges: Heavy-duty, galvanized-steel hinges of not less than 0.079-inch- nominal coated thickness at each end stile and at each intermediate stile, according to manufacturer's written recommendations for door size. Attach hinges to door sections through stiles and rails with bolts and lock nuts or lock washers and nuts. Use rivets or self-tapping fasteners where access to nuts is not possible. Provide double-end hinges where required, for doors over 16 feet wide unless otherwise recommended by door manufacturer.
- C. Rollers: Heavy-duty rollers with steel ball-bearings in case-hardened steel races, mounted with varying projections to suit slope of track. Extend roller shaft through both hinges where double hinges are required. Provide 3-inch- diameter roller tires for 3-inch- wide track and 2-inch- diameter roller tires for 2-inch- wide track.

2.4 COUNTERBALANCE MECHANISM

- A. Torsion Spring: Counterbalance mechanism consisting of adjustable-tension torsion springs fabricated from steel-spring wire complying with ASTM A 229/A 229M, mounted on torsion shaft made of steel tube or solid steel. Provide springs designed for number of operation cycles indicated.
- B. Cable Drums and Shaft for Doors: Cast-aluminum or gray-iron casting cable drums mounted on torsion shaft and grooved to receive door-lifting cables as door is raised. Mount counterbalance mechanism with manufacturer's standard ball-bearing brackets at each end of torsion shaft. Provide one additional midpoint bracket for shafts up to 16 feet long and two additional brackets at one-third points to support shafts more than 16 feet long unless closer spacing is recommended by door manufacturer.
- C. Cables: Galvanized-steel lifting cables with cable safety factor of at least 5 to 1.
- D. Cable Safety Device: Include a spring-loaded steel or spring-loaded bronze cam mounted to bottom door roller assembly on each side and designed to automatically stop door if either lifting cable breaks.
- E. Bracket: Provide anchor support bracket as required to connect stationary end of spring to the wall and to level the shaft and prevent sag.
- F. Bumper: Provide a spring bumper at each horizontal track to cushion door at end of opening operation.

2.5 ELECTRIC DOOR OPERATORS

- A. General: Electric door operator assembly of size and capacity recommended and provided by door manufacturer for door and "operation cycles" requirement specified, with electric motor

and factory-prewired motor controls, starter, gear-reduction unit, solenoid-operated brake, clutch, remote-control stations, control devices, integral gearing for locking door, and accessories required for proper operation.

1. Comply with NFPA 70.
2. Provide control equipment complying with NEMA ICS 1, NEMA ICS 2, and NEMA ICS 6; with NFPA 70, Class 2 control circuit, maximum 24-V ac or dc.
- B. Usage Classification: Electric operator and components capable of operating for not less than number of cycles per hour indicated for each door.
- C. Door-Operator Type: Unit consisting of electric motor, gears, pulleys, belts, sprockets, chains, and controls needed to operate door and meet required usage classification.
 1. Trolley driven
- D. Electric Motors: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency.
 1. Electrical Characteristics: Single phase
 - a. Volts: 140 V.
 - b. Hertz: 60.
 2. Motor Type and Controller: Reversible motor and controller (disconnect switch) for motor exposure indicated.
 3. Motor Size: Minimum size as indicated. If not indicated, large enough to start, accelerate, and operate door in either direction from any position, at a speed not less than 8 in./sec. and not more than 12 in./sec., without exceeding nameplate ratings or service factor.
 4. Operating Controls, Controllers (Disconnect Switches), Wiring Devices, and Wiring: Manufacturer's standard unless otherwise indicated.
 5. Coordinate wiring requirements and electrical characteristics of motors and other electrical devices with building electrical system and each location where installed.
 6. Use adjustable motor-mounting bases for belt-driven operators.
- E. Limit Switches: Equip each motorized door with adjustable switches interlocked with motor controls and set to automatically stop door at fully opened and fully closed positions.
- F. Obstruction Detection Device: Equip motorized door with indicated external automatic safety sensor capable of protecting full width of door opening. Activation of device immediately stops and reverses downward door travel.

- a. Monitored Entrapment Protection: Photoelectric sensor designed to interface with door-operator control circuit to detect damage to or disconnection of sensor and complying with requirements in UL 325.
 2. Remote-Control Station: Momentary-contact, three-button control station with push-button controls labeled "Open," "Close," and "Stop."
 3. Exterior units (mounted inside building at each door), full-guarded, standard-duty, surface-mounted, weatherproof type, NEMA ICS 6, Type 4 enclosure, key operated.
- G. Emergency Manual Operation: Equip each electrically powered door with capability for emergency manual operation. Design manual mechanism so required force for door operation does not exceed 25 lbf.
- H. Emergency Operation Disconnect Device: Equip operator with hand-operated disconnect mechanism for automatically engaging manual operator and releasing brake for emergency manual operation while disconnecting motor without affecting timing of limit switch. Mount mechanism so it is accessible from floor level. Include interlock device to automatically prevent motor from operating when emergency operator is engaged.
- I. Motor Removal: Design operator so motor may be removed without disturbing limit-switch adjustment and without affecting emergency manual operation.
- J. Radio-Control System: Consisting of the following:
1. Three-channel universal coaxial receiver to open, close, and stop door; one per operator.
 2. Multifunction remote control capable of operating both doors (individually) at either end of drive-through bay.
 3. Provide 2 remotes per door.
 4. Remote antenna and mounting kit.

2.6 DOOR ASSEMBLY

- A. Steel Sectional Door: Sectional door formed with hinged sections.
1. Basis-of-Design Product: Subject to compliance with requirements, provide Overhead Door Company 470 or an approved equal product by one of the following:
 - a. C.H.I. Overhead Doors.
 - b. Clopay Building Products; a Griffon company.
 - c. Overhead Door Company
 - d. Wayne-Dalton Corp.

- B. Operation Cycles: Standard Duty.
- C. Installed R-Value: 9.83 deg F x h x sq. ft./Btu.
- D. Steel Sections: Zinc-coated (galvanized) steel sheet with G60 Z180 zinc coating.
 - 1. Section Thickness: 2 inches.
 - 2. Exterior-Face, Steel Sheet Thickness: 0.040-inch- nominal coated thickness.
 - a. Surface: Flat.
 - 3. Insulation: Foamed in place.
 - 4. Interior Facing Material: Zinc-coated (galvanized) steel sheet of manufacturer's recommended thickness to meet performance requirements nominal coated thickness.
- E. Track Configuration: high-lift track (to extend tight to ceiling)
- F. Weatherseals: Fitted to bottom and top and around entire perimeter of door. Provide combination bottom weatherseal and sensor edge.
- G. Windows: Manufacturer's standard window units of shape and size and in locations indicated on Drawings. Set glazing in vinyl, rubber, or neoprene glazing channel. Provide removable stops of same material as door-section frames. Provide the following glazing:
 - 1. Insulating Glass Units: Manufacturer's standard.
- H. Roller-Tire Material: Manufacturer's standard.
- I. Locking Devices: Equip door with locking device assembly.
 - 1. Locking Device Assembly: Cremone type, both jamb sides, locking bars, operable from inside with thumbturn outside with cylinder.
- J. Counterbalance Type: Torsion spring.
- K. Electric Door Operator: Overhead Door Company Odyssey – 1000 or approved equal
 - 1. Usage Classification: Standard Duty
 - 2. Operator Type: Trolley, center mounted.
 - 3. Motor Exposure: Exterior, dusty, wet, or humid.
 - 4. Obstruction-Detection Device: Photo eye
 - 5. Remote-Control Station: Exterior grade (installed inside near door).
 - 6. Other Equipment: Radio-control system.

7. Remote Controls – 2 devices

L. Door Finish:

1. Baked-Enamel or Powder-Coated Finish: Selected by Architect from Manufacturer's full range.
2. Finish of Interior Facing Material: Match finish of exterior section face.

2.7 GENERAL FINISH REQUIREMENTS

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.8 STEEL AND GALVANIZED-STEEL FINISHES

- A. Baked-Enamel or Powder-Coat Finish: Manufacturer's standard baked-on finish consisting of prime coat and thermosetting topcoat. Comply with coating manufacturer's written instructions for cleaning, pretreatment, application, and minimum dry film thickness.
 1. Color: Selected by Architect from Manufacturer's full range.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for substrate construction and other conditions affecting performance of the Work.
- B. Examine locations of electrical connections.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install sectional doors and operating equipment complete with necessary hardware, anchors, inserts, hangers, and equipment supports; according to manufacturer's written instructions and as specified.
- B. Tracks:
 1. Fasten vertical track assembly to opening jambs and framing, spaced not more than 24 inches apart.

2. Hang horizontal track assembly from structural overhead framing with angles or channel hangers attached to framing by welding or bolting, or both. Provide sway bracing, diagonal bracing, and reinforcement as required for rigid installation of track and door-operating equipment.
 3. Repair galvanized coating on tracks according to ASTM A 780.
- C. Accessibility: Install sectional doors, switches, and controls along accessible routes in compliance with regulatory requirements for accessibility.

3.3 STARTUP SERVICES

- A. Engage a factory-authorized service representative to perform startup service.
1. Complete installation and startup checks according to manufacturer's written instructions.
 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 ADJUSTING

- A. Adjust hardware and moving parts to function smoothly so that doors operate easily, free of warp, twist, or distortion.
- B. Lubricate bearings and sliding parts as recommended by manufacturer.
- C. Adjust doors and seals to provide weathertight fit around entire perimeter.
- D. Align and adjust motors, pulleys, belts, sprockets, chains, and controls according to manufacturer's written instructions.
- E. Touch-up Painting: Immediately after welding galvanized materials, clean welds and abraded galvanized surfaces and repair galvanizing to comply with ASTM A 780.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain sectional doors.

END OF SECTION 08 3613

**SECTION 09 9600
HIGH PERFORMANCE COATINGS**

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes surface preparation and field application of high-performance coating systems to items and surfaces scheduled.
- B. Related Sections include the following
 - 1. Division 40: Process Interconnections
 - 2. Division 46: Water and Wastewater Equipment

1.3 DEFINITIONS

- A. Standard coating terms defined in ASTM D 16 apply to this Section.
- B. Coating Inspector: Owner's coating observer on site. Coating Inspector may or may not be the same as the Resident Project Representative. Coating Inspector has no formal inspection responsibilities (i.e. approving surface preparation). Coating Inspector's role is to observe and document observations. Coating Inspector will inform Applicator of areas that, in the Coating Inspector's professional opinion, do not meet the intent of the specification.
- C. Immersed Surface: Any surface that will be submerged in a tank. Submerging level shall be considered 1 foot above the overflow elevation of the tank.
 - 1. Any surface that will see condensation on the surface over the majority of its life shall be considered an immersed surface. All piping (excluding air piping) shall be considered immersed.
- D. Atmospheric Surface: Any surface that is not considered immersed.

1.4 SUBMITTALS

- A. Applicator experience qualifications.
 - 1. No product information will be reviewed until Engineer has received and approved applicator qualifications.
 - 2. Include all information required in Paragraph 1.4A "Quality Assurance" of this Section.
 - 3. Quality Control Plan.

4. Applicator Training and Product Certification Records

B. Product Data: For each coating system indicated.

1. An inclusive list of required coating materials. Indicate each material and cross-reference the specific coating, finish system, and application. Identify each material by manufacturer's catalog number and general classification.
 - a. Acknowledgement that products submitted meet requirements of standards referenced.
 - b. Manufacturer's surface preparation instructions.
 - c. Manufacturer's application instructions.
 - d. If products being used are manufactured by Company other than listed, provide complete individual data sheet comparison of proposed products with specified products including application procedure, coverage rates and verification that product is designed for intended use.
 - e. Contractor's written plan of action for containing airborne particles created by blasting operation and location of disposal of spent contaminated blasting media.
 - f. Coating manufacturer's recommendation on abrasive blasting.
 - g. Manufacturer's recommendation for universal barrier coat.
2. Manufacturer's statement regarding applicator instruction on product use.
3. Certification that coating systems proposed as Substitutions have been reviewed and approved by Senior Corrosion Specification Specialist employed by the coating manufacturer.

C. Coating Schedule:

1. Provide a schedule including all surfaces to be coated. Schedule shall include the following:
 - a. Surface identification.
 - b. Specified coating system number.
 - c. Surface preparation.
 - d. For each coat:
 - 1) Product name.
 - 2) Color.

- 3) Coating thickness.
- e. Note any deviations from the specification.
- D. Miscellaneous Submittals:
 - 1. Applicator's daily records:
 - a. Submit daily records at end of each week in which coating work is performed unless requested otherwise by Engineer's on-site representative.
 - b. All records shall be submitted through a computer generated form.
 - 2. Product Coating Submittal Information Form
 - a. Form is included at the end of the Section.
 - b. Form shall be submitted with all products that have shop applied coatings.
- E. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for each type of finish-coat material indicated.
 - 1. After color selection, Architect will furnish color chips for surfaces to be coated.

1.5 QUALITY ASSURANCE

- A. Applicator Qualifications: Engage an experienced applicator who has completed high-performance coating system applications similar in material and extent to those indicated for Project and whose work has a record of successful in-service performance.
 - 1. Applicator shall furnish, to the Engineer, a letter from all selected coating manufacturer(s), stating that they have been trained in the proper preparation mixing, thinning, and application of the high performance coating system(s) with the Submittals.
 - 2. Application of the high performance coating system(s) by anyone other than the applicator trained by the Manufacturer(s) will not be allowed.
 - 3. Coating Superintendent shall have minimum of 10 years experience in application of similar products on similar projects. Applicators shall have a minimum of 3 years experience in application of similar products on similar projects.
 - a. Provide references for minimum of three (3) different projects completed in last five (5) years with similar scope of work. References shall be from projects w/ same proposed Coating Superintendent for Project.
 - b. Include name and address of project, size of project in value (coating) and contact person.

4. Except in extreme circumstances, Coating Superintendent shall not be replaced without written notice provided to the Engineer at least seven (7) days prior to change. If replacement is necessary, an additional pre-job conference may be held at the Engineer's discretion prior to continuing coating application.
- B. Miscellaneous:
 1. Furnish paint through one (1) manufacturer unless noted otherwise.
- C. Deviation from specified mil thickness or product type is not allowed unless approved, in writing, by manufacturer's authorized representative and Engineer.
- D. Material shall not be thinned unless approved, in writing, by coating manufacturer's authorized representative and Engineer.
- E. Accelerators shall not be used unless approved, in writing, by coating manufacturer's authorized representative and Engineer.
- F. Source Limitations: Obtain primers and undercoat materials for each coating system from the same manufacturer as the finish coats.
 1. All top coats shall be provided from the same manufacturer, regardless of whether it was shop or field coated. Contractor shall coordinate this between suppliers and Field Applicators.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Project site in manufacturer's original, unopened packages and containers bearing manufacturer's name and label with the following information:
 1. Name or title of material.
 2. Product description (generic classification or binder type).
 3. Manufacturer's stock number and date of manufacture.
 4. Contents by volume, for pigment and vehicle constituents.
 5. Thinning instructions.
 6. Application instructions.
 7. Color name and number.
 8. Handling instructions and precautions.
- B. Store materials not in use in tightly covered containers in a well-ventilated area and environmentally controlled atmosphere in accordance with Manufacturer's recommendations. Temperature of storage shall be monitored for minimum and maximum ambient air temperature

in accordance with product data sheets. Maintain containers used in storage in a clean condition, free of foreign materials and residue.

1. Protect materials from freezing and heat above manufacturer's published recommendations. Keep storage area neat and orderly. Remove oily rags and waste daily. Take necessary measures to ensure that workers and work areas are protected from fire and health hazards resulting from handling, mixing, and applying coatings.

1.7 EXISTING CONDITIONS

- A. It is the responsibility of the applicator to visit the project site prior to bidding. No claims of unknown or differing conditions will be allowed if no pre-bid site visit was performed. Given the nature of the work, it is strongly recommended that the foreman that will be performing the work be included on the site visit.

1.8 COATING APPLICATION PRE-JOB CONFERENCE

- A. Notify Engineer at least 2 weeks prior to start of coating application work.
- B. Pre-job conference is required prior to any coating application work.
- C. Pre-job conference shall be attended by General Contractor, Applicator (including all personnel with supervisor responsibilities on the job), Coating Manufacturer's technical representative, Engineer/Architect, and Coating Inspector (if obtained by Owner).
 1. A second pre-job conference shall be required to address deck-traffic coating application only.
- D. Agenda shall include (but not be limited to):
 1. Scope of Work
 2. Work schedule.
 3. Quality control plan.
 4. Safety requirements.
 5. Areas of concern or problem areas
 6. Access
- E. At the pre-job conference, Applicator shall prepare (surface preparation and application of prime coat) sample plates in accordance with the specifications for each system of coating and level of surface preparation. Sample plate shall be a minimum of 4 inches by 8 inches by 1/8 inch thick. Three (3) sample plates of each system shall be provided, at a minimum.

1.9 REFERENCES

A. ASTM International:

1. D 4258 – “Standard Practice for Surface Cleaning Concrete for Coating”
2. D 4259 – “Standard Practice for Abrading Concrete”
3. D 4262 – “Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces”
4. D 4263 – “Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method”
5. D 4541 – “Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers”
6. D 5402 – “Standard Practice for Assessing the Solvent Resistance of Organic Coatings Using Solvent Rubs”
7. F 1869 – “Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride”
8. D 4285 – “Standard Test Method for Indicating Oil or Water in Compressed Air”.
9. D 5402 – “Standard Practice for Assessing the Solvent Resistance of Organic Coatings Using Solvent Rubs”.
10. D 7091 – “Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals”.

B. International Concrete Repair Institute (ICRI)

1. Guideline No. 310.2R – “Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair”

C. ISO (International Organization for Standardization):

1. 8502-3 – “Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)”.

D. NACE International:

1. SP0188 – “Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates”.
2. RP0287 – Field Measurement of Surface Profile of Abrasive Blast-Cleaned Steel Surfaces Using a Replica Tape”.

- E. SSPC (Society for Protective Coatings):
 - 1. PA2 – “Procedure for Determining Conformance to Dry Coating Thickness Requirements”.
 - 2. SP1 – “Solvent Cleaning”.
 - 3. SP16 – “Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals”.
- F. Joint NACE International and SSPC (Society for Protective Coatings)
 - 1. NACE No. 1/SSPC-SP 5 – “White Metal Blast Cleaning”
 - 2. NACE No. 2/SSPC-SP 10 – “Near-White Metal Blast Cleaning”
 - 3. NACE No. 6/SSPC-SP 13 – “Surface Preparation of Concrete”
- G. NAPF (National Association of Pipe Fabricators, Inc.)
 - 1. NAPF 500-03 – “Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coating and/or Special Internal Linings”.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide products by the following:
 - 1. Sherwin-Williams Company (S-W)
 - 2. Tnemec Company, Inc. (Tnemec)
 - 3. Or approved equal.

2.2 COATINGS MATERIALS, GENERAL

- A. Material Compatibility: Provide primers, undercoats, and finish-coat materials that are compatible with one another and substrates indicated under conditions of service and application, as demonstrated by manufacturer based on testing and field experience.
- B. Material Quality: Provide manufacturer's highest grade of the various high-performance coatings specified. Materials not displaying manufacturer's product identification are not acceptable.
 - 1. Proprietary Names: Use of manufacturer's proprietary product names to designate colors or materials is not intended to imply that products named are required to be used to the exclusion of equivalent products of other manufacturers. Furnish manufacturer's material data and certificates of performance for proposed substitutions.

2.3 COLORS

A. Piping Color Schedule

1. Process Piping
 - a. MINE WATER
 - 1) Red (match existing) - - -
 - 2) Shall use Orange Labels with Black Letters
 - b. AIR
 - 1) Galvanized
 - 2) Shall use Green Labels with White Letters
 - c. BACKWASH
 - 1) PVC
 - 2) Shall use Brown Labels with White Letters
 - d. POTABLE WATER
 - 1) Blue
 - 2) Shall use Dark Blue Labels with White Letters
2. Other approved manufacturers shall be the equivalent of listed colors.
3. Pipe identification shall be as indicated on Drawings.

2.4 PIPE IDENTIFICATION

A. Identification labels on piping shall be one of the following:

1. Self-Adhesive Labels
 - a. Interior/Exterior Grade Vinyl with a minimum thickness of 5 mils.
 - b. Permanent adhesive.
 - c. Resistant to high temperatures, weathering and UV light.
 - d. Label color shall be same as specified pipe color

B. Color and band piping in accordance with Article 2.3 of this Section.

1. Band piping using maximum of three (3) different colors at 8 FT maximum centers.

2. Place bands:
 - a. Along continuous lines.
 - b. At changes in direction.
 - 1) This requirement is in addition to the typical 8 FT maximum spacing requirement for banding piping.
 - c. At changes of elevation.
 - 1) This requirement is in addition to the typical 8 FT maximum spacing requirement for banding piping.
 - d. On both sides of an obstruction (e.g., wall, ceiling) that painted item passes through.
 - 1) This requirement is in addition to the typical 8 FT maximum spacing requirement for banding piping.
 3. Band width for individual colors (pipe diameter measured to outside of insulation, if applicable):
 - a. Piping up to 8 IN DIA: 2 IN minimum.
 - b. Piping greater than 8 IN up to 24 IN DIA: 4 IN minimum.
 - c. Piping greater than 24 IN up to 48 IN DIA: 6 IN minimum.
 - d. Piping greater than 48 IN DIA: 8 IN minimum.
- C. A flow arrow shall be included with the identification. Direction shall be as indicated on Drawings.

2.5 HIGH-PERFORMANCE COATING SYSTEMS

- A. Any coating applied to surfaces in contact with potable water shall be NSF certified.
- B. PIPING, PUMPS AND MISCELLANEOUS FERROUS METALS (ATMOSPHERIC EXPOSURE)
 1. Prime Coat:
 - a. Product: Zinc-Rich Primer
 - 1) S-W: Corothane I Galvapak 2K Zinc Primer
 - 2) Tnemec: Series 90-97 Tneme-Zinc
 - b. Dry Film Thickness: 2.5 – 3.5 mils

2. Intermediate Coat

a. Product: Epoxy

- 1) S-W: Macropoxy 646 Fast Cure Epoxy
- 2) Tnemec: Series 69 Hi-Build Epoxoline II

b. Dry Film Thickness: 4.0 – 6.0 mils

3. Top Coat:

a. Product: Polyurethane

- 1) S-W: Acrolon Ultra
- 2) Tnemec: Series 1074U Endura-Shield

b. Dry Film Thickness: 2.0 – 3.0 mils

c. Color: As indicated in piping schedule.

C. WASTEWATER IMMERSED PIPING (CARBON STEEL, DUCTILE IRON OR STAINLESS STEEL)

1. Prime Coat:

a. Product: Epoxy

- 1) S-W: Dura-Plate 5900
- 2) Tnemec: Series G435 Perma-Glaze

b. Dry Film Thickness: 15.0 – 20.0 mils

2. Top Coat:

a. Product: Epoxy

- 1) S-W: Dura-Plate 5900
- 2) Tnemec: Series G435 Perma-Glaze

b. Dry Film Thickness: 15.0 – 20.0 mils

D. NON-FERROUS METALS (WHERE INDICATED)

1. Prime Coat

a. Product: Epoxy

- 1) S-W: Macropoxy 646 Fast Cure Epoxy
- 2) Tnemec: Series 69 Hi-Build Epoxoline II

b. Dry Film Thickness: 4.0 – 6.0 mils

2.6 SHOP COATED SURFACES

- A. The following items are required to be entirely shop coated. These items are NOT to be top coated in the field.
 1. Division 40 – Valves and Fittings
 2. Division 46 – Blowers
- B. Coating system shall be the same as specified in this Section.
- C. Surface preparation shall be the same as specified in this Section.
- D. Quality control requirements shall be the same as specified in this Section for “Field Quality Control”.
 1. Documentation shall be provided at the same interval as specified.
 2. Documentation shall be provided prior to the equipment arriving on site.
- E. Manufacturer supplying shop coated surfaces shall provide touch-up paint for all coats of entire system applied.
 1. All touch-up painting shall be performed by Applicator.
 2. Touch-up paint shall be the same products as provided on the surface.

PART 3 EXECUTION

3.1 ITEMS TO BE PAINTED

- A. Items to be painted shall be prepared and have coating applied in the manner specified.
- B. Items to be painted include the following:
 1. All piping (not including stainless steel, aluminum or PVC), including valves and fittings, except immersed in potable water. This includes new piping and any existing piping indicated to be coated or damaged during construction.
 - a. Ductile Iron Piping
 - b. Carbon Steel Piping
 2. Miscellaneous ferrous metal surfaces

3. Equipment with ferrous metal surfaces
4. Aluminum surfaces (where in contact with concrete)

3.2 ITEMS NOT TO BE PAINTED

- A. All items indicated not to be painted shall be protected from surface preparation and application of coatings.
- B. Items not to be painted include the following:
 1. Any existing coated surface, unless specifically indicated to be painted.
 2. Pump surfaces, unless specifically indicated to be painted.
 3. Stainless steel surfaces, unless specifically indicated to be painted.
 4. Aluminum surfaces, unless specifically indicated on the Drawings or required in "Items to be Painted".
 5. PVC surfaces.
 6. Pipe insulation jacketing, unless specifically indicated to be painted.
 7. Any moving parts where the coating would hinder the operation of the equipment.
 8. Concrete surfaces, unless indicated to be coated in room finish schedule.
 9. Any item indicated to be entirely shop coated shall not be field coated.

3.3 EXAMINATION

- A. With Applicator present, examine substrates and conditions under which high-performance coatings will be applied, for compliance with coating application requirements.
 1. Apply coatings only after unsatisfactory conditions have been corrected and surfaces to receive coatings are thoroughly dry.
 2. Start of application is construed as Applicator's acceptance of surfaces within that particular area.
- B. Coordination of Work: Review other Sections in which primers or other coatings are provided to ensure compatibility of total systems for various substrates. On request, furnish information on characteristics of specified finish materials to ensure compatible primers.
 1. If a potential incompatibility of primers applied by others exists, obtain the following from the primer Applicator before proceeding:
 - a. Confirmation of primer's suitability for expected service conditions.

- b. Confirmation of primer's ability to be top coated with materials specified.
- 2. Notify Engineer about anticipated problems before using the coatings specified over substrates primed by others.

3.4 GENERAL PREPARATION

- A. Remove plates, machined surfaces, and similar items already in place that are not to be coated. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and coating.
 - 1. After completing coating operations, reinstall items that were removed; use workers skilled in the trades involved.
- B. Environmental Conditions
 - 1. Prior to the start of any coating work (surface preparation or coating application) verify conditions are within acceptable limits as specified.
 - a. Ambient air temperature shall be in the same areas as the work being performed.
 - b. Minimum and maximum surface temperatures and air temperatures shall be as indicated in writing from coating manufacturer. Minimum surface and air temperatures shall not be less than 45 degrees F and maximum surface and air temperatures shall not more than 95 degrees F, unless approved, in writing, by coating manufacturer's authorized representative and Engineer. Temperatures shall be followed for standard coating; shall not be adjusted for accelerator.
 - c. Ambient air temperature and surface temperature of substrate shall be at least 5 degrees F above dew point. If the difference is less than 10 degrees F; on following measurements, the difference shall be increasing.
 - d. Relative humidity shall be less than 85 percent.
 - e. Coating application and surface preparation shall not be performed in rain, snow, fog or mist.
 - f. Allow any wet or damp surfaces to dry thoroughly, and attain temperature prior to beginning coating application or surface preparation.
 - g. Avoid painting surfaces exposed to hot sun.
 - 1) Provide artificial shade if required.
 - h. Any additional environmental requirements stated on manufacturer's data sheets shall also be followed.

- i. Entire area where work is being performed shall be adequately ventilated. Use artificial methods if work space doesn't vent naturally.
 - 1) Provide adequate ventilation of confined spaces to prevent dust/blast media from accumulating or coming in contact with wet paint.
- C. Artificial Environmental Control
 - 1. Provide temporary heating as required (in-direct fired type only).
 - a. Provide clean heat with heat exchanger type equipment sufficient in size to maintain temperature.
 - b. No exhaust gases shall be allowed to vent into the space being painted.
 - 2. Provide temporary dehumidification equipment as required to maintain humidity levels within specified limits, if necessary to complete Work.
 - 3. Provide temporary ventilation equipment as required to complete Work.
- D. Prepare surfaces to be coated in accordance with coating manufacturer's instructions and this Section unless noted otherwise in the Specification.
- E. Remove all dust, grease, oil, compounds, dirt and other foreign matter which would prevent bonding of coating to surface.
 - 1. Adhere to manufacturer's recoat time surface preparation requirements.
 - a. Recoat time surface preparation requirement will not be waived.
 - b. Schedule cleaning and coating application so dust and other contaminants from cleaning process will not fall on wet, newly coated surfaces.

3.5 SURFACE PREPARATION

- A. Clean and prepare surfaces to be coated according to manufacturer's written instructions for each substrate condition and as specified.
- B. Prior to any further surface preparation, remove all visible oil, grease, soil, drawing and cutting compounds, and other soluble contaminants in accordance with SSPC-SP1 for steel surfaces or NAPF 500-03-01 for ductile iron surfaces.
- C. All corners and edges shall be rounded to a minimum of 1/8".
- D. Dry Abrasive Blasting
 - 1. Do not begin surface preparation if environmental conditions are not within acceptable limits.

2. Provide compressed air for blasting that is free of water and oil.
 - a. Provide accessible separators and traps.
 - b. Perform blotter test at start of work and after extended breaks. Test in accordance with ASTM D 4285.
 - c. If oil is found on surface during or after blasting, blotter test shall be performed immediately. Blasting shall not continue until problem is found, solved and blotter test is passed.
3. Surface Profile
 - a. Provide a minimum 2 mil surface profile on all blast cleaned surfaces, unless coating manufacturer indicates otherwise, in writing. Maximum surface profile shall be as indicated by coating manufacturer, in writing, prior to start of coating work.
 - b. Profile shall have an angular profile.
4. Perform additional blasting and cleaning as required to achieve surface preparation required.
 - a. Prior to painting, reblast surfaces allowed to set overnight and surfaces that show rust bloom.
5. Confine blast abrasives to area being blasted.
 - a. Provide shields of polyethylene sheeting or other such barriers to confine blast material.
 - b. Plug pipes, holes, or openings before blasting and keep plugged until blast operation is complete and residue is removed.
6. Protect any surfaces that may be damaged from blasting.
7. Abrasive blasting media may be recovered, cleaned and reused providing Contractor submits, for Engineer's review, a comprehensive recovery plan outlining all procedures and equipment proposed in reclamation process.
8. Properly dispose of blasting material contaminated with debris from blasting operation not scheduled to be reused.

E. Carbon Steel Surfaces

1. Atmospheric Exposure (Interior or Exterior)
 - a. Dry-abrasive blast clean all carbon steel surfaces exposed to atmospheric conditions to a near-white metal blast in accordance with NACE No. 2/SSPC-

SP10.

2. Immersed Exposure

- a. Dry-abrasive blast clean all carbon steel surfaces exposed to immersed conditions to a white metal blast in accordance with NACE No. 1/SSPC-SP5.

F. Ductile Iron Surfaces

1. Atmospheric Exposure (Interior or Exterior)

- a. Dry-abrasive blast clean all ductile iron pipe surfaces exposed to atmospheric conditions in accordance with NAPF 500-03-04.
- b. Dry-abrasive blast clean all ductile iron fitting surfaces exposed to atmospheric conditions in accordance with NAPF 500-03-05 "Ductile Iron Fitting Blast Clean #2". If previously coated with asphaltic (bituminous) paint, blast clean to "Ductile Iron Fitting Blast Clean #1".

2. Immersed Exposure

- a. Dry-abrasive blast clean all ductile iron pipe surfaces exposed to immersed conditions in accordance with NAPF 500-03-04.
- b. Dry-abrasive blast clean all ductile iron fitting surfaces exposed to immersed conditions in accordance with NAPF 500-03-05 "Ductile Iron Fitting Blast Clean #1".

G. Non-Ferrous Metal Surfaces (Aluminum, Stainless Steel, Copper)

1. Dry-abrasive brush blast clean any non-ferrous metal surfaces indicated to be coated in accordance with SSPC-SP16.

H. Existing Coated Surfaces specifically noted to be painted

1. Existing coating shall be entirely removed and the substrate shall be prepared according to requirements within this Section.

I. Shop Primed Surfaces

1. Touch up bare areas and shop-applied prime coats that have been damaged. Wire brush, solvent clean, and touch up with same primer as the shop coat.
2. Shop primed surfaces shall be lightly brush blasted prior to application of next coat, unless approved, in writing, by manufacturer's authorized representative and Engineer.

J. Pipe and Fitting Preparation:

1. Painter shall install a 360 degree bead of caulk, prior to or after topcoat, in the void between mating flange faces and in the void between any pipe and the dismantling joint or thread-on-flange, for ductile iron pipe. The bead of caulk shall prevent water from penetrating into the described void and leaving rust streaks. Caulking shall not be performed until after passing pressure or leak testing of the pipe.

3.6 APPLICATION

- A. General: Apply high-performance coatings according to manufacturer's written instructions.
 1. Use applicators and techniques best suited for the material being applied.
 2. Thin, mix and apply coatings by brush, roller, or spray in accordance with manufacturer's installation instructions.
 3. Surface Cleanliness
 - a. Do not apply high-performance coatings over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions detrimental to forming a durable coating film.
 - b. Avoid degradation and contamination of blasted surfaces and avoid intercoat contamination.
 - 1) Clean contaminated surfaces before applying next coat.
 - c. Prior to the application of any single coat, surface must be free of all visible contaminants.
 - 1) Maximum allowable dust content is "Level 2" as defined in Figure 1 of ISO Standard 8502-3.
 - a) Any overall discoloration of the tape shall be deemed dust content "Level 5" and is not acceptable.
 - 2) Maximum size of dust particles is "Class 2" as defined in Table 1 of ISO Standard 8502-3.
 - 3) Above indicated requirements are the maximum allowed; if coating manufacturer's authorized representative specifies a more restrictive requirement, then follow manufacturer's recommendation.
 4. Provide complete coverage to dry film thickness specified.
 - a. No individual gage readings shall be lower than specified.
 5. If so directed by Engineer, do not apply consecutive coats until Engineer has had an opportunity to observe previous coats.
 6. Apply materials under adequate illumination.

7. Evenly spread to provide full, smooth coverage.
8. Smooth out runs or sags immediately, or remove prior to next coat; if on top coat remove and reapply entire top coat.
9. Allow preceding coats to dry before recoating.
 - a. Allow sufficient time between successive coats to permit proper drying. Do not recoat surfaces until coating has dried to where it feels firm, does not deform or feel sticky under moderate thumb pressure, and application of another coat does not cause undercoat to lift or lose adhesion.
 - b. Do not apply succeeding coats until previous coat has cured as recommended by manufacturer.
 - c. Recoat within time limits specified by coating manufacturer.
 - d. If recoat time limits have expired reprepare surface in accordance with coating manufacturer's printed recommendations.
 - e. If epoxy coating is exterior exposed for more than 30 days, coating shall be lightly brush blasted prior to application of next coat.
10. Allow coated surfaces to cure prior to allowing traffic or other work to proceed.
11. Coating colors, surface treatments, and finishes are indicated in the coating system descriptions.
12. Provide finish coats compatible with primers used.
13. The term "exposed surfaces" includes areas visible when permanent or built-in fixtures, convector covers, grilles, covers for finned-tube radiation, and similar components are in place. Extend coatings in these areas, as required, to maintain system integrity and provide desired protection.
 - a. Coat surfaces behind movable equipment the same as similar exposed surfaces. Before final installation, coat surfaces behind permanently fixed equipment with prime coat only.
 - b. Coat back sides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.
 - c. Pipe surfaces covered by pipe supports shall be coated with entire specified system prior to the installation of the pipe support.
14. Tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of the same material are to be applied. Tint undercoats to match color of finish coat, but provide sufficient difference in shade of undercoats to distinguish each separate

coat.

15. If undercoats or other conditions show through final coat, apply additional coats until cured film has a uniform coating finish, color, and appearance.
 16. Apply coatings to produce surface films without cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections. Produce sharp glass lines and color breaks.
 17. Where manufacturer's written instructions require sanding, sand between applications to produce a smooth, even surface.
- B. Material Preparation: Carefully mix and prepare coating materials according to manufacturer's written instructions.
1. Maintain containers used in mixing and applying coatings in a clean condition, free of foreign materials and residue. If a bucket must be kept open, keep in an area protected from wind and wind-blown debris. Strain any coating that gets contaminated.
 2. Stir materials before applying to produce a mixture of uniform density. Stir as required during application. Do not stir surface film into the material. Remove film and, if necessary, strain coating material before using.
 3. For multiple component coatings, stir components individually prior to mixing.
 4. Do not mix previously catalyzed material with newly mixed material.
 5. Use only the type of thinners approved by manufacturer (if thinning is approved by Engineer) and only within recommended limits.
 - a. Exact quantity of thinner shall be measured and recorded prior to mixing with coating material.
- C. Prime Coat:
1. Apply prime coat within 8 hours of start of surface preparation. Surface shall not be allowed to flash rust prior to application of coatings.
 2. Prime coat can be shop applied if the following conditions are met:
 - a. Shop applied prime coats shall be same as prime coat indicated for specified system to be applied.
 - b. Submit form, included at end of this Section, for all products that have shop primed. Form shall be included in submittal documents.
 - c. Written notice is provided to Engineer at least two (2) weeks in advance.
 - d. Coordinate schedule of shop priming with Engineer to allow for observation.

- e. Engineer or Coating Inspector is allowed access to shop to observe surface preparation and/or coating application.
- f. Quality control requirements shall be the same as specified in this Section for "Field Quality Control".
 - 1) Documentation shall be provided at the same interval as specified.
 - 2) Documentation shall be provided prior to the equipment arriving on site.
- 3. Prime coat on ferrous metals cast in concrete shall extend from atmospheric or immersed exposure to at least 1 IN past face of concrete.

D. Stripe Coat:

- 1. Apply stripe coat to all welds, corners, edges, gouges, any other change in surface profile and any surface narrower than 6 inches wide.
- 2. Apply between the prime coat and intermediate coat.
- 3. Stripe coat shall be of the same product as the intermediate coat, unless indicated otherwise in the coating system.
- 4. Apply with brush only; work coating material into all crevices.
- 5. Stripe coat shall also be applied to areas that are difficult to spray or reach with roller.
- 6. Stripe coat is to be an individual coat; cannot be applied concurrently with intermediate coat.
- 7. Color of stripe coat shall also be of a different tint. If necessary due to limited color selection, the stripe coat shall be the same as the intermediate coat and different than the prime coat, but only when just 2 colors are available.

E. Intermediate/Top Coats:

- 1. If undercoats or other conditions show through final coat, apply additional coats until cured film has a uniform coating finish, color, and appearance. Give special attention to edges, corners, crevices, welds, exposed fasteners, and similar surfaces to ensure that they receive a dry film thickness equivalent to that of flat surfaces.

F. Application Procedures:

- 1. Brush Application: Use brushes best suited for material applied and of appropriate size for the surface or item being coated.
 - a. Brush out and work brush coats into surfaces in an even film.

- b. Eliminate cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections. Neatly draw glass lines and color breaks.
 - 2. Rollers: Use rollers of carpet, velvet back, or high-pile sheep's wool as recommended by manufacturer for the material and texture required.
 - 3. Spray Application: Use mechanical methods to apply coating if permitted by manufacturer's written instructions and governing regulations.
 - a. Conventional Air Spray:
 - 1) Use spray equipment with orifice size recommended by manufacturer for material and texture required.
 - 2) Provide compressed air for conventional air spray that is free of water and oil.
 - a) Provide accessible separators and traps.
 - b) Perform blotter test at start of work and after extended breaks. Test in accordance with ASTM D 4285.
 - b. Airless Spray:
 - 1) Use equipment (pump, orifice, etc.) sized appropriately for the application as recommended by manufacturer.
- G. Minimum/Maximum Coating Thickness: Apply each coat no thinner or thicker than manufacturer's recommended thickness. Provide total dry film thickness of each system as specified.
 - 1. The number of coats and film thickness required is the same regardless of application method.
- H. Completed Work: Match approved Samples for color, texture, and coverage. Remove, refinish, or recoat work that does not comply with specified requirements.

3.7 CURING

- A. Environmental conditions shall be monitored and maintained until coating has sufficient time to cure. If required by ambient conditions, artificial environmental control shall be used during the cure of the coating.
- B. Ventilation (natural or artificial) shall also be continued until coating has achieved complete cure.

3.8 CLEANING

- A. Cleanup: At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.
 - 1. After completing coating application, clean spattered surfaces. Remove spattered coatings by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

3.9 PROTECTION

- A. Protect work of other trades, whether being coated or not, against damage from coating operation. Correct damage by cleaning, repairing, replacing, and recoating, as approved by Architect, and leave in an undamaged condition.
 - 1. Provide "Wet Paint" signs to protect newly coated finishes. After completing coating operations, remove temporary protective wrappings provided by others to protect their work.
 - 2. At completion of construction activities of other trades, touch up and restore damaged or defaced coated surfaces. Comply with procedures specified in PDCA P1.

3.10 FIELD QUALITY CONTROL

- A. Maintain Daily Records:
 - 1. Applicator shall provide daily records.
 - 2. Daily records shall be submitted weekly.
 - 3. Daily records shall include the following:
 - a. Date, starting time, end time, and all breaks taken by painters.
 - b. Area worked and work performed in area.
 - c. Start and end time of any coating application.
 - d. Batch numbers, dates, and quantity of coating used each day.
 - e. All quality control information below.
- B. Applicator is required to provide all equipment necessary to perform quality control work. All equipment shall be specifically designed for intended use.
- C. Quality control shall be performed by only qualified personnel.
- D. Environmental Conditions

1. The information required shall be measured and recorded during surface preparation, coating application and during the time required to achieve the necessary curing time.
2. Readings shall be taken in the morning prior to starting work, after lunch and at the end of the day prior to leaving the site. Readings may be required more frequently if the environmental conditions are continually changing. Frequency may be considered a judgement call. Applicator is responsible for any work affected by changing environmental conditions.
3. The information required shall include but not be limited to the following:
 - a. For exterior painting:
 - 1) Sky condition.
 - 2) Wind speed and direction.
 - b. Air temperature
 - c. Relative humidity
 - d. Dew point
 - e. Surface temperature of substrate to which paint is being applied.
 - f. Date and start time of cure period.
 - g. Written documentation of all occurrences when air temperature, humidity, dew point or surface temperature reached or violated manufacturer's recommended minimum or maximum limits.

E. Surface Preparation

1. Visually inspect entire surface for any visible contaminants (oil, dust, dirt, rust, mill scale, etc.). Document and correct any contaminants found.
2. Surface Cleanliness
 - a. Abrasive blast cleaned surfaces shall be visually compared to written standard at minimum every 100 sq. ft. of blasting performed.
3. Surface profile measurements
 - a. Surface profile measurements of all abrasive blast cleaned surfaces shall be taken at minimum every 100 sq. ft. of blasting performed.
 - b. Surface profile measurements shall be conducted in accordance with the latest version of NACE RP0287

4. Dust

- a. Dust measurements shall be taken every 100 sq. ft. of surface to be coated (both blasted surfaces and previously coated surfaces).
- b. Dust measurements shall be conducted in accordance with the latest version of ISO 8502-3.

F. Application

1. Verify mixing and induction (sweat-in) times are met. Document shortest times.
2. Verify pot life is not exceeded. Document longest times.
3. Verify mixing is being performed in accordance with manufacturer's written recommendations.
4. Verify and document amount of thinner used.
5. Document method of application.
6. Wet mil thickness verification frequency is not required. Applicator to perform as necessary to ensure consistent thickness. Document any wet mil thickness measurements performed.
7. After each coat has sufficiently cured, perform dry mil thickness verification. Perform measurements in accordance with ASTM D 7091. Frequency of measurements shall be in accordance with SSPC-PA2, with the following modifications.
 - a. Average readings per the standard with restrictions as noted in "Level 2", except individual gage readings shall also be restricted to as specified. All individual gage readings shall be above specified mil thickness.
 - b. Coating Inspector shall be present during measurements taken of the completed coating system.

G. Curing

1. Provide environmental data at minimum every 12 hours during the curing period.
2. Perform solvent rub test in accordance with ASTM D 5402, if environmental data provided is inadequate to determine cure.

H. Holiday Test

1. Owner reserves the right to have the Applicator conduct holiday test on 100 percent of coated surfaces.
2. Perform holiday testing in accordance with NACE SP0188.

3. Holiday testing shall be performed under the observation of the Engineer or Coating Inspector during normal business hours.
4. Providing equipment for holiday testing is the responsibility of the Applicator.

I. Adhesion Test

1. Owner reserves the right to have the Applicator conduct coating adhesion tests, if cleanliness or surface preparation are questioned.
2. Applicator is responsible for the cost and repair of the adhesion test.
3. Adhesion test shall be performed in accordance with ASTM D 4541.
4. Adhesion tests will not be performed more than once every 1000 sq. ft. of coated surface.
 - a. If adhesion test fails, additional tests may be performed at the Applicator's expense to determine extent of non-adherent coating.

J. Summary Report

1. At completion of Work, prepare and submit a summary report.
2. Summary report shall include the following:
 - a. Dry film thickness reports.
 - b. Holiday test reports, if performed.
 - c. Adhesion test reports, if performed.
 - d. All coating batch numbers used.
 - e. All repairs performed.

3.11 COORDINATION WITH OWNER OBSERVATION (COATING INSPECTOR)

- A. The Owner may choose to hire a coating inspector to observe all aspects of the work covered by these Specifications.
- B. Contractor or Applicator shall provide access and safety equipment, if necessary, for coating inspector and/or resident project representative to all areas where coating work is being performed.
- C. Applicator is responsible for coordination of Work with Coating Inspector. Applicator shall hold to allow observation by Coating Inspector at the following points:
 1. After surface preparation, but before application of prime coat.
 2. Between coats.

3. Prior to performing repairs.
- D. Coating Inspector shall be present for the following tests.
1. Dry film thickness measurements for completed coating system.
 2. Holiday testing.
 3. Adhesion testing.
- E. Coating inspector may perform tasks similar to Applicator required quality control items. The performance of these tasks does not relieve the Applicator of having to perform these requirements.
1. In the event that readings between the coating inspector's equipment and Applicator's equipment are substantially different; the calibration of both instruments shall be verified.
 - a. If readings still conflict, new readings shall be taken with the following equipment, provided by the Applicator:
 - 1) Ambient Conditions: Sling Psychrometer and Psychrometric Tables from the National Weather Service.
 - 2) Surface Temperature: Magnetic Surface Contact Thermometer.
 - 3) Dry Film Thickness: Type 1 – Magnetic Pull-Off Gage w/ calibration certificate within the past 6 months.
- F. The Contractor will be required to provide at least a seven (7) calendar day written notice to the Engineer/Owner to provide adequate time to schedule the observation. In the event that the Contractor must cancel a scheduled observation, the Contractor must notify the Engineer at least two (2) working days (not less than 48 hours) in advance of the scheduled inspection or will be responsible for all expenses as discussed in Part 3.11 G.
- G. In the event of a failed test that requires the Coating Inspector to return to the site for observation of the repair and retest of the failed work, the Contractor will be responsible for reimbursing the Owner for all expenses related to the additional inspection/test up to a maximum of \$1,000.00 per day.
1. These costs will be incorporated into the Contract via Change Order at the completion of the coating work.

3.12 REPAIR OF COATING DEFECTS

- A. Coating defects include all spots found during the holiday test, gouges or wear from other trades or assembly, issues found during manufacturer's walk through at completion of coating work, and anything that doesn't resemble a uniform, undisturbed coating.

- B. All repairs shall be performed in accordance with coating manufacturer's written recommendations. Written recommendations shall be provided prior to any repairs being made. For typical repairs, provide written recommendations prior to the start of any coating work.
- C. Coating manufacturer shall supply written recommendations for typical coating defects (such as runs/sags, gouges, misses, excessive film thickness, chalking, overspray) prior to the start of coating work.
- D. Repair coatings shall consist of the same number of coats and thicknesses as the coating system that is being repaired.

3.13 TRAINING

- A. Coating Manufacturer and Applicator shall conduct training for the Owner on procedures for coating repair and maintenance. Coating Manufacturer's authorized representative and Applicator shall be present for training.
 - 1. Time allotted for training shall be 4 hours.
 - 2. This training may be provided around the same time as the Coating Completion Conference.

END OF SECTION 09 9600

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Equipment Coating Submittal Information

Equipment Information	Project Name		Equipment Supplied Under Specification Section:	
	Equipment Name			
	Supplied Equipment Tag No(s).			
	Equipment Manufacturer/Supplier		Contact Person	
			Phone #	
	Sales Representative		Contact Person	
			Phone #	
Material of Equipment Body (Exterior)				
Is equipment coated?				
Coating Information	If product is shop coated, complete the following:			
	Level Surface Preparation Obtained			
	Coating Information:			
	Coating Manufacturer		Coating Representative Contact Person	
			Phone #	
	Coating Product of Each Coat (Name & Generic Classification)			
	DFT (Dry Film Thickness) of Coating (mils) Individual Coats:			
	Total System (Provide measured result, once available):			
	Date Coated (or to be coated):			
Can coating be field top coated?				
If coating can be field top coated and is specified to be field top coated, is factory coating compatible with top coat submitted and approved? (Provide written approval from coating manufacturer of top coat material with specific surface preparation requirements)				

Prepared By: _____
Name, Company

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**SECTION 10 4416
FIRE EXTINGUISHERS**

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes portable, hand-carried fire extinguishers and mounting brackets for fire extinguishers.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rating and classification, material descriptions, dimensions of individual components and profiles, and finishes for fire extinguisher and mounting brackets.
- B. Product Schedule: For fire extinguishers. Coordinate final fire extinguisher schedule with fire protection cabinet schedule to ensure proper fit and function. Use same designations indicated on Drawings.
- C. Operation and Maintenance Data: For fire extinguishers to include in maintenance manuals.
- D. Warranty: Sample of special warranty.

1.4 QUALITY ASSURANCE

- A. NFPA Compliance: Fabricate and label fire extinguishers to comply with NFPA 10, "Portable Fire Extinguishers."
- B. Fire Extinguishers: Listed and labeled for type, rating, and classification by an independent testing agency acceptable to authorities having jurisdiction.
 - 1. Provide fire extinguishers approved, listed, and labeled by FMG.

1.5 COORDINATION

- A. Coordinate type and capacity of fire extinguishers with fire protection brackets to ensure fit.

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace fire extinguishers that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:

- a. Failure of hydrostatic test according to NFPA 10.
 - b. Faulty operation of valves or release levers.
2. Warranty Period: Six years from date of Substantial Completion.

PART 2 PRODUCTS

2.1 PORTABLE, HAND-CARRIED FIRE EXTINGUISHERS

- A. Fire Extinguishers: Type, size, and capacity for each mounting bracket indicated.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. J.L. Industries, Inc.; a division of Activar Construction Products Group.
 - b. Larsen's Manufacturing Company.
 2. Valves: Manufacturer's standard.
 3. Handles and Levers: Manufacturer's standard.
 4. Instruction Labels: Include pictorial marking system complying with NFPA 10, Appendix B and bar coding for documenting fire extinguisher location, inspections, maintenance, and recharging.
- B. Multipurpose Dry-Chemical Type in Steel Container: UL-rated 4-A:80-B:C, 10-lb nominal capacity, with mono-ammonium phosphate-based dry chemical in enameled-steel container.

2.2 MOUNTING BRACKETS

- A. Mounting Brackets: Manufacturer's standard galvanized steel, designed to secure fire extinguisher to wall or structure, of sizes required for types and capacities of fire extinguishers indicated, with plated or black baked-enamel finish.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. J. L. Industries, Inc.; a division of Activar Construction Products Group.
 - b. Larsen's Manufacturing Company.
- B. Identification: Lettering complying with authorities having jurisdiction for letter style, size, spacing, and location. Locate as indicated by Architect.

1. Identify bracket-mounted fire extinguishers with the words "FIRE EXTINGUISHER" in red letter decals applied to mounting surface.
 - a. Orientation: Vertical.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine fire extinguishers for proper charging and tagging.
 1. Remove and replace damaged, defective, or undercharged fire extinguishers.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. General: Install fire extinguishers and mounting brackets in locations indicated and in compliance with requirements of authorities having jurisdiction.
 1. Mounting Brackets: 54 inches (137.2 cm) above finished floor to top of fire extinguisher.
- B. Mounting Brackets: Fasten mounting brackets to surfaces, square and plumb, at locations indicated.

END OF SECTION 10 4416

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**SECTION 23 0500
COMMON WORK RESULTS FOR HVAC**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Equipment installation requirements common to equipment sections.
 - 2. Painting and finishing.
 - 3. Supports and anchorages.

1.3 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
- F. The following are industry abbreviations for plastic materials:
 - 1. ABS: Acrylonitrile-butadiene-styrene plastic.
 - 2. CPVC: Chlorinated polyvinyl chloride plastic.
 - 3. PE: Polyethylene plastic.
 - 4. PVC: Polyvinyl chloride plastic.
- G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- B. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Materials and equipment stored on the site shall have protective covering to prevent damage and to prevent entrance of dirt, debris, and moisture.

1.6 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.
- B. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 8 Section "Access Doors and Frames."

1.7 PROJECT CLOSEOUT

- A. Refer to Division 1 Section "Closeout Procedures" for additional requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURER

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

PART 3 - EXECUTION

- A. Verify final equipment locations for roughing-in.
- B. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.2 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel, and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- D. Install equipment to allow right of way for piping installed at required slope.

3.3 PAINTING

- A. Remove markings, stickers, tags, lubricants, protective oils, and other substances and repair damaged surfaces of equipment, piping, ductwork that will be exposed to view in finished spaces. Clean and prepare surfaces that are specified to be finish painted.
- B. Painting of HVAC systems, equipment, and components is specified in Division 9 Sections "Interior Painting" and "Exterior Painting."
- C. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.4 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 5 Section "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.5 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.
- B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
- C. Attach to substrates as required to support applied loads.

END OF SECTION 23 0500

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**SECTION 23 0513
COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes general requirements for single-phase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on AC power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor Controllers: Variable frequency drives and variable flow motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 5200 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
 - 2. Split phase.
 - 3. Capacitor start, inductor run.
 - 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

2.4 ECM MOTORS

- A. Where indicated motors shall be Electronically Commutated Motor, ECM, variable-speed, DC, brushless motors specifically designed for use with single phase, 60 hertz electrical input. Motor shall be complete with and operated by a single-phase integrated controller/inverter that operates the wound stator and senses rotor position to electronically commutate the stator. All motors shall be designed for synchronous rotation. Motor rotor shall be permanent magnet type with near zero rotor losses. Motor shall have built-in soft start and soft speed change ramps. Motor shall be able to be mounted with shaft in horizontal or vertical orientation. Motor shall be permanently lubricated with ball bearings. Motor shall be direct coupled to the driven equipment. Motor shall maintain a minimum of 70% efficiency over its entire operating range. Provide manual or remote motor speed output control for field adjustment of the motor speed setpoint. Inductors shall be provided to minimize harmonic distortion and line noise. Provide isolation between fan motor assembly and driven equipment to eliminate any vibration. Provide a motor that is designed to overcome reverse rotation and not affect life expectancy. Manufacturer shall provide a factory installed Pulse Width Modulation, PWM, controller for either manual or DDC controlled speed adjustment. The manual PWM controller shall be field adjustable with a standard screwdriver. The remote PWM controller shall be capable of receiving a 0-10 Vdc signal from the DDC controller (provided by the controls contractor) to control the motor speed.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 0513

SECTION 23 0529
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal framing systems.
 - 2. Fastener systems.
 - 3. Equipment supports.
- B. Related Sections:
 - 1. Division 23 Section "Vibration Controls for HVAC Piping and Equipment" for vibration isolation devices.
 - 2. Division 23 Section "Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

- A. MSS: Manufacturers Standardization Society of the Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design pipe hangers and equipment supports using performance requirements and design criteria indicated. If necessary, engage the services of a professional engineer to provide pipe hangers and equipment support design assistance.
- B. Structural Performance: Hangers and supports for HVAC equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - 1. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
 - 2. Obtain approval from authorities having jurisdiction.

1.5 QUALITY ASSURANCE

- A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 METAL FRAMING SYSTEMS

- A. Manufactured Metal Framing Systems:
 - 1. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
 - 2. Standard: MFMA-4.
 - 3. Channels: Continuous slotted steel channel with in-turned lips.
 - 4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
 - 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized-steel or stainless steel.
 - 6. Coating: Metallic, painted, or plastic coating (not bare metal).

2.2 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated or stainless-steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.3 EQUIPMENT SUPPORTS

- A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes. Finished supports shall be galvanized or prime-painted.

2.4 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

- A. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- B. Fastener System Installation:
 - 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 - 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- C. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- D. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- E. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
 - 1. Do not install building attachments to metal roof decking, or other non-structural members.

3.2 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

- A. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

- A. Galvanized or Prime-Painted Metallic Coatings: Provide galvanized coatings for ferrous hangers and supports, including building attachments, structural steel supports and miscellaneous metals. Prime-painted materials may be used if completed prior to assembly and installation. Provide prime-painted materials for hangers and supports exposed to view.
- B. Touching Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop priming. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- C. Galvanized Surfaces: Clean welded connections, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.
- D. Finish Painting: Clean and prepare surfaces of any hangers and supports that are to be field finish painted. Refer to Division 9 Sections for field finish painting (if any).

3.6 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- C. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- D. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 23 0529

**SECTION 23 0553
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Warning signs and labels.
 - 3. Duct labels.
 - 4. Warning tags.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.

1.4 COORDINATION

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:
 - 1. Material and Thickness: Aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 - 3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - 4. Fasteners: Stainless-steel rivets or self-tapping screws.

5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Plastic Labels for Equipment:
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick and having predrilled holes for attachment hardware.
 2. Letter Color: Black.
 3. Background Color: White.
 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 7. Fasteners: Stainless-steel rivets or self-tapping screws.
 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.
- D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick and having predrilled holes for attachment hardware.
- B. Letter Color: Black.
- C. Background Color: White.
- D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

- F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 WARNING TAGS

- A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
 - 1. Size: Approximately 4 by 7 inches.
 - 2. Fasteners: Reinforced grommet and wire or string.
 - 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 - 4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.3 WARNING-TAG INSTALLATION

- A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 23 0553

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SECTION 23 0593
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Balancing Air Systems:
 - a. Constant-volume air systems.

1.3 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. NEBB: National Environmental Balancing Bureau.
- C. TAB: Testing, adjusting, and balancing.
- D. TABB: Testing, Adjusting, and Balancing Bureau.
- E. TAB Specialist: An entity engaged to perform TAB Work.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Certified TAB reports.
- C. Sample report forms.
- D. Instrument calibration reports, to include the following:
 - 1. Instrument type and make.
 - 2. Serial number.
 - 3. Application.
 - 4. Dates of use.

5. Dates of calibration.

1.5 QUALITY ASSURANCE

- A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC or NEBB.
 1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC or NEBB.
 2. TAB Technician: Employee of the TAB contractor and who is certified by AABC or NEBB as a TAB technician.
- B. Certify TAB field data reports and perform the following:
 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.
- C. TAB Report Forms: Use standard TAB contractor's forms approved by Engineer and Owner.
- D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."
- E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- F. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.6 COORDINATION

- A. The Owner uses a digital platform for recording airflow readings. Contractor will be responsible to provide a field device of their own or can load software on their own laptop/netbook PC.
- B. Notice: Provide seven days' advance notice for each test to the Engineer, and Owner and include scheduled test dates and times.
- C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
- B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine equipment performance data including fan and pump curves.
 - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
- F. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- G. Examine test reports specified in individual system and equipment Sections.
- H. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- I. Examine operating safety interlocks and controls on HVAC equipment.
- J. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures.
- B. Complete system-readiness checks and prepare reports. Verify the following:

1. Permanent electrical-power wiring is complete.
2. Automatic temperature-control systems are operational.
3. Equipment and duct access doors are securely closed.
4. Balance, smoke, and fire dampers are open.
5. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.
 1. Comply with requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
 1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 2. After testing and balancing, install test ports and duct access doors that comply with requirements in Division 23 Section "Air Duct Accessories."
 3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section insulation sections.
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- D. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

- E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- F. Verify that motor starters are equipped with properly sized thermal protection.
- G. Check dampers for proper position to achieve desired airflow path.
- H. Check for airflow blockages.
- I. Verify that air duct system is sealed as specified in Division 23 Section "Metal Ducts."

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure total airflow.
 - a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.
 - 2. Measure fan static pressures as follows to determine actual static pressure:
 - a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
 - b. Measure static pressure directly at the fan outlet or through the flexible connection.
 - c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
 - d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
 - 3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
 - a. Report the cleanliness status of filters and the time static pressures are measured.
 - 4. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 - 5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

- B. Adjust volume dampers for main duct to indicated airflows within specified tolerances.
 - 1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.

3.6 PROCEDURES FOR MOTORS

- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
 - 1. Manufacturer's name, model number, and serial number.
 - 2. Motor horsepower rating.
 - 3. Motor rpm.
 - 4. Efficiency rating.
 - 5. Nameplate and measured voltage, each phase.
 - 6. Nameplate and measured amperage, each phase.
 - 7. Starter thermal-protection-element rating.

3.7 TOLERANCES

- A. Set HVAC system's air flow rates and water flow rates within the following tolerances:
 - 1. Exhaust Fans and Equipment with Fans: Plus or minus 10 percent .
 - 2. Air Outlets and Inlets: Plus or minus 10 percent .

3.8 REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

3.9 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
 - 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 - 2. Include a list of instruments used for procedures, along with proof of calibration.

- B. Final Report Contents: In addition to certified field-report data, include the following:
1. Fan curves.
 2. Manufacturers' test data.
 3. Field test reports prepared by system and equipment installers.
 4. Other information relative to equipment performance; do not include Shop Drawings and product data.
- C. General Report Data: In addition to form titles and entries, include the following data:
1. Title page.
 2. Name and address of the TAB contractor.
 3. Project name.
 4. Project location.
 5. Architect's name and address.
 6. Engineer's name and address.
 7. Contractor's name and address.
 8. Report date.
 9. Signature of TAB supervisor who certifies the report.
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Notes to explain why certain final data in the body of reports vary from indicated values.
 14. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outdoor- and exhaust-air dampers.

- b. Conditions of filters.
 - c. Fan drive settings including settings and percentage of maximum pitch diameter.
 - d. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
 - 1. Quantities of outdoor and exhaust airflows.
 - 2. Duct, outlet, and inlet sizes.
 - 3. Balancing stations.
 - 4. Position of balancing devices.
- E. Fan Test Reports: For supply, return, and exhaust fans, include the following:
 - 1. Fan Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches, and bore.
 - h. Center-to-center dimensions of sheave, and amount of adjustments in inches.
 - 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches.

- g. Number, make, and size of belts.
 - 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Suction static pressure in inches wg.
- F. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
 - 1. Report Data:
 - a. System and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F.
 - d. Duct static pressure in inches wg.
 - e. Duct size in inches.
 - f. Duct area in sq. ft.
 - g. Indicated air flow rate in cfm.
 - h. Indicated velocity in fpm.
 - i. Actual air flow rate in cfm.
 - j. Actual average velocity in fpm.
 - k. Barometric pressure in psig.
- G. Instrument Calibration Reports:
 - 1. Report Data:
 - a. Instrument type and make.
 - b. Serial number.
 - c. Application.

- d. Dates of use.
- e. Dates of calibration.

3.10 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
2. Check the following for each system:
 - a. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
 - b. Verify that balancing devices are marked with final balance position.
 - c. Note deviations from the Contract Documents in the final report.

B. Final Inspection:

1. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Construction Manager.
2. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
3. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.

END OF SECTION 23 0593

SECTION 23 0900
INSTRUMENTATION AND CONTROLS SYSTEMS FOR HVAC

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes control equipment for HVAC systems and components.
- B. Provide the following Electrical Work complying with the requirements of Division 26.
 - 1. Power supply wiring needed in addition to or different from electrical power supply wiring shown on the Electrical Drawings. Include disconnects and required electrical devices. Power supply wiring shall extend from separate circuits on electrical power panels located as indicated on the Electrical Drawings.
 - 2. Power wiring control wiring between field-installed sensing and control devices, controlled equipment, and unit control panels. Include disconnects and required electrical devices.
 - 3. Connection to the building-wide local or wide area internet network.

1.3 SUBMITTAL

- A. Product Data: Include manufacturer's technical literature for each control device and component in the control system. Include a complete list of equipment and materials, including manufacturers catalog data sheets and installation instructions for all controllers, valves, dampers, sensors, routers, etc.
- B. Shop Drawings: Include complete wiring and schematic diagrams, software descriptions, calculations, and any other details required to demonstrate that the system has been coordinated and will properly function as a system. Terminal identification for all control wiring shall be shown on the shop drawings. A complete written Sequence of Control shall also be included with the submittal package.
- C. Damper Schedule: Damper and operator sizing shall be performed, and a schedule created by the Control Contractor. The damper schedule shall include a separate line for each damper and a column for each of the damper attributes such that each damper and operator are fully described.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons through shipping, storage, and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

1.6 COORDINATION

- A. Coordination with Other Trades: Coordinate the Work of this Section with that of other sections to ensure that the Work will be carried out in an orderly fashion. It shall be this Contractor's responsibility to check the Contract Documents for possible conflicts between his Work and that of other trades in equipment location, pipe, duct and conduit runs, electrical outlets and fixtures, air diffusers, and structural and architectural features.
- B. Coordinate location of temperature and humidity sensors, and other exposed control sensors with plans and room details before installation.
- C. Coordinate the location and installation of automatic control dampers. Installation of control dampers is the Work of Division 23 Sections "Duct Accessories."
- D. Coordinate equipment with Division 26 Sections to achieve compatibility electrical power systems.

PART 2 – PRODUCTS

2.1 OTHER CONTROL SYSTEM HARDWARE

- A. Actuators, General. Automatically controlled devices, unless specified otherwise elsewhere, shall be provided with actuators sized to operate their appropriate loads with sufficient reserve power to provide smooth modulating action or two-position action and tight close-off. Actuators shall be power failure return type where valves or dampers are required to fail to a safe position and where specified.
 - 1. Spring Return Direct Coupled Actuators. Actuators shall have torque ratings of 44lb-in., 88 lb-in., or 175 lb-in. Actuators shall be modulating 90 seconds nominal timing or two-position 45 seconds nominal timing types with strokes for 90-degree rotation applications and designed for operation between -40 and 140 F.
 - a. Each torque rating group shall have optionally selected control types, floating control, 2-position 24 Vac, 2-position line voltage, or analog input which is switch selectable as 0-10Vdc, 10-0 Vdc, 2-10 Vdc, or 10-2 Vdc.
 - b. Actuator spring return direction (open or closed) shall be easily reversed in the field, and actuators shall spring return in no greater than 20 seconds.

- c. Actuators shall be direct connected (no linkages) and shall have integral position indication.
- d. Actuators shall have NEMA 2 environmental protection rating, and UL approved and plenum rated per UL873.
- e. Minimum design life of modulating actuators shall be for 1,500,000 repositions and 60,000 spring returns, except 2-position actuators shall be for 50,000 spring returns.
- f. Each actuator shall be provided with a manual power-off positioning lever for manual positioning during power loss or system malfunctions, including a gear-train lock to prevent spring action.
- g. Upon power restoration after gear lock, normal operation shall automatically recur.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install system and materials in accordance with manufacturer's instructions, and as detailed on the project drawing set.
- B. Verify location of temperature and humidity sensors, and other exposed control sensors with Drawings and room details before installation. Install devices 60 inches above the floor, unless otherwise indicated.
- C. Coordinated the installation of automatic control dampers. Installation is the Work of Division 23 Section "Air Duct Accessories."
- D. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.
- E. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. Electrical control wiring and power wiring to the control panels, NAC, computers and network components shall be the responsibility of the Contractor.
- B. Install raceways, boxes, and cabinets according to Division 26 Section "Raceways and Boxes for Electrical Systems."
- C. Install building wire and cable according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- D. Controls Wiring Installation:

1. Wiring Exposed to View, or Inaccessible: Run wiring within electric metallic tubing where exposed to view and where subject to physical damage, such as in mechanical rooms; and where inaccessible such as in concrete walls or floors, furred walls, or above ceilings with no access.
 - a. Wiring routed above sheet rock ceilings will be considered inaccessible.
2. Wiring Concealed and Accessible: Run wiring within or without electric metallic tubing where concealed and accessible, such as above suspended ceilings. If run without conduit, it shall be run parallel and perpendicular to building lines with a maximum unsupported length of 48-inches.
 - a. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
 - b. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
 - c. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
 - d. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
- F. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
- G. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.3 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
 2. Test and adjust controls and safeties.
 3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
 4. Test each point through its full operating range to verify that safety and operating control set points are as required.
 5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
 6. Test each system for compliance with sequence of operation.

7. Test software and hardware interlocks.

3.4 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
5. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
6. Provide diagnostic and test instruments for calibration and adjustment of system.
7. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

3.5 ACCEPTANCE TESTING

- A. This contractor shall perform all necessary calibration and testing and perform all required operational checks to ensure that the system is functioning in full accordance with these specifications.
- B. This contractor shall perform tests to verify proper performance of components, routines, and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100% of the input and output points.
- C. System Acceptance: Satisfactory completion is when this contractor and the Division 26 contractor have performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the Owner's Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

END OF SECTION 23 0900

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**SECTION 23 3113
METAL DUCTS**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Single-wall rectangular ducts and fittings.
 - 2. Single-wall round ducts and fittings.
 - 3. Sheet metal materials.
 - 4. Sealants and gaskets.
 - 5. Hangers and supports.
- B. Related Sections:
 - 1. Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
 - 2. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's 2005 "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article. References given in this specification are from SMACNA's 2005 edition.
- B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 SUBMITTALS

- A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
- B. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to the following:
 1. AWS D1.1, "Structural Welding Code - Steel," for hangers and supports.
 2. AWS D1.2, "Structural Welding Code - Aluminum," for aluminum supports.
 3. AWS D9.1M "Sheet Metal Welding Code," for duct joint and seam welding.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."
- C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's 2005 Edition "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class.
 1. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of non-braced panel unless ducts are lined.
 2. Unless otherwise indicated, the net free area of the duct dimensions given on the Drawings shall be maintained. The duct dimensions shall be increased as necessary to compensate for the liner thickness.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions.
 1. Prefabricated Slide-on Joints and Components:
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - i. Ductmate Industries, Inc.

- ii. Ward Industries, Inc.
 - b. Apply joints using manufacturer's "Duct Construction Standards" for material thickness, reinforcement size and spacing, and joint reinforcement
 - c. Slide-on joints must include the use of corners, bolts, cleats, and gaskets.
 - d. Prefabricated slide-on joints shall be used on duct sizes larger than allowed for formed-on flanges. Refer to the following paragraph.
- 2. Formed-on Flanges and Components:
 - a. Construct according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Formed-on flanges shall be constructed as T-25A (T.D.C.) and T-25B (T.D.F.) joints.
 - b. Formed-on flanges must include the use of corners, bolts, cleats, and gaskets.
 - c. Maximum Duct Size:
 - i. Up to 60-inches wide for 2-inch pressure class (for 5 ft. joints).
 - ii. Up to 42-inches wide for 4-inch pressure class (for 5 ft. joints).
- 3. Slips and Drives (Traditional):
 - a. Construct according to SMACNA's "HVAC Duct Construction Standards-Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions.
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions.
 - 1. Elbows: Fabricate fittings with a centerline radius equal to 1.5 times the associated duct widths up to 28 inches wide, and 1.0 times the duct width for duct widths 30 inches wide and wider. Figure 4-2; Type RE-1 radius elbow and Type RE-5 dual radius elbow.
 - a. Where elbows with a shorter radius are necessary, fabricate elbows with a 4-inch minimum throat radius, full radius heel, and with two vanes. Figure 4-2; Type RE-3.
 - b. Where square throat elbows are indicated, fabricate elbows with turning vanes. Figure 4-2; Type RE-2. Use vanes and vane runners according to Figure 4-3.

2. Transitions: Limit concentric transitions to 45-degrees for diverging, and 60-degrees for converging; limit single-sided transitions to 30-degrees. Figure 4-7.
 - a. Transitions include changes in duct areas or profiles including square-to-round fittings.
3. Offsets: Limit angled offsets to a maximum of 45-degrees. Use mitered offsets, Figure 4-7; Type 2.
 - a. Fabricate offsets with radius throats and heels wherever possible. Figure 4-7; Type 3.

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with the latest edition of SMACNA's 2005 Edition "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Lindab Inc.
 - b. McGill AirFlow LLC.
 - c. Semco, Inc.
 - d. Sheet Metal Connectors, Inc.
 - e. Spiral Manufacturing Co., Inc.
- B. Transverse Joints: Select joint types and fabricate according to the latest edition of SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions.
 1. Ducts Up to 16-inch Diameter:
 - a. Interior, center-beaded sleeve joint. Figure 3-1; Type RT-1.
 - b. Beaded crimp joints may be used for longitudinal seam ducts. Figure 3-1; Type RT-5.
 - c. Prefabricated three-piece, gasketed, flanged joint consisting of two inner ring flanges with sealant and one external closure band with gasket. Similar to Ductmate "Spiralmate."
 2. Ducts 17 to 60-inch Diameter:
 - a. Interior, center-beaded sleeve joint. Figure 3-1; Type RT-1.

- b. Prefabricated three-piece, gasketed, flanged joint consisting of two inner ring flanges with sealant and one external closure band with gasket. Similar to Ductmate “Spiralmate.”
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions.
 - 1. Fabricate round ducts with grooved seam. Figure 3-1; Type RL-5.
 - 2. Fabricate round ducts with spiral lock seam. Figure 3-2; Type RL-1.
 - 3. Snaplock seams, Figure 3-2; Types RL-6A, RL-6B, RL-7, RL-8 may be used for duct sizes 16-Inch Diameter and Smaller for 2-inch static pressure class ducts.
 - 4. Fabricate round ducts Larger than 60 inches in diameter with continuous butt-welded or continuous lap and seam welded longitudinal seams. Figure 3-2; Type RL-4.
- D. Elbows: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "Elbows," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions.
 - 1. Elbows: Fabricate fittings with welded seam, die-formed or segmented construction with centerline radius 1.5 times the elbow diameter.
 - a. Die-Formed Elbows (8-inches and smaller): Fabricate elbows with two-piece, die-formed, stamped or pleated construction.
 - b. Segmented Elbows (Larger than 8-inches): Fabricate elbows with welded seam construction with multiple segments or gores. Number of segments or gores as follows:
 - i. 90 degrees - 5 pieces.
 - ii. 60 degrees - 4 pieces.
 - iii. 45 degrees - 3 pieces.
 - iv. 30 degrees - 2 pieces.
 - c. Adjustable Mitered Elbow (16-inch and Smaller): Adjustable seam, mitered elbows (4-piece 90 degree, 3-piece 45 degree) with bend radius 0.6 times the elbow diameter may be used for 2-inch duct static-pressure class. Seal joints after installation.

2.3 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's 2005 Edition "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and

duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

- B. Galvanized Sheet Steel: Lock-forming quality. Comply with ASTM A 653.
 - 1. Galvanized Coating Designation: G-90.
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized “Paint-Grip.”
- E. Reinforcement Shapes and Plates: ASTM A 36, steel plates, shapes, and bars; use black for carbon-steel ducts and galvanized for galvanized steel ducts.
 - 1. Use stainless steel for stainless steel duct reinforcement.
 - 2. Use aluminum for aluminum duct reinforcement. Where galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- F. Tie Rods: Galvanized steel, 3/8-inch minimum diameter.

2.4 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Water-Based Joint and Seam Sealant:
 - 1. Application Method: Brush on.
 - 2. Solids Content: Minimum 65 percent.
 - 3. Shore A Hardness: Minimum 20.
 - 4. Water resistant.
 - 5. Mold and mildew resistant.
 - 6. VOC: Maximum 75 g/L (less water).
 - 7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 - 8. Service: Indoor or outdoor.
 - 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- C. Solvent-Based Joint and Seam Sealant:
 - 1. Application Method: Brush on.

2. Base: Synthetic rubber resin.
 3. Solvent: Toluene and heptane.
 4. Solids Content: Minimum 60 percent.
 5. Shore A Hardness: Minimum 60.
 6. Water resistant.
 7. Mold and mildew resistant.
 8. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 9. VOC: Maximum 395 g/L.
 10. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
 11. Service: Indoor or outdoor.
 12. Substrate: Compatible with galvanized sheet steel, stainless steel, or aluminum sheets.
- D. Flanged Joint Sealant: Comply with ASTM C 920.
1. General: Single-component, acid-curing, silicone, elastomeric.
 2. Type: S.
 3. Grade: NS.
 4. Class: 25.
 5. Use: O.
- E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- F. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
 2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
 3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.5 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- E. Trapeze and Riser Supports:
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - 2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
 - 3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's 2005 Edition "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install round ducts in maximum practical lengths.
- D. Install ducts with fewest possible joints.
- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- G. Install ducts as high as possible, unless otherwise indicated. Where overhead structure permits, route ducts between and through structural elements.
- H. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- I. Install ducts with a clearance of 1 inch plus allowance for insulation thickness.

- J. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- K. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
- L. Where ducts are exposed to view in finished spaces, protect exposed duct surfaces from physical damage.
- M. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged. Repair scratches, dents, cuts and other physical imperfections. Surfaces shall be like-new condition.
- B. Remove markings, stickers, labels, etc. from the duct surface. and markers. Prepare for field painting. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. Hangers and support systems shall be likewise cleaned and prepared for finish painting.
- D. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- E. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- F. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 WALL LOUVERS

- A. Provide a watertight air plenum with soldered drain pan at each louver. Connect air plenum directly to louver frame. The air plenum drain pan shall be arranged to drain to a threaded drain fitting. Extend air plenum drain untrapped to a floor drain.
- B. Provide 2-inch-thick insulated double-wall blank-off panels at unused areas of wall louvers. Blank-off panels shall be attached to the louver frame with gasketed, watertight construction.

3.4 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Seal Class A for all ducts: Seal transverse joints, longitudinal joints, and duct wall penetrations.

3.5 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's 2005 Edition "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 1. Where practical, install concrete inserts before placing concrete.
 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
 5. Do not install building attachments to metal roof decking, or other non-structural members.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at maximum intervals of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.6 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."
- B. Comply with SMACNA's 2005 Edition "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Leakage Tests:
 - 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 - 2. Test the following systems:
 - a. Outside-Air Ducts with a Pressure Class of 2-Inch wg: Test entire lengths of concealed ducts. In addition, test representative sections totaling no less than 10 percent of total installed duct area for each system.
 - b. Exhaust-Air Ducts with a Pressure Class of 2-Inch wg: Test entire lengths of concealed ducts. In addition, test representative sections totaling no less than 10 percent of total installed duct area for each system.
 - 3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 - 4. Test for leaks before applying external insulation.
 - 5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
 - 6. Give seven days' advance notice for testing.
- C. Duct System Cleanliness Tests:
 - 1. Visually inspect duct system to ensure that no visible contaminants are present.
 - 2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
 - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
- D. Duct system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.9 DUCT CLEANING

- A. Clean new duct system(s) that have not been kept clean during construction and do not pass the “Acceptable Cleanliness Level” in the previous Article. Clean before testing, adjusting, and balancing.
- B. Particulate Collection and Odor Control:
 - 1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
 - 2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
- C. Clean the following components by removing surface contaminants and deposits:
 - 1. Exhaust fans including fan housings, plenums, scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - 2. Dedicated exhaust and ventilation components and makeup air systems.
- D. Mechanical Cleaning Methodology:
 - 1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 - 2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 - 3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
 - 4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
 - 5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
 - 6. Provide drainage and cleanup for wash-down procedures.
 - 7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.10 START UP

- A. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

3.11 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated.
- B. Outside Air Ducts:
 - a. Pressure Class: Positive 2-inch wg; negative 2-inch wg.
 - b. SMACNA Seal Class: B.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round: 6.
- C. Exhaust Ducts:
 - 1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
 - a. Pressure Class: Positive or negative 2-inch wg.
 - b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round: 6.

END OF SECTION 23 3113

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**SECTION 23 3300
AIR DUCT ACCESSORIES**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Control dampers.
 - 2. Duct accessory hardware.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

- A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G60 (Z180).
 - 2. Exposed-Surface Finish: Mill phosphatized.
- B. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- C. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 CONTROL DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck Fan Corporation.

2. Pottorff.
3. Ruskin Company.
- B. Low-leakage rating and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
- C. Frames:
 1. Hat shaped.
 2. 0.094-inch- thick, galvanized sheet steel.
 3. Mitered and welded corners.
- D. Blades:
 1. Multiple blade with maximum blade width of 6 inches.
 2. Parallel-blade design.
 3. Galvanized-steel.
 4. 0.064 inch thick single skin.
 5. Blade Edging: PVC.
- E. Blade Axles: 1/2-inch- diameter; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
 1. Operating Temperature Range: From minus 40 to plus 200 deg F.
- F. Bearings:
 1. Molded synthetic.
 2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 3. Thrust bearings at each end of every blade.

2.4 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install backdraft dampers, as indicated at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Set dampers to fully open position before testing, adjusting, and balancing.
- E. Install test holes at fan inlets and outlets and elsewhere as indicated.
- F. Install duct test holes where required for testing and balancing purposes.

3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Operate dampers to verify full range of movement.

END OF SECTION 23 3300

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**SECTION 23 3423
HVAC POWER VENTILATORS**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. In-line centrifugal fans.

1.3 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base fan-performance ratings on 5200 ft.
- B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:
 - 1. Certified fan performance curves with system operating conditions indicated.
 - 2. Certified fan sound-power ratings.
 - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 4. Material thickness and finishes, including color charts.
 - 5. Dampers, including housings, linkages, and operators.
 - 6. Fan speed controllers.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.
- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.
- C. UL Standards: Power ventilators shall comply with UL 705.

1.7 COORDINATION

- A. Coordinate size and location of structural-steel support members.

PART 2 - PRODUCTS

2.1 IN-LINE CENTRIFUGAL FANS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Carnes Company.
 - 2. Greenheck Fan Corporation.
 - 3. Loren Cook Company.
 - 4. Twin City Fan.
- B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- C. Direct-Drive Units: Motor mounted in airstream; factory wired to disconnect switch located on outside of fan housing.
- D. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.
- E. Accessories:
 - 1. Companion Flanges: For inlet and outlet duct connections.
 - 2. Disconnect switch.
 - 3. Vibration isolators.

- F. Capacities and Characteristics: See schedule on drawings.

2.2 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
- B. Enclosure Type: Totally enclosed, fan cooled.
- C. Motor shall be an electronically commutated motor rated for continuous duty and furnished either with internally mounted potentiometer speed controller or with leads for connection to 0-10 VDC internal controller.

2.3 SOURCE QUALITY CONTROL

- A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install power ventilators level and plumb.
- B. Support suspended units from structure using threaded steel rods and spring hangers with vertical-limit stops having a static deflection of .5 inch (25 mm) .
- C. Install units with clearances for service and maintenance.
- D. Label units according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct

connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Duct Accessories."

- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding."
- D. Connect wiring according to Division 26 Section "Conductors and Cables."

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 3. Verify that cleaning and adjusting are complete.
 - 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system.
 - 5. Adjust damper linkages for proper damper operation.
 - 6. Verify lubrication for bearings and other moving parts.
 - 7. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 - 8. Disable automatic temperature-control operators, energize motor, and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 - 9. Shut unit down and reconnect automatic temperature-control operators.
 - 10. Remove and replace malfunctioning units and retest as specified above.
- C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Prepare test and inspection reports.

3.4 ADJUSTING

- A. Adjust damper linkages for proper damper operation.

- B. Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.
- C. Lubricate bearings.

END OF SECTION 23 3423

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**SECTION 23 3725
INTAKE AND RELIEF VENTILATORS**

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Louvers.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated. For louvers, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.
- B. Shop Drawings: Include plans, elevations, sections, details, and ventilator attachments.
- C. Coordination Drawings: Framing plans and other details, drawn to scale, on which the louvers are shown and coordinated with each other, based on input from installers.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063-T5 or T-52.
- B. Aluminum Sheet: ASTM B 209 (ASTM B 209M), Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.
- C. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel, unless otherwise indicated. Do not use metals that are incompatible with joined materials.
 - 1. Use types and sizes to suit unit installation conditions.
 - 2. Use Phillips flat-head screws for exposed fasteners, unless otherwise indicated.
- D. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors, made from stainless-steel components, with capability to sustain, without failure, a load equal to 4 times the loads imposed, for concrete, or 6 times the load imposed, for masonry, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.
- E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.2 LOUVERS

- A. Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work are limited to the following. Submit alternate manufacturers to the Engineer for review and approval before bidding.
 - 1. Ruskin.

2. Greenheck,
 3. Pottorff.
- B. Construction: All-welded assembly with 4-inch-deep louvers, mitered corners, and aluminum sheet roof.
- C. Frame and Blade Material and Nominal Thickness: Extruded aluminum, of thickness required to comply with structural performance requirements, but not less than 0.080 inch (2.0 mm) for frames and 0.060 inch for blades.
1. Blade Spacing: 54% free area.
 2. Blade Angle: 37.5°.
 3. Air Performance: Not more than 0.15-inch wg (25-Pa) static pressure drop at 875-fpm free-area velocity.
 4. AMCA Seal: Mark units with the AMCA Certified Ratings Seal.
 5. Finish: Suitable for field painting. Prefabricated corner units with mitered blades with concealed close-fitting splices.
- D. Bird Screening: Aluminum, 1/2-inch-square mesh.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install intake and relief louvers level, plumb, and at indicated alignment with adjacent work.
- B. Secure with cadmium-plated hardware. Use concealed anchorages where possible.
- C. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- D. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses.
- E. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.
- F. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories.

END OF SECTION 23 3725

**SECTION 23 4100
PARTICULATE AIR FILTRATION**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal panel filters.
 - 2. Filter gages.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Provide one complete set of filters for each filter bank. If system includes prefilters, provide only prefilters.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE Compliance:
 - 1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
 - 2. Comply with ASHRAE 52.1 for arrestance and ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.
- C. Comply with NFPA 90A and NFPA 90B.
- D. UL Classified 900.

PART 2 - PRODUCTS

2.1 METAL PANEL FILTERS

- A. Description: Factory-fabricated, self-supported, cleanable, all-metal, impingement-type, panel-type, permanent air filters with holding frames.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AAF International.
 - b. Airguard.
 - c. American Metal Filter Company.
 - d. Camfil Farr.
 - 2. Nonoiled for grease removal application.
- B. Filter-Media Frame: Aluminum hinged, and with pull and retaining handles fastened to the media.
- C. Construction: Frame alloy of 0.030" thick aluminum and 28-gauge galvanized steel face grids. Maximum rated temperature of 275°F. Filter to be constructed with corner drain holes and be washable and reusable.

2.2 FILTER GAGES

- A. Diaphragm-type gage with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings or comparable product by one of the following:
 - a. Airguard.
 - b. Dwyer Instruments, Inc.
 - 3. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg or Less
- B. Manometer-Type Filter Gage: Molded plastic, with epoxy-coated aluminum scale and logarithmic-curve tube gage with integral leveling gage, graduated to read from 0- to 3.0-inch wg, and accurate within 3 percent of the full-scale range.

- C. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.
- B. Install filters in position to prevent passage of unfiltered air.
- C. Install filter gage for each filter bank.
- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.
- E. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.
- F. Coordinate filter installations with duct and air-handling-unit installations.

3.2 FIELD QUALITY CONTROL

- A. Perform tests and inspections:
 - 1. Test for leakage of unfiltered air while system is operating.
- B. Air filter will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.3 CLEANING

- A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 23 41 00

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**SECTION 23 8239
UNIT HEATERS**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Electric Unit Heaters

1.3 SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.
- B. Operation and Maintenance Data: For unit heaters to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. 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.

PART 2 - PRODUCTS

2.1 ELECTRIC UNIT HEATERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Qmark
 - 2. Berko
 - 3. Fahrenheat
 - 4. Trane
 - 5. Markel
- B. Heating Element

1. The heating element shall be of the non-glowing design consisting of an 80/20 nickel-chromium resistance wire enclosed in a steel sheath to which plate fins are copper brazed. The element shall cover the entire air discharge area to ensure uniform heating of all discharged air. It shall be warrantied for 5 years.
- C. On/Off Switch
 1. A double-pole, single throw on/off switch shall be mounted on the back box for positive disconnect of power supply. It will be completely concealed behind the front cover.
- D. Hanging Bracket
 1. Heater shall be supplied with manufacturer's bracket for wall or hanging application.
- E. Motor and Controls
 1. The fan motor shall be impedance protected, permanently lubricated. Fan control shall be of the bi-metallic, snap-action type and shall activate fan after heating element reaches operating temperature and continue to operate the fan after the thermostat is satisfied and until all heated air has been discharged. The thermostat shall be single-pole type on all models. Thermal cutout shall be self-hold (manual-reset) type designed to shut off heat in the event of overheating.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before unit heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install unit per manufacturer's specifications.

3.3 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

- B. Remove and replace malfunctioning units and retest as specified above.

3.4 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters.
Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 23 8239

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**SECTION 26 0500
COMMON WORK RESULTS FOR ELECTRICAL**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Electrical equipment coordination and installation.
 - 2. Sleeves for raceways and cables.
 - 3. Sleeve seals.
 - 4. Grout.
 - 5. Common electrical installation requirements.

1.3 DEFINITIONS

- A. Basic Contract definitions are as follows:
 - 1. Provide: The term "provide" means "to furnish and install, ready for the intended use and in complete operating condition."
 - 2. Furnish: The term "furnish" means "to purchase devices and/or equipment and hand over to another entity for installation"
 - 3. Install: The term "install" is used to describe operations at project site including the actual "unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations."
 - 4. Directed: Terms such as "directed," "requested," "authorized," "selected," "approved," "required," and "permitted" mean "directed by the Engineer," "requested by the Engineer," and similar phrases.
 - 5. Approve: The term "approved," where used in conjunction with the Engineer's action on the Contractor's submittals, applications and requests, is limited to the Engineer's duties and responsibilities as stated in the Conditions of the Contracts.
 - 6. Indicated: The term "indicated" refers to graphic representations, notes or schedules on the Drawings, or other Paragraphs or Schedules in the Specifications, and similar requirements in the Contract Documents. Where terms such as "shown," "noted,"

"scheduled and "specified" are used, it is to help the reader locate the reference; no limitation on location is intended.

7. Contractor: The term "Contractor" shall carry the same meaning as "Electrical Contractor" or "Division 26 Contractor".
8. Or Equal: The term "Or equal" shall carry the same meaning as "approved as equal by the Engineer"
9. Owner: All references here-in and on drawings to "Owner" shall be the same as "South Dakota Science and Technology Authority."

B. Product specific to this section definitions:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 COORDINATION

- A. All drawings, specifications and documents for this project shall be taken as a whole. Prior to installation, the Contractor shall be familiar with this project by carefully reviewing and comparing all documents that pertain to this project.
- B. In preparation of the contract documents, a reasonable effort has been made to provide layouts and connections based on selected and specified manufacturer's equipment. Since physical space, electrical connections, equipment arrangements and other requirements may vary according to each manufacturer, the final responsibility for connections, initial access and proper fit is the responsibility of this Contractor.
- C. Coordinate arrangement, mounting, and support of electrical equipment:
 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 2. To provide for ease of disconnecting the equipment with minimum interference to other installations and maintain working clearances per the NEC or additional as required by these documents.
 3. To allow right of way for piping and conduit installed at required slope.
 4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- D. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations.
- E. Coordinate installation locations of panelboards, MCCs, and switchboards with Divisions 21, 22, and 23. The drawings diagrammatically show electrical gear, ductwork, piping, etc. The

Contractors shall coordinate on site for actual installation locations. Ducts, piping, etc cannot be installed over panelboards, MCCs, or switchboards.

- F. Coordinate installation locations of all equipment with other trades to verify proper fit and function. The General Contractor and/or Construction Manager shall facilitate a pre-construction planning meeting for all major sub-contractors (Divisions 21 thru 28) to coordinate actual equipment with installation locations. General Contractor and/or Construction Manager shall provide meeting minutes.
- G. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- H. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Provide access doors and panels as specified in Division 08 Section "Access Doors and Frames."
- I. Prior to roughing in for electrical equipment furnished by others, verify the voltage and current characteristics and control connections of this equipment. Notify the Engineer where equipment connection requirements do not match the provisions indicated on the documents.
- J. Where electrical identification devices are applied to field-finished surfaces, coordinate installation of identification devices with completion of finished surface.
- K. Electrical contractor shall pay all fees for permits, licensing, and inspections applicable to the work of Division 26. Secure regular inspections as required by State and local regulations. Pay charges by regulating agencies for Drawings, Specifications, review of Drawings and Specifications, and the inspections of installations. Contractor shall pay all charges and fees levied by the serving utility and include these charges in the bid.

1.5 QUALITY ASSURANCE

- A. Drawings and Measurements
 - 1. The drawings are not intended to be scaled for roughing-in measurements or to serve as shop drawings. The Contractor shall consult the architectural, structural, mechanical, or equipment drawings for dimensions, obstructions and location of equipment of other trades.
 - 2. Outlet devices, switches, panels, cabinets, fixtures and special equipment are shown on the drawings only in a schematic manner and not necessarily in their specific location. The Contractor shall be responsible for exact locations of the outlets to form a functional and aesthetic installation either by careful review of all architectural elevations, tile patterns, surface finishes, and equipment arrangements or by consultation with the Engineers and/or other trades involved.
- B. Ordinances and Codes
 - 1. All work shall be executed in accordance with the current edition of the City Electrical Ordinances, State Electrical Laws and Statutes and National Electrical Code (NEC) and

be subject to the inspection of these departments. All fees, permits, licenses, etc., necessary in order to complete the work of this section shall be paid by this Contractor.

C. Workmanship

1. The installation work included in this specification shall be performed in a neat workmanlike manner by persons experienced and skilled in the Electrical trade. Only the best quality workmanship will be accepted. All exposed parts of the electrical wiring systems such as exposed conduits, flush plates, cabinet trim, fixtures, etc., shall be square and true with the building construction.

D. Guarantee

1. This Contractor shall assume responsibility for any defects which may develop in any part of his work caused by faulty workmanship, material or equipment, and agrees to replace, repair, or alter, at his expense, any such faulty workmanship, material or equipment that has been brought to his attention during a period of one year from the date of substantial completion. Acceptance of the work shall not waive this guarantee.

E. Materials and Equipment

1. All materials and equipment shall be new and of best quality, of the type best suited for the purpose intended. All items shall be furnished by the Manufacturer's Authorized Supplier. All electrical materials used in this work shall be listed by the Underwriter's Laboratories, Inc., where testing is provided and shall bear their label.

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel.
 1. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE SEALS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Metraflex Co.
 - d. Pipeline Seal and Insulator, Inc.
 - 2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - 3. Pressure Plates: Plastic. Include two for each sealing element.
 - 4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

2.4 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
 - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
 - 2. Low-Emitting Materials: Liquid floor treatments shall have a VOC content of 420 g/L or less
 - 3. Low-Emitting Materials: Liquid floor treatments shall comply with the testing and product requirements of California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers Version 1.1-2010.
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- E. Right of Way: Give to piping systems installed at a required slope.
- F. Securely fasten and support electrical components and devices.
- G. All devices installed in the ceiling grid shall be centered on the tile. Corridor devices shall be mounted in a straight line.
- H. Make electrical connections in accordance with equipment manufacturer's instructions.
- I. See all Drawings and contract documents, including Division 21, 22, and 23 for mechanical schedules, for additional installation requirements.
- J. All wiring shall be installed in conduit unless otherwise noted and of a type allowed by the contract documents. All conduits shall be concealed unless otherwise noted.
- K. In general, the electrical loads shall be circuited as shown on the Drawings. If the Division 26 contractor modifies the circuiting and can meet all the requirements of the contract documents, then it shall be allowed to be different from that shown. If changes are made, ensure that these changes are shown on the as-built drawings.
- L. Conduit routing is not shown on the Drawings. Circuit number is shown by fixtures. It is the Contractor's responsibility to provide required wire count and conduit sizing for complete and operating systems. Coordinate conduit routing on site with other disciplines. Base final installation of raceways on actual dimensions and conditions at project site.
- M. All devices/equipment in fire rated ceiling spaces and walls shall be installed in such a manner as to retain fire rating as required. All penetrations of fire rated floors or walls shall be protected by materials and installation details that conform to Underwriter Laboratories Listings for through penetration fire stop systems.
- N. See all Drawings and contract documents, including Division 21, 22, and 23, for approximate equipment locations and confirm locations on site. Coordinate equipment connections with Divisions 21, 22, 23, and 26 and review shop drawings and verify connection requirements

(voltage, amperage, phase, location, etc). See equipment schedules for additional electrical connection requirements.

O. Motor Phase Rotation:

1. Verify proper motor rotation by “bumping” the motor. Coordinate this test with Divisions 21, 22, 23, and 26. Modify circuiting if phase rotation is not correct.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls before concrete is poured in place.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- E. Cut sleeves to length for mounting flush with both surfaces of walls.
- F. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
- G. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.
- H. Seal space outside of sleeves with grout for penetrations of concrete and masonry
 1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
- I. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- J. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- K. Underground, Exterior-Wall Penetrations: Install Schedule 80 PVC rigid pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

- A. Install to seal exterior wall penetrations.

- B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.4 DEMOLITION

- A. Protect existing electrical equipment and installations indicated to remain. If damaged or disturbed in the course of the Work, remove damaged portions and install new products of equal capacity, quality, and functionality.
- B. Accessible Work: Remove exposed electrical equipment and installations, indicated to be demolished, in their entirety. Remove all unused cabling not labeled for future use.
- C. Abandoned Work: Cut and remove buried raceway and wiring, indicated to be abandoned in place, 2 inches (50 mm) below the surface of adjacent construction. Cap raceways and patch surface to match existing finish.
- D. Remove demolished material from Project site. Recycle all materials per Construction Waste Management Specification 01 7419.
- E. Remove, store, clean, reinstall, reconnect, and make operational components indicated for relocation.
- F. Contractor shall visit existing building before submitting bid and become familiar with existing conditions.
- G. In general, wiring in existing building shall remain as is except as noted on drawings or specified elsewhere. When existing walls, ceilings, floors, electrical panels, light fixtures, switches or other outlets are removed, Contractor shall extend existing circuiting, if required, install junction boxes in walls, ceilings or floors, if required, to continue circuiting; remove all unused wire; remove all unused conduit where accessible; and install new plates with blank gangs as required on existing outlet boxes.
- H. Added loads to existing circuiting shall be balanced between phases. On existing panelboards where circuitry is changed, this Contractor shall furnish a revised, typed panel directory.
- I. Contractor shall assume in his bid that all existing equipment and fixtures noted to be reused are in good working condition and can be installed without any repairs. If certain items are found to be in need of repair or in unusable condition, Contractor shall notify the A/E for decision; however, Contractor shall be responsible for any damage caused by him to equipment in removal or handling.
- J. Fixtures and other equipment removed and to be re-used shall be cleaned before reinstallation. New lamps shall be provided for all fixtures.
- K. Any existing switches or receptacles that are relocated shall be replaced with new device.

- L. Existing equipment removed and not re-used, at owner's option, shall be returned to owner. If owner does not wish to keep the items, they shall become the Contractor's property and be removed from the site, unless otherwise specified or shown.
- M. Contractor shall work closely with the Telephone Company to coordinate removal or relocation of all telephone conduit and outlets. Provide Telephone Company minimum of 48 hours notice of any demolition affecting telephone services or equipment.
- N. The Owner will be occupying the existing building during construction. Contractor shall provide any temporary connections necessary to maintain services to the existing service. Provide advance notice of minimum 72 hours to the Owner of any temporary service outages, and have this downtime approved before proceeding with work. Advance notice shall be in writing with copies to the A/E.
- O. Demolition shown on plans is based on information shown on Owner's existing plans and an on-site review of the facility. Quantities, types, and locations of items shown are believed to be accurate. However, this contractor shall be responsible for removing and/or relocating electrical equipment as required to accommodate remodeling.
- P. In general, Contractor shall assume that all work which involves a service outage to areas occupied by the Owner or other building tenants shall be performed on an overtime basis. Work shall continue until service is restored.
- Q. Coordinate all work with the Power Company for revisions to the electrical service.

3.5 CUTTING AND PATCHING

- A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved. Any cutting or drilling shall not affect structural integrity. Contractor shall contact A/E prior to drilling through any structural beam. No such cutting or drilling process shall endanger the structure integrity of the building.
- B. Repair and refinish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces. Install new fireproofing where existing firestopping has been disturbed. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

3.6 CLEANING AND PROTECTION

- A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.
- B. Protect equipment and installations and maintain conditions to ensure that coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

END OF SECTION 26 05 00

SECTION 26 0519
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.

1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. Low-Voltage (Power): 90 to 2000 volts.
- C. NBR: Acrylonitrile-butadiene rubber.

1.4 QUALITY ASSURANCE

- A. 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.
- B. Comply with NFPA 70.

1.5 COORDINATION

- A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Alcan Products Corporation; Alcan Cable Division.
 - 2. American Insulated Wire Corp.; a Leviton Company.
 - 3. General Cable Corporation.

4. Southwire Company.
5. Encore Wire Corporation.

B. Copper Conductors: Comply with NEMA WC 70.

C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN-2 and XHHW-2.

2.2 CONNECTORS AND SPLICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AFC Cable Systems, Inc.
2. Hubbell Power Systems, Inc.
3. O-Z/Gedney; EGS Electrical Group LLC.
4. 3M; Electrical Products Division.
5. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Services: Copper.
- B. Feeders: Copper. Solid or stranded for No. 12 AWG; stranded for No. 10 AWG and larger.
- C. Branch Circuits: Copper. Solid or stranded for No. 12 AWG; stranded for No. 10 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type THHN-THWN-2, or type XHHW-2 single conductors in raceway.
- B. Feeders: Type THHN-THWN-2, or type XHHW-2 single conductors in raceway.
- C. Branch Circuits: Type THHN-THWN, single conductors in raceway. Use a minimum No. 12 AWG.
- D. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

- E. Class 1 Control Circuits: Type THHN-THWN, in raceway.
- F. Class 2 Control Circuits: Power-limited cable, in raceway where concealed in building finishes.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway. Use Mule Tape where any friction can occur in non-metallic conduit.
- D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
- E. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."
- F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."
- G. Conduit fill: A maximum of three phase conductors, each of a different phase, neutral(s), and a grounding conductor shall be installed per conduit home run.
- H. Compensate for voltage drop. Where conductor is indicated (#10, #8, etc) adjacent to the circuit number, provide a minimum of that conductor size. Where the conductor is not indicated, calculate a maximum of 3 percent voltage drop (for branch circuit) and a maximum of 2 percent for feeder. For general convenience receptacles and lighting loads, size conductors for a minimum load of 12 amperes (1440VA) (this applies to the entire circuit, not just the homerun). For loads larger than 12 amperes, size conductors per the load on the panel schedule. For dedicated circuits (one load on a breaker) size conductors per the load on the panel schedule.
- I. All multi-wire branch circuits shall use dedicated neutrals for each phase circuit. Do not use combined neutral conductors.
- J. GFI receptacles may feed other receptacles on the same circuit from the load side only if they are in the same room and within sight of each other.
- K. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.
- L. Derate conductors where conduits are exposed to sunlight on rooftops per NEC 310.15(B)(3)c.
- M. Stranded conductors shall be terminated in a proper way so all strands are effectively conductive together.

3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack from face of box.
- D. All connections shall guarantee a good electrical and mechanical connection with conductor to conductor contact. No intermediary current path (material between conductors) is allowed. Connections shall be made using twist-on type connectors such as IDEAL INDUSTRIES connector brands WIRE-NUT®, WING NUT®, OR TWISTER®. Quick connect “stab-in” connectors will not be allowed.
- E. Splices or taps in handholes, manholes, or other in-ground enclosures for conductors size No. 6 AWG and smaller:
 - 1. "King Safety Sealed" connectors, taped and then coated with a waterproofing product equal to 3M "ScotchKote Electrical Coating".
- F. Splices or taps in handholes, manholes, or other in-ground enclosures for conductors larger than size No. 6 AWG:
 - 1. "King Safety Sealed" connectors, taped and then coated with a waterproofing product equal to 3M Scotchcast "Resin Splice Kits".

3.5 FIELD QUALITY CONTROL

- A. Inspect installed components for damage and faulty work, including building wire, connections, and connectors.
- B. Voltage Drop Calculation:
 - 1. Indicate on as-builts drawings, the conductors being up-sized due to voltage drop. Indicate length of conductors, calculated load (amperage or wattage), and conductor size.

END OF SECTION 26 0519

SECTION 26 0526
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes methods and materials for grounding and bonding systems and equipment.

1.3 QUALITY ASSURANCE

- A. 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.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Tinned Conductors: ASTM B 33.
 - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
 - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.2 CONNECTORS

- A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
 - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Compression Direct-Burial Grounding: System connectors of types recommended by manufacturer for materials being joined and installation conditions.
- E. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression or exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar. Non-reversible type.

2.3 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad; 3/4 inch by 10 feet (19 mm by 3 m) in diameter.

2.4 GROUNDING BUSBARS

- A. Predrilled rectangular bars of annealed copper, 1/4 by 4 inches by 18" (6.3 by 100 by 450 mm) in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart, or as indicated on drawings. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.
- B. Rectangular bars of annealed copper, 1/4 by 2 inches (6 by 50 mm) in cross section, unless otherwise indicated; with insulators.
- C. Intersystem Bonding Bar: Rectangular bars of annealed copper.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 12 AWG and smaller, and stranded conductors for No. 10 AWG and larger, unless otherwise indicated.
- B. Grounding Bus: Install intersystem bonding bar at electrical service equipment in electrical room and telecommunications busbar in each telecommunications rooms, and elsewhere as indicated.
 - 1. Install bus on insulated spacers 1 inch (25 mm), minimum, from wall 6 inches (150 mm) above finished floor, unless otherwise indicated.

2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.

C. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors, except as otherwise indicated.
3. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Compression Direct-Buried Grounding System: Install per Manufacturer's recommendations.

1. Must Comply with the industry requirements of IEEE Std. 837. The fully inspectable system that is UL 467 Listed and CSA 22.2 Certified.
2. IEEE Std 837 requiring sequences of environmental simulations including: lightning strike, freeze-thaw cycling, and chemical corrosion, to provide better assurance that the grounding system will remain viable throughout its installed life.
3. Complies with vibration tests per MIL-STD-202G (METHOD 201A).
4. Pre-applied conductive antioxidant compound ensuring a high quality mechanical and electrical bond.
5. Slotted Tap Design and Locator Die to insure crimp Quality.
6. Panduit Compression Grounding Connector Series Allowed: GCE, GCC, GUBC, GPC4H.
7. Panduit Dies for compression Grounding Connectors: CD-930G-1/0, CD-930G-250, CD-930G-500.

3.3 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

C. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors. Bond grounding electrode and branch circuit equipment grounding conductor to pole assembly.

- D. Communication Circuits Operating at Less than 50 Volts: Circuits operating at less than 50 volts shall be grounded in accordance with NEC articles 720 and 725.

3.4 GROUNDING ELECTRODE SYSTEM

- A. Bond to Structure:
 - 1. Bonding to Metal Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
- B. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 AWG.
 - 1. If concrete foundation is less than 20 feet (6 m) 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 grounding grid or to grounding electrode external to concrete.
- C. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade, unless otherwise indicated.
 - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
 - 2. For grounding electrode system, install at least three rods spaced at least 20 feet from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

3.5 INSTALLATION

- A. All grounding electrodes in the above section that are present shall be bonded together to form the grounding electrode system. Provide ground rods at all installations.
- B. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- C. Where grounding or bonding conductors are routed in ferrous metallic conduit, the grounding conductor must be bonded at both ends of conduit.
- D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
 3. Use exothermic-welded connectors, or compression direct-burial system, for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
- E. Bonding for Piping:
1. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- F. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.
- G. Bond together each metallic raceway (2" and larger), pipe, duct, and other metal object at non-contact entry into equipment enclosures. Use #2 AWG bare copper conductor.
- H. Bond bushings where reducing washers or concentric knockouts are used.
- I. Bond the Intersystem Bonding Bar to the equipment grounding conductors with a #3/0 AWG copper conductor. Provide a #3/0 bonding backbone from the Intersystem Bonding Bar to the telecommunications busbars. Provide an exo-thermic weld, or compression direct-burial system, at the backbone conductor to connect to each telecommunications busbar. Do not terminate the bonding backbone unless it is the end-of-the-line busbar.

END OF SECTION 26 0526

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**SECTION 26 0529
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. IMC: Intermediate metal conduit.
- C. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 QUALITY ASSURANCE

- A. Comply with NFPA 70.

1.6 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.
 - f. Unistrut; Tyco International, Ltd.
 - g. Wesanco, Inc.
 - 2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - 4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 5. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported. Supports shall be Listed for the installation.
- D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- F. Low Voltage Cable Supports:

1. Cables shall be supported by conduit, cable tray (ladder racks), or approved cable hooks.
 2. Cable hooks shall be installed no farther than 5' apart.
 3. J-hooks: Steel, UL listed, ultimate static load limit 50 lbs. minimum. Wide base, beveled edges. Provide corners, drop-outs, and direction changes with coating (Xylan) for smooth, frictionless surface. Rated to support Category 6 and higher cables, and optical fiber cables. Size and quantity shall be as required.
 4. If required, assemble to manufacturer recommended specialty fasteners including beam clips, flange clips, drop wire/rod, C and Z purlin clips.
 5. Provide CADDY CableCat J-hooks as manufactured by ERICO, Inc, Cooper's B-Line CAT32 Series, the Hook as manufactured by MonoSystems, or approved equivalent.
 6. Supply velcro straps, length and strength as required to properly organize and bundle cables. Straps shall NOT be used for supporting cables.
- G. Conduit and Cabling: All conduit and cabling shall be supported with UL Listed and Approved supports.
- H. Wire ties are not an acceptable form of raceway supports.
- I. Metal decking shall not be used to support electrical devices, light fixtures, boxes or raceway.
- J. Raceways must be a minimum of 1 1/2" from nearest surface of roof decking per NEC 300.4(E).
- K. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Hilti Inc.
 - 2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti Inc.
 - 4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 5) MKT Fastening, LLC.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
- B. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 1. Secure raceways and cables to these supports with two-bolt conduit clamps, single-bolt conduit clamps, or single-bolt conduit clamps using spring friction action for retention in support channel.

- C. **Air-craft cable (or Gripple) supports are not allowed.**

3.2 SUPPORT INSTALLATION

- A. Raceway Support Methods: In addition to methods described in NECA 1. EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).
- C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated:
1. Backboards: Mount cabinets, lighting and appliance branch-circuit panelboards, disconnect switches, and control enclosures on plywood, fire-retardant treated, painted (gray), 3/4 inch. Comply with requirements for plywood backing panels specified in Division 6 Section "Rough Carpentry."
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
1. To Wood: Fasten with lag screws or through bolts.
 2. To New Concrete: Bolt to concrete inserts.
 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 4. To Existing Concrete: Expansion anchor fasteners.
 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
 6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69 or Spring-tension clamps.
 7. To Light Steel: Sheet metal screws.
 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, distribution panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 4000-psi (27.6-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- C. Anchor equipment to concrete base.
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

- A. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 0529

**SECTION 26 0533
RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical and controls wiring.
- B. Related Sections include the following:
 - 1. Division 26 Section “Identification for Electrical Systems”.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. FMC: Flexible metal conduit.
- C. IMC: Intermediate metal conduit.
- D. LFMC: Liquidtight flexible metal conduit.
- E. LFNC: Liquidtight flexible nonmetallic conduit.
- F. RNC: Rigid nonmetallic conduit.
- G. RMC: Rigid metal (steel) conduit.
- H. RTRC: Reinforced Thermosetting Resin Conduit (fiberglass conduit).

1.4 SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.
 - 1. PVC-Coated RMC Steel Conduit (indicate sizes and locations being used).

1.5 QUALITY ASSURANCE

- A. 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.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Alflex Inc.
 - 3. Allied Tube & Conduit; a Tyco International Ltd. Co.
 - 4. Anamet Electrical, Inc.; Anaconda Metal Hose.
 - 5. Electri-Flex Co.
 - 6. Manhattan/CDT/Cole-Flex.
 - 7. Maverick Tube Corporation.
 - 8. O-Z Gedney; a unit of General Signal.
 - 9. Wheatland Tube Company.
- B. RMC Rigid Steel Conduit: ANSI C80.1.
- C. Aluminum Rigid Conduit: ANSI C80.5.
- D. IMC: ANSI C80.6.
- E. PVC-Coated Steel Conduit: PVC-coated RMC.
 - 1. Comply with NEMA RN 1.
 - 2. Factory applied PVC bond.
 - 3. Coating Thickness (on exterior): 0.040 inch (1 mm), minimum.
 - 4. Hot dipped galvanized after fabrication.
 - 5. Threads hot dipped galvanized.

- 6. Coating Thickness (on interior): 0.002 inch urethane.
- F. EMT: ANSI C80.3.
- G. FMC: Zinc-coated steel.
- H. LFMC: Flexible steel conduit with PVC jacket.
- I. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
 - 2. Fittings for EMT: Zinc coated steel with set-screw or compression fittings with insulated throat type.
 - 3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.
- J. Joint Compound for Rigid Steel Conduit (RMC) or IMC: Listed for use in cable connector assemblies and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 NONMETALLIC CONDUIT AND TUBING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Anamet Electrical, Inc.; Anaconda Metal Hose.
 - 3. Arnco Corporation.
 - 4. CANTEX Inc.
 - 5. CertainTeed Corp.; Pipe & Plastics Group.
 - 6. Champion Fiberglass.
 - 7. Condux International, Inc.
 - 8. ElecSYS, Inc.
 - 9. Electri-Flex Co.
 - 10. Lamson & Sessions; Carlon Electrical Products.
 - 11. Manhattan/CDT/Cole-Flex.

- 12. RACO; a Hubbell Company.
- 13. Thomas & Betts Corporation.
- B. ENT: NEMA TC 13.
- C. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.
- D. LFNC: UL 1660.
- E. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.
- F. Fittings for LFNC: UL 514B.

2.3 METAL WIREWAYS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper B-Line, Inc.
 - 2. Hoffman.
 - 3. Square D; Schneider Electric.
- B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise indicated.
- C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type.
- E. Finish: Manufacturer's standard enamel finish.

2.4 BOXES AND ENCLOSURES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
 - 2. EGS/Appleton Electric.
 - 3. Erickson Electrical Equipment Company.
 - 4. Garvin Industries.
 - 5. Hoffman.

6. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
 7. O-Z/Gedney; a unit of General Signal.
 8. RACO; a Hubbell Company.
 9. Robroy Industries, Inc.; Enclosure Division.
 10. Scott Fetzer Co.; Adalet Division.
 11. Spring City Electrical Manufacturing Company.
 12. Thomas & Betts Corporation.
 13. Walker Systems, Inc.; Wiremold Company (The).
 14. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.
- B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
- C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, aluminum, Type FD, with gasketed cover.
- D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- E. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.
- F. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

2.5 HANDHOLES AND BOXES (JUNCTION/PULL/UTILITY ACCESS) FOR EXTERIOR UNDERGROUND WIRING

- A. Description: Comply with SCTE 77.
1. Color of Frame and Cover: Green.
 2. Configuration: Units shall be designed for flush burial and have closed bottom, unless otherwise indicated.
 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 5. Cover Legend: Molded lettering, ["ELECTRIC."] ["TELEPHONE."] as indicated for each service.

6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 7. Handholes and boxes (junction/pull/utility) 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.
- B. Fiberglass Handholes and Boxes (junction/pull/utility) with Polymer-Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester-resin enclosure joined to polymer-concrete top ring or frame.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. Christy Concrete Products.
 - d. Synertech Moulded Products, Inc.; a division of Oldcastle Precast.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
1. Exposed Conduit: Rigid steel conduit (RMC).
 2. Concealed Conduit, Aboveground: RMC.
 3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried with PVC-coated RMC elbows.
 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 5. Enclosures, Aboveground: NEMA 250, Type 3R or 4.
 6. Boxes: Cast aluminum. Malleable iron is prohibited.
 7. Application of Handholes and Boxes for Underground Wiring:
 - a. Handholes and Pull Boxes in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Fiberglass enclosures with polymer-concrete frame and cover, SCTE 77, Tier 15 structural load rating.

- b. Handholes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Heavy-duty fiberglass units with polymer-concrete frame and cover, SCTE 77, Tier 8 structural load rating.
 - c. Handholes and Pull Boxes Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf (**13 345-N**) vertical loading.
- B. Comply with the following indoor applications, unless otherwise indicated:
 - 1. Exposed, Not Subject to Physical Damage: Rigid steel conduit (RMC).
 - 2. Exposed, Not Subject to Severe Physical Damage: RMC.
 - 3. Exposed and Subject to Severe Physical Damage: RMC.
 - 4. Concealed in Ceilings and Interior Walls and Partitions: RMC.
 - 5. Risers: All through floor conduit risers shall be RMC.
 - 6. Embedded in or below slabs: RNC, PVC-coated RMC, or RTRC. Use PVC-coated RMC or RTRC elbows if a service conduit (of any length), a feeder conduit (of any length), or a branch/telecommunications conduit over 50 feet. RNC, PVC-coated RMC, or RTRC elbows can be used if branch circuit conduits or telecommunications conduits are 50 feet or under. At floor change to EMT, RMC, or RTRC. RNC or PVC coating of RMC shall not be above floor.
 - 7. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations. Maximum of 6' in length unless otherwise approved.
 - 8. Damp or Wet Locations: Rigid steel conduit (RMC).
 - 9. Raceways for Concealed General Purpose Distribution of Optical Fiber or Communications Cable: RMC.
 - 10. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4X, stainless steel in damp or wet locations.
 - 11. Hazardous Locations: Comply with the NEC.
- C. Minimum Raceway Size: 3/4-inch (21-mm) trade size for all work unless otherwise noted.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
 - 1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.

- 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.
- E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.
- F. Do not install aluminum conduits in contact with concrete.
- G. Communication cabling shall have long sweep elbows.
- H. All conduits 2" and larger shall have grounding bushings on ends.

3.2 INSTALLATION

- A. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- B. Complete raceway installation before starting conductor installation.
- C. Protect stub-ups from damage where conduits rise through floor slabs. Arrange stub-ups so curved portions of bends are not visible above the finished slab.
- D. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; FMC may be used 6 inches (150 mm) above the floor. Install screwdriver-operated, threaded plugs flush with floor for future equipment connections.
- E. Sleeves: See Specifications 260500 for sleeve requirements through concrete slabs and walls.
- F. Mounting Heights: Install equipment and devices at heights indicated on Electrical Symbols & Abbreviations sheet, unless noted otherwise.
- G. Backboxes shall not be installed back-to-back. Provide 6-inch separation minimum unless otherwise noted.
- H. Do not install backboxes in fully grouted cells of masonry walls.
- I. Outlet boxes shall not be set back more than 1/4" from finished wall. Devices shall be rigidly supported to the box (not the wall) at the surface of the wall.
- J. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.
- K. Conduit and Cabling: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.
- L. Conduit shall be concealed in pre-cast panels. The electrical contractor is responsible for the installation, coordination, material, and labor of conduit, boxes, etc installed in pre-cast panels.

- M. Install no more than the equivalent of four 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
- N. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
- O. Conceal raceways in gymnasium, clerestories, and similar with exposed structure (no false ceiling) in walls until above the bottom of the structure supports.
- P. Raceways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
 - 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 - 3. Embedded in or below slabs: RNC or PVC-coated RMC. Use PVC-coated RMC elbows if a service conduit (of any length), a feeder conduit (of any length), or a branch/telecommunications conduit over 50 feet. RNC or PVC-coated RMC elbows can be used if branch circuit conduits or telecommunications conduits are 50 feet or under. At floor change to EMT, RMC, or RTRC. RNC or PVC coating of RMC shall not be above floor.
- Q. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- R. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
- S. Terminations:
 - 1. Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against box. Use two locknuts, one inside and one outside box.
 - 2. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so end bears against wire protection shoulder. Where chase nipples are used, align raceways so coupling is square to box; tighten chase nipple so no threads are exposed.
- T. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire.
- U. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a

blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:

1. Where otherwise required by NFPA 70.

V. Expansion Joints:

1. Conduits 3 inches and larger, rigidly secured to building construction on opposite sides of a building expansion joint, shall be provided with expansion and deflection couplings. The couplings shall be installed in accordance with the manufacturer's recommendations.
2. Conduits smaller than 3 inches shall be provided with junction boxes on both sides of the expansion joint, and connected by 15 inches of slack flexible conduit. Flexible conduit shall have a copper green ground bonding jumper installed. In lieu of this flexible conduit, expansion and deflection couplings as specified above may be installed.
3. An expansion fitting is required to compensate for thermal expansion and contraction for RNC where the length of the raceway change is expected to be 1/4 in. or greater in a straight run between securely mounted items such as boxes, cabinets, elbows, or other conduit terminations per NEC 352.44.

W. Flexible Conduit Connections: Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semirecessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors. Flex shall be supported per NEC. Flex to light fixtures shall not rest on ceiling grid.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

X. Hazardous Locations: Comply with the NEC.

Y. Masonry Box Support: Provide supports to secure box even with top of concrete blocks.

Z. All homerun conduits shall terminate directly into the top of panelboards and not have a wireway with nipple conduits between panelboard and wireway. Multiple splices (wirenuts) in a gutter above panels will not be allowed.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.
2. Install backfill as specified in Division 31 Section "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction

as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."

4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
 - b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
6. Install raceways at an angle away from the structure so moisture, etc does not enter building. Provide sealant and drainage as required.

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.
- D. Install handholes and boxes with bottom below the frost line.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.
- F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 PROTECTION

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 26 0533

**SECTION 26 0553
IDENTIFICATION FOR ELECTRICAL SYSTEMS**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Identification for raceway.
 - 2. Identification for conductors and communication and control cable.
 - 3. Underground-line warning tape.
 - 4. Warning labels and signs.
 - 5. Instruction signs.
 - 6. Equipment identification labels.
 - 7. Miscellaneous identification products.

1.3 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 and ANSI C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.145.

1.4 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, Owner, Owner's room numbers (not plan room numbers) manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.
- B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- C. Write-On Tags: Polyester tag, 0.010 inch (0.25 mm) thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
- D. Permanent Black Marker: Provide neatly handwritten label on each junction box and on the inside of each device cover plate indicating associated panel and circuit number.

2.2 UNDERGROUND-LINE WARNING TAPE

- A. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.
 - 1. Not less than 6 inches (150 mm) wide by 4 mils (0.102 mm) thick.
 - 2. Compounded for permanent direct-burial service.
 - 3. Embedded continuous metallic strip or core.
 - 4. Printed legend shall indicate type of underground line.

2.3 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.
- C. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 7 by 10 inches (180 by 250 mm).
- D. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 10 by 14 inches (250 by 360 mm).
- E. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."
3. Available Fault Current Warning: "WARNING – ARC FLASH AND SHOCK HAZARD – APPROPRIATE PPE REQUIRED – AVAILABLE FAULT CURRENT: (Value calculated by Contractor) – INSTALLATION DATE: (Date)."
4. Label electrical equipment per NEC 110.16(A).
5. Label service equipment per NEC 110.16(B).
6. Label the Available Interrupting Current (AIC) on each panelboard per NEC 408.6.
7. Label all Industrial Control Panels (including mechanical equipment with a starter), as defined in the NEC definitions, per NEC 409.22 (A) and (B) and 409.110(4).

2.4 INSTRUCTION SIGNS

- A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. in. (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.
 1. Engraved legend with black letters on white face.
 2. Punched or drilled for mechanical fasteners.
 3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.5 EQUIPMENT IDENTIFICATION LABELS

- A. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background for all "normal" systems. For all "emergency" systems, provide engraved legend in white letters on red background. Minimum letter height shall be 3/8 inch (10 mm).

2.6 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Paint materials and application requirements are specified in Division 09 painting Sections.
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Branch-Circuit Conductor Identification: Identify all conductors in same junction or pull box, use color-coding conductor tape. Identify each ungrounded conductor according to phase.
- B. Permanent Black Marker: Provide neatly handwritten label on each junction box indicating associated panel and circuit number.
- C. Where the premises wiring system has branch circuits supplied from more than one nominal voltage system, each ungrounded conductor of a branch circuit, where accessible, shall be identified by system per NEC 210.5(C). The means of identification shall be permanently posted on each branch-circuit distribution panelboard/equipment.
- D. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source and circuit number.
- E. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
 - 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 - 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 - 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.
- F. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable. Install underground-line warning tape for both direct-buried cables and cables in raceway.
- G. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.
 - 1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
 - a. Power transfer switches.
 - b. Controls with external control power connections.
 - 2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.
- H. Apply warning, caution, and instruction signs as follows:

1. Warnings, Cautions, and Instructions: Install to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
 - a. Install a plaque on all disconnect switches controlling remote equipment that identifies its purpose per NEC.
 - b. Install a plaque at each main disconnect for services with multiple main disconnects per NEC.
 - c. Install a plaque on each piece of distribution equipment that incorporates series rated circuit breaker devices per NEC.
 2. Flash Protection: Switchboards, panelboards, and motor control center shall be field marked to warn qualified persons of potential electric arc flash hazards per NEC 110.16.
- I. Each panelboard, new and existing, shall be provided with a neatly typed directory with plastic protector. The Division 26 Contractor is responsible for providing the room name and/or number per the Owner's designations. The Owner's designation may not be the same as the Drawings. Division 26 is responsible for coordinating with the Owner for the designations.
- J. Instruction Signs:
1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
 2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer (transfer switches).
- K. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
1. Labeling Instructions:
 - a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where 2 lines of text are required, use labels 2 inches (50 mm) high.
 - b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.

- c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
- 2. Equipment to Be Labeled:
 - a. Panelboards, electrical cabinets, and enclosures.
 - b. Access doors and panels for concealed electrical items.
 - c. Electrical switchgear and switchboards.
 - d. Transformers.
 - e. Emergency system boxes and enclosures.
 - f. Motor-control centers.
 - g. Disconnect switches.
 - h. Enclosed circuit breakers.
 - i. Motor starters.
 - j. Push-button stations.
 - k. Power transfer equipment.
 - l. Contactors.
 - m. Remote-controlled switches, dimmer modules, and control devices.
 - n. Monitoring and control equipment.

3.2 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Attach nonadhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

- F. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side.
- G. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors.
 - 1. Color shall be factory applied.
 - 2. Colors for 208/120-V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Neutral: White.
 - e. Ground: Green.
 - 3. Colors for 240/120-V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Orange.
 - c. Phase C: Blue.
 - d. Neutral: White.
 - e. Ground: Green.
 - 4. Colors for 480/277-V Circuits:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
 - d. Neutral: Gray; or White with colored stripe (other than green).
 - e. Ground: Green.
 - 5. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

- H. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 inches (400 mm) overall.
- I. Painted Identification: Prepare surface and apply paint according to Division 09 painting Sections.

END OF SECTION 26 0553

SECTION 26 0573
SHORT CIRCUIT/COORDINATION STUDY/ARC FLASH HAZARD ANALYSIS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. The Contractor shall be required to perform the arc flash risk assessment calculations and apply arc flash labeling on newly installed electrical equipment and other equipment whose available fault current has been impacted by the electrical changes in this project. The arc flash label design shall follow the SDSTA's arc flash label design requirements provided in Exhibit 10. The SDSTA will provide copies of the facility model in SKM PowerTools format for the Contractor to add to and run the arc flash calculations. The Contractor shall edit and return the modified facility SKM model back to SDSTA during project closeout.
- B. The Contractor shall provide short circuit and protective device coordination studies and arc flash hazard analysis study as prepared by the equipment manufacturer.
 - 1. Short circuit and equipment duty study to verify that equipment is rated to safely handle short circuit currents without creating hazardous conditions.
 - 2. Protective device coordination study and review to help ensure proper electrical system reliability and to determine how arc flash hazard energy levels can be reduced. At no point in the buildings electrical system shall incident energy exceed 40 cal/cm².
 - 3. Coordinate overcurrent protective devices for the period of time that a fault's duration extends beyond 0.1 second.
 - 4. Arc flash hazard analysis study to determine arc flash energy levels.
 - 5. Coordinate all electronic breakers.
- C. Protective devices shall be set based on results of the protective device coordination study.
- D. Electrical equipment shall be labeled based on the results of the Arc Flash Hazard Analysis study, as well as the available short circuit ratings.
- E. Label the clearing time of service overcurrent protective devices at the service equipment.
- F. Label service equipment per 2020 NEC 110.16(B).
- G. Label all panels with AIC per 2020 NEC 408.6.
- H. Label all air conditioning and refrigeration equipment per NEC 440.10.

- I. Label all Industrial Control Panels, as defined in the 2020 NEC definitions, per 2020 NEC 409.22 (A) and (B) and 409.110(4).
- J. Provide adjustable breaker trip settings and set breakers accordingly.

1.3 SUBMITTALS

- A. Product Data: For computer software program to be used for studies, including proof of compliance with IEEE 399, NFPA 70E, and IEEE 1584.
- B. Provide preliminary studies and associated recommendations, prior to submitting associated electrical equipment shop drawings. Indicate where equipment AIC ratings or overcurrent protection device settings are recommended to change due to the preliminary studies. Provide one (1) printed copy (hardcopy) of the completed study report, in addition to one (1) digital copy in Adobe Acrobat (pdf) format.
- C. Final Study Submittals: The following submittals shall be made after all final field feeder sizes and lengths have been incorporated into the study and the approval process for system protective devices has been completed.
 - 1. Coordination-study input data, including completed computer program input data sheets.
 - 2. Study and Equipment Evaluation Reports.
 - 3. Short Circuit Study Report
 - 4. Coordination-Study Report.
 - 5. Arc Flash Hazard Analysis Report.

1.4 QUALITY ASSURANCE

- A. The studies shall be in conformance with the NFPA and ANSI Standards, and IEEE recommended practices detailed in this section. No substitutions in study methods or software conformance will be allowed.
- B. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.
- C. Short Circuit/Coordination Study/Arc Flash Hazard Analysis Specialist Qualifications: An entity experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
 - 1. Professional engineer, licensed in the state where Project is located, shall be responsible for the study. All elements of the study shall be performed under the direct supervision and control of engineer.
- D. Comply with IEEE 242 for short-circuit currents and coordination time intervals.
- E. Comply with IEEE 399 for general study procedures.

- F. Comply with the following for arc flash hazard analysis study procedures:
1. OSHA 29 Code of Federal Regulations (CFR) Part 1910 Subpart S.
 2. NFPA 70 National Electrical Code
 3. NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces.
 4. IEEE Standard 1584 Guide for Performing Arc Flash Hazard Calculations.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

- A. The SDSTA will provide copies of the facility model in SKM PowerTools format for the Contractor to add to and run the Short Circuit/Coordination Study/Arc Flash Hazard Analysis. The Contractor shall edit and return the modified facility SKM model back to SDSTA during project closeout.

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

- A. The system model shall be developed using a commercially available, fully integrated software package that meets the performance specifications developed in this Section. To ensure compliance with NFPA-70E (the latest version), ANSI, and IEEE Standards, and OSHA mandates, no exceptions or substitutions to the performance specification are allowed.
- B. The software shall provide complete integration of the one-line, database, short circuit, protective device coordination, and arc flash functions. Software using separate short circuit, protective device coordination, or arc flash programs is not allowed. Spreadsheet calculations are not allowed.
- C. The system model shall be laid out in one drawing/view and in a manner that provides for easy viewing of all analysis results. The one drawing/view requirement ensures that problem areas found and highlighted by the program are easily seen and not hidden or buried in multiple drawings, eliminating potential human errors where multiple drawing verification is required.
1. All one-line symbols shall be spaced properly to facilitate viewing results on the one-line.
 2. Equipment names used in the modeling software shall be identical to the equipment and naming convention shown on the construction document drawings and equipment unless conflicts exist.
 3. All low voltage power circuit breaker (LVPCB), insulated case (ICCB), molded case (MCCB) and fuse data shall be modeled based on the actual nameplate data including manufacturer, type, style, trip device, and actual settings. Generic substitutions or assumptions shall not be allowed unless data cannot be field verified. All assumptions shall be documented in the report.
- D. Short Circuit/Coordination Study
1. Comply with IEEE 399.

2. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
3. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

E. Arc Flash Hazard Analysis

1. Comply with NFPA 70E and IEEE 1584.
2. Arc flash calculations shall be performed with enhanced IEEE-1584 equations, which eliminate voltage discontinuities and the non-conservative/average results of the standard equations. The purpose of this requirement is to ensure that the calculated incident energies are closer to actual test results insuring a conservative calculation minimizing personnel risk.
3. Computer software program shall be capable of calculating the following values for each specific piece of electrical equipment in the study.
 - a. Arc Flash Protection Boundary – worst cast for each piece of equipment.
 - b. Arc flash hazard incident energy in cal/cm² for the equipment – worst case for each piece of equipment.
 - c. Calculated kV Shock Hazard with cover removed
 - d. Approach Boundaries
 - 1) Prohibited Approach
 - 2) Restricted Approach
 - 3) Limited Approach
 - e. Required PPE category based on calculated energy level and optional risk reduction.
4. Computer software shall print labels that include the following information, and that can be applied to each specific piece of electrical equipment.
 - a. Flash Hazard Boundary (shown in feet and inches).
 - b. Incident Energy in cal/cm².
 - c. Flash Hazard at Estimated Working Distance.
 - d. KV Shock Hazard with cover removed.
 - e. Limited Approach Distance (shown in feet and inches).

- f. Restricted Approach Distance (shown in feet and inches)
 - g. Prohibited Approach Distance (shown in feet and inches)
5. Labels shall be in accordance with the SDSTA Standard label and SDSTA's SKM customlable.dat file will be provided upon request.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Proceed with final studies and analysis only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in the final study.
- B. Actual field data collection shall be performed by a qualified (as defined by NFPA 70E) consultant/contractor to ensure accurate equipment modeling.
- C. Equipment shall be visually inspected to collect the necessary nameplate data used in the analysis. Consultant/contractor is responsible for visual verification of this data, including transformers, switchgear and breakers, relays, direct-acting trip units, etc. Data that may not have nameplate data such as conductors, busway, etc. can be taken from drawings. Conductor lengths shall be field verified.

3.2 POWER SYSTEM DATA

- A. Gather and tabulate the following input data to support coordination study:
 - 1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
 - 2. Impedance of utility service entrance.
 - 3. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:
 - a. Equipment name, type, voltage, and rating.
 - b. Circuit-breaker and fuse-current ratings and types.
 - c. Relays and associated power and current transformer ratings and ratios.
 - d. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.

- e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.
 - f. Motor horsepower and code letter designation according to NEMA MG 1.
4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
- a. Special load considerations, including starting inrush currents and frequent starting and stopping.
 - b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
 - c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
 - d. Ratings, types, and settings of utility company's overcurrent protective devices.
 - e. Special overcurrent protective device settings or types stipulated by utility company.
 - f. Time-current-characteristic curves of devices indicated to be coordinated.
 - g. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
 - h. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
 - i. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes RMS symmetrical.

3.3 SHORT CIRCUIT STUDY

- A. Calculate the maximum available short-circuit current in amperes RMS symmetrical at circuit-breaker positions of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:
- 1. Main switchboard bus
 - 2. Distribution panelboards
 - 3. Branch circuit panelboards
 - 4. Load centers
 - 5. Enclosed circuit breakers

6. Step down transformers
 7. Air conditioning and refrigeration equipment
 8. Industrial control panels
- B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system affected by the Project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.
- C. Calculate momentary and interrupting duties on the basis of maximum available fault current.
- D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 241 and IEEE 242.
1. Transformers: IEEE C57.12.00
 2. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1.
 3. Low-Voltage Fuses: IEEE C37.46.
- E. Study Report:
1. Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.
- F. Equipment Evaluation Report:
1. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
 2. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
 3. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
 4. A report of all problem areas shall be provided. Consultant/contractor shall notify A/E immediately of all problems found in this system before proceeding in the study.
 5. A preliminary action list shall accompany preliminary report submitted with shop drawings.
 6. A recommended action list shall be provided for all underrated equipment in the system.

3.4 PROTECTIVE DEVICE COORDINATION STUDY

- A. Perform coordination study using approved computer software program. Prepare a written report using results of short circuit study. Comply with IEEE 399.

1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.
2. Calculate the maximum and minimum ground-fault currents.
- B. Comply with IEEE 242 recommendations for fault currents and time intervals.
- C. Transformer Primary Overcurrent Protective Devices:
 1. Device shall not operate in response to the following:
 - a. Inrush current when first energized.
 - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
 - c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
 2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.
- D. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.
- E. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:
 1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
 - a. Device tag.
 - b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
 - c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
 - d. Fuse-current rating and type.
 - e. Ground-fault relay-pickup and time-delay settings.
 2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

- a. Device tag.
 - b. Voltage and current ratio for curves.
 - c. Three-phase and single-phase damage points for each transformer.
 - d. No damage, melting, and clearing curves for fuses.
 - e. Cable damage curves.
 - f. Transformer inrush points.
 - g. Maximum fault-current cutoff point.
3. A report of all problem areas shall be provided. Consultant/contractor shall notify A/E immediately of all problems found in this system before proceeding in the final study.
 4. A recommended action list shall be provided for all underrated equipment in the system. A preliminary action list shall accompany preliminary report submitted with shop drawings.
- F. Overcurrent Protective Device changes, replacements or setting changes implemented in study to reduce arc flash hazard exposure, as calculated in arc flash study.
- G. Completed data sheets for setting of overcurrent protective devices.

3.5 ARC FLASH HAZARD ANALYSIS

- A. A detailed arc flash study shall be performed to determine potential arc flash incident energies, arc flash boundaries, and shock hazard boundaries for all energized electrical system equipment tasks for the electrical system studied. The calculations shall comply with NFPA-70E 2009, and IEEE-1584. Bolted short circuit calculations used in the above standards shall comply with ANSI C37.010, C37.13, C37.5, IEEE-141, and IEEE-399.
- B. Calculate the incident energy and associated arc flash hazard at the following pieces of equipment:
1. Main switchboard sections and switchboard bus.
 2. Distribution panelboards.
 3. Branch circuit panelboards
 4. Load centers
 5. Disconnecting means for large individual loads greater than 75 kVA.
- C. Arc Flash Hazard Analysis: Prepare a written report indicating the following results of the analysis for the electrical equipment:
1. Arc Flash Protection Boundary – worst case for each piece of equipment.

2. Arc flash hazard incident energy in cal/cm² for the equipment – worst case for each piece of equipment.
3. Calculated kV Shock Hazard with cover removed
4. Approach Boundaries
 - a. Prohibited Approach
 - b. Restricted Approach
 - c. Limited Approach
5. Prioritized recommendations to reduce arc flash hazards for equipment with incident energies over 40 cal/cm².
6. Recommended overcurrent protective device changes, replacements or setting changes implemented in study to reduce arc flash hazard exposure.
7. A report of all problem areas shall be provided. Consultant/contractor shall notify A/E immediately of all problems found in this system before proceeding in the study.
8. A recommended action list shall be provided for all underrated equipment in the system. A preliminary action list shall accompany preliminary report submitted with shop drawings.
9. Copy of arc flash label.

3.6 STUDY COORDINATION

- A. Results of the individual studies shall be linked and coordinated to provide the optimal system design, layout, and settings. Results and recommendations in one study shall NOT conflict with other study results and recommendations.

3.7 LABELING

- A. Short Circuit Current Labels
 1. Provide labels on all electrical equipment included in the study, but at a minimum at the service entrance equipment and all panels, indicating the maximum available short circuit fault current, including the date the fault current calculation was performed and the clearing time of service overcurrent protective devices at the service equipment. Label must be of sufficient durability to withstand the environment in which it is installed. Apply labels to associated equipment in locations where label can be easily read.
 2. Label service equipment per 2020 NEC 110.16(B).
 3. Label all panels with AIC 2020 NEC 408.6.
 4. Label all air conditioning and refrigeration equipment per NEC 440.10.

5. Label all Industrial Control Panels, as defined in the 2020 NEC definitions, per 2020 NEC 409.22 (A) and (B) and 409.110(4).

B. Arc Flash Hazard Labels

1. Provide labels indicating the calculated incident energy, shock hazard, Flash Protection Boundary, and Approach Boundaries for each piece of equipment included in the analysis. Label must be of sufficient durability to withstand the environment in which it is installed.
2. Apply labels to associated equipment in locations where label can be easily read.
3. Labels shall include the following information:
 - a. Flash Hazard Boundary (shown in feet and inches).
 - b. Incident Energy in cal/cm^2 .
 - c. Flash Hazard at Estimated Working Distance.
 - d. KV Shock Hazard with cover removed.
 - e. Limited Approach Distance (shown in feet and inches).
 - f. Restricted Approach Distance (shown in feet and inches).
 - g. Prohibited Approach Distance (shown in feet and inches).
4. Labels shall be in accordance with the SDSTA Standard label and SDSTA's SKM customlable.dat file will be provided upon request.

END OF SECTION 26 0573

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**SECTION 26 2200
LOW-VOLTAGE TRANSFORMERS**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:
 - 1. Distribution transformers.

1.3 SUBMITTALS

- A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- C. Adjusting (voltage taps) test reports.
- D. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain each transformer type through one source from a single manufacturer.
- 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.
- C. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.6 COORDINATION

- A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Products.
 - 2. General Electric Company.
 - 3. MGM Transformer Company.
 - 4. Siemens Energy & Automation, Inc.
 - 5. Square D; Schneider Electric.

2.2 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
- B. Cores: Grain-oriented, non-aging silicon steel.
- C. Coils: Continuous windings without splices except for taps.
 - 1. Internal Coil Connections: Brazed or pressure type.
 - 2. Coil Material: Aluminum.

2.3 DISTRIBUTION TRANSFORMERS

- A. Comply with 2016 DOE Energy Conservation Standards, and list and label as complying with UL 1561.
- B. Meet minimum energy efficiencies set forth with 10 CFR Part 431.192 (DOE 2016).
- C. Cores: One leg per phase.
- D. Enclosure: Ventilated, NEMA 250, Type 2.
 - 1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

- E. Transformer Enclosure Finish: Comply with NEMA 250.
 - 1. Finish Color: Gray.
- F. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.
- G. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.

2.4 IDENTIFICATION DEVICES

- A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

- A. Test and inspect transformers according to IEEE C57.12.91.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D. Verify that ground connections are in place and requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions. Install and anchor transformers level on concrete bases, 4-inch (100-mm) nominal thickness. Concrete base is specified in concrete materials and installation requirements are specified in Division 3.
- B. Provide 6 inches clearance between dry-type transformers and walls.

3.3 CONNECTIONS

- A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 ADJUSTING

- A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
- B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.5 CLEANING

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 26 2200

**SECTION 26 2416
PANELBOARDS**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Lighting and appliance branch-circuit panelboards.
 - 2. Distribution panelboards.
 - 3. Surge Protective Devices (SPD).

1.3 SUBMITTALS

- A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
 - 1. Detail enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Detail bus configuration, current, and voltage ratings.
 - 3. Short-circuit current rating of panelboards and overcurrent protective devices.
 - 4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 5. Surge Protective Devices (SPD): Provide verification that the SPD complies with the required ANSI/UL 1449 3rd Edition listing by Underwriters Laboratories (UL) or other Nationally Recognized Testing Laboratory (NRTL). The submittal shall contain the following information at a minimum: model number, SPD Type, system voltage, phases, modes of protection, Voltage Protection Rating (VPR), and Nominal Discharge Current (I_n).
- C. Field Quality-Control Reports:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- D. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.
- E. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NEMA PB 1.
- E. Comply with NFPA 70.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.6 PROJECT CONDITIONS

- A. Environmental Limitations:
 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding minus 22 deg F (minus 30 deg C) to plus 104 deg F (plus 40 deg C).

- b. Altitude: Not exceeding 6600 feet (2000 m).
- B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
 - 1. Ambient temperatures within limits specified.
 - 2. Altitude not exceeding 6600 feet (2000 m).
- C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - 1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
 - 2. Do not proceed with interruption of electric service without Owner's written permission.
 - 3. Comply with NFPA 70E.

1.7 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate installation locations of panelboards with Divisions 21, 22, and 23. The drawings diagrammatically show electrical gear, ductwork, piping, etc. The Contractors shall coordinate on site for actual installation locations. Ducts, piping, etc cannot be installed over panelboards.

1.8 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Keys: Six spares for each type of panelboard cabinet lock.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Enclosures: Flush- and surface-mounted cabinets.
 - 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1 unless otherwise noted.
 - 2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.

3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
 4. Finishes:
 - a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Galvanized steel.
 5. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.
- B. Incoming Mains Location: Top and bottom.
- C. Phase, Neutral, and Ground Buses:
1. Material: Hard-drawn copper, 98 percent conductivity.
 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 3. All space provisions and unused space to be fully prepared for future circuit breakers including mounting kits.
- D. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Hard-drawn copper, 98 percent conductivity.
 2. Main and Neutral Lugs: Mechanical type.
 3. Ground Lugs and Bus-Configured Terminators: Mechanical type.
- E. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.
- F. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- G. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Mains: Circuit breaker or lugs only as indicated on schedule.
- D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits.
 2. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (4-6-mA trip).
 3. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
 - c. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator. Where noted on drawings or where required by NEC.
 - d. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.

- e. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.

2.4 PANELBOARD SUPPRESSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Current Technology; a subsidiary of Danahar Corporation.
 - 2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 4. Liebert Corporation.
 - 5. Siemens Energy & Automation, Inc.
 - 6. Square D; a brand of Schneider Electric.
- B. Surge Protective Devices (SPD)]: The SPD applications covered under this section include distribution panelboards, lighting and appliance branch-circuit panelboards, electronic grade panelboards and switchboards. All SPDs shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category C, B, and A environments. IEEE C62.41, integrally mounted, solid-state, and parallel-connected. SPD Type – all SPDs installed on the line side of the service entrance disconnect shall be Type 1 SPDs. All SPDs installed on the load side of the service entrance disconnect shall be Type 2 SPDs.
 - 1. General Requirements:
 - a. Units and all components shall be designed, manufactured, and tested in accordance with the latest applicable UL standard (ANSI/UL 1449 3rd Edition).
 - b. Unit Operating Voltage – Refer to drawings for operating voltage and unit configuration.
 - c. Maximum Continuous Operating Voltage (MCOV) – The MCOV shall not be less than 150Vrms (120/208V) and 320Vrms (277/480V) of the nominal system operating voltage.
 - d. The suppression system shall incorporate thermally protected metal-oxide varistors (MOVs) as the core surge suppression component for the service entrance and all other distribution levels. The system shall not utilize silicon avalanche diodes, selenium cells, air gaps, or other components that may crowbar the system voltage leading to system upset or create any environmental hazards.
 - e. Protection Modes: The SPD must protect all modes of the electrical system being utilized.

- f. Nominal Discharge Current (I_n): All SPDs applied to the distribution system shall have a 20kA I_n rating regardless of their SPD Type (includes Types 1 and 2) or operating voltage. SPDs having an I_n less than 20kA shall be rejected.
- g. Maintenance Free Design: The SPD shall be maintenance free and shall not require any user intervention throughout its life. SPDs containing items such as replaceable modules, replaceable fuses, or replaceable batteries shall not be accepted. SPDs requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPDs requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.
- h. Balanced Suppression Platform: The surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The surge suppression platform must provide equal impedance paths to each matched MOV. Designs incorporating replaceable SPD modules shall not be accepted.
- i. Electrical Noise Filter: Each unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be up to 50 dB from 10 kHz to 100 MHz using the MIL-STD-220A insertion loss test method. Products unable able to meet this specification shall not be accepted.
- j. Internal Connections: No plug-in component modules or printed circuit boards shall be used as surge current conductors. All internal components shall be soldered, hardwired with connections utilizing low impedance conductors.
- k. Monitoring Diagnostics: Each SPD shall provide the following integral monitoring options:
 - 1) Protection Status Indicators - Each unit shall have a green / red solid-state indicator light that reports the status of the protection on each phase.
 - 2) Remote Status Monitor – The SPD must include Form C dry contacts (one NO and one NC) for remote annunciation of its status. Both the NO and NC contacts shall change state under any fault condition.
 - 3) Audible Alarm and Silence Button – The SPD shall contain an audible alarm that will be activated under any fault condition. There shall also be an audible alarm silence button used to silence the audible alarm after it has been activated.
 - 4) Surge Counter – The SPD shall be equipped with an LCD display that indicates to the user how many surges have occurred at the location. The surge counter shall trigger each time a surge event with a peak current magnitude of a minimum of $50 \pm 20A$ occurs. A reset pushbutton shall also be standard, allowing the surge counter to be zeroed. The reset button shall contain a mechanism to prevent accidental resetting of the counter via a single, short-duration button press. In order to prevent accidental resetting, the surge counter reset button shall be depressed for a minimum of 2 seconds in order to clear the surge count total.

- l. Overcurrent Protection: The unit shall contain thermally protected MOVs. These thermally protected MOVs shall have a thermal protection element packaged together with the MOV in order to achieve overcurrent protection of the MOV. The thermal protection element shall disconnect the MOV(s) from the system in a fail-safe manner should a condition occur that would cause them to enter a thermal runaway condition.
 - m. Fully Integrated Component Design: All of the SPD's components and diagnostics shall be contained within one discrete assembly. SPDs or individual SPD modules that must be ganged together in order to achieve higher surge current ratings or other functionality shall not be accepted.
 - n. Safety Requirements: The SPD shall minimize potential arc flash hazards by containing no user serviceable / replaceable parts and shall be maintenance free. SPDs containing items such as replaceable modules, replaceable fuses, or replaceable batteries shall not be accepted. SPDs requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPDs requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.
 - o. The SPD application covered under this section includes lighting and distribution panelboards. The SPD units shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category B environments.
 - 1) SPDs shall be installed immediately following the load side of the main breaker. SPDs installed in main lug only panelboards shall be installed immediately following the incoming main lugs.
 - 2) The panelboard shall be capable of re-energizing upon removal of the SPD.
 - 3) The SPD shall be interfaced to the panelboard via a direct bus bar connection.
 - 4) The SPD shall be included and mounted within the panelboard by the manufacturer of the panelboard.
 - 5) The SPD shall be of the same manufacturer as the panelboard.
 - 6) The complete panelboard including the SPD shall be UL67 listed.
2. Peak Single-Impulse Surge Current Rating: Minimum surge current capacity: 60 kA per mode/120 kA per phase.
3. ANSI/UL 1449 3rd Edition Voltage Protection Rating (VPR) – The maximum ANSI/UL 1449 3rd Edition VPR for the device shall not exceed: 700 V for L-N, L-G, and N-G and 1200 V for L-L on 208Y/120 V. 1200 V for L-N, L-G, and N-G and 2000 V for L-L on 480Y/277 V.

2.5 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1.
- B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- C. Mount top of trim 78 inches (2286 mm) above finished floor unless otherwise indicated.
- D. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- E. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated:
 - 1. Backboards: Mount cabinets, lighting and appliance branch-circuit panelboards, disconnect switches, and control enclosures on plywood, fire-retardant treated, painted (gray), 3/4 inch. Comply with requirements for plywood backing panels specified in Division 6 Section "Rough Carpentry."
- F. Install filler plates in unused spaces.
- G. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.
- H. Comply with NECA 1.
- I. All homerun conduits shall terminate directly into the top of panelboards and not have a wireway with nipple conduits between panelboard and wireway. Multiple splices (wirenuts) in a gutter above panels will not be allowed.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
- D. Provide label on each panelboard indicating where the source of supply is located, per the NEC 408.4(B). Provide label complying with requirements of Division 26 Section "Identification for Electrical Systems."
- E. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Acceptance Testing Preparation:
 - 1. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- D. Panelboards will be considered defective if they do not pass tests and inspections.
- E. Engineer's Observations: This Contractor shall open/remove panel covers for observation of panels by Engineer.

3.5 ADJUSTING

- A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.
- B. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
 - 1. Measure as directed during period of normal system loading.

2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.6 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 26 2416

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**SECTION 26 2726
WIRING DEVICES**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Receptacles, receptacles with integral GFCI, and associated device plates.
 - 2. Snap switches.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- D. TVSS: Transient voltage surge suppressor.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.
- 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.

- C. Comply with NFPA 70.

1.6 COORDINATION

- A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
 - 1. Cord and Plug Sets: Match equipment requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
 - 1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
 - 2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
 - 3. Leviton Mfg. Company Inc. (Leviton).
 - 4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.2 STRAIGHT BLADE RECEPTACLES

- A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 5361 (single), 5362 (duplex).
 - b. Hubbell; 5361 (single), 5362 (duplex).
 - c. Leviton; 5361 (single), 5362-S (duplex).
 - d. Pass & Seymour; 5351 (single), 5352 (duplex).

2.3 GFCI RECEPTACLES

- A. General Description: Straight blade, feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.
- B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper;

- b. Hubbell; GFRST20.
 - c. Leviton; GFNT2
 - d. Pass & Seymour; 2097
2. Provide self-test GFCI.

2.4 SNAP SWITCHES

- A. Comply with NEMA WD 1 and UL 20.
- B. Switches, 120/277 V, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221 (single pole), 2222 (two pole), 2223 (three way), 2224 (four way).
 - b. Hubbell; 1221 (single pole), 1222 (two pole), 1223 (three way), 1224 (four way).
 - c. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 1224-2 (four way).
 - d. Pass & Seymour; PS20AC1 (single pole), PS20AC2 (two pole), PS20AC3 (three way), PS20AC4 (four way).

2.5 WALL PLATES

- A. Single and combination types to match corresponding wiring devices.
 - 1. Plate-Securing Screws: Metal with head color to match plate finish.
 - 2. Material: 0.035-inch- (1-mm-) thick, 302 stainless steel.
 - 3. Material for Unfinished Spaces: Galvanized steel.
 - 4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover and listed and labeled for use in "wet locations."
- B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum with while-in-use, gasketed, extra-duty, lockable cover. Covers shall be Hubbell #WP26E series, or equivalent.

2.6 FINISHES

- A. Color: Wiring device catalog numbers in Section Text do not designate device color.
 - 1. Wiring Devices Connected to Normal Power System: Gray, unless otherwise indicated or required by NFPA 70 or device listing.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
- B. Coordination with Other Trades:
 - 1. Take steps to ensure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
 - 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 - 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 - 4. Install wiring devices after all 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 the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 - 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
 - 4. Provide the grounded conductor at the switches controlling lighting loads.
 - 5. Existing Conductors:
 - a. Cut back and pigtail or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pigtailing existing conductors is permitted provided the outlet box is large enough.
- D. Device Installation:
 - 1. Replace all devices that have been in temporary use during construction or that show signs that 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 the last possible moment.
 4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
 5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
 6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
 7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
 8. Tighten unused terminal screws on the device.
 9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
- E. Receptacle Orientation:
1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right.
- F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
- G. Dimmers:
1. Install dimmers within terms of their listing.
 2. Verify that dimmers used for fan speed control are listed for that application.
 3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.
 4. Install wall dimmers to achieve indicated/required rating after derating for ganging as instructed by manufacturer.
- H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.
- I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.
- J. Receptacle outlets shall accommodate connection of attachment plug of associated equipment.
- K. Install blank faceplate on any j-box not having a device.

- L. Provide GFCI protection for receptacles in kitchens, at water coolers, within 6' of sink, outdoors, and where otherwise indicated on Drawings.
- M. Provide weatherproof covers at all exterior receptacles, at interior wet or spray locations, and where otherwise indicated on Drawings.
- N. GFCI receptacles shall not be installed behind equipment (refrigeration, vending, at water coolers, etc). Place receptacle where cord is accessible or provide the ground fault protection at the breaker.

3.2 IDENTIFICATION

- A. Comply with Division 26 Section "Identification for Electrical Systems."
 - 1. Receptacles: Identify panelboard and circuit number from which served. Use permanent marker inside outlet boxes.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
 - 1. In all facilities, prepare reports, or indicate on as-builts drawings, the conductors being up-sized due to voltage drop. Indicate length of conductors, calculated load (amperage or wattage), and conductor size.
- B. Tests for Convenience Receptacles:
 - 1. Line Voltage: Acceptable range is 105 to 132 V.
 - 2. Voltage Drop: See Specification Section 26 05 19. Voltage drop higher than 3 percent is not acceptable.
 - 3. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
 - 4. Using the test plug, verify that the device and its outlet box are properly wired and securely mounted.
 - 5. The tests shall be diagnostic, indicating damaged conductors, high resistance at the 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 26 2726

SECTION 26 2816
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Fusible switches (FS).
 - 2. Nonfusible switches (NF).
 - 3. Enclosures.

1.3 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.4 PERFORMANCE REQUIREMENTS

1.5 SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Current and voltage ratings.
 - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
 - 4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
- B. Shop Drawings: For enclosed switches and circuit breakers.
- C. Field quality-control reports.
 - 1. Test procedures used.

2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- D. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.6 QUALITY ASSURANCE

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NFPA 70.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
 2. Altitude: Not exceeding 6600 feet (2010 m).
- B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
 2. Indicate method of providing temporary electric service.
 3. Do not proceed with interruption of electric service without Owner's written permission.
 4. Comply with NFPA 70E.

1.8 COORDINATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- B. Type HD, Heavy Duty, Single Throw, 240 or 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Accessories:
 - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - 3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
 - 4. Lugs: Mechanical type, suitable for number, size, and conductor material.
 - 5. Service-Rated Switches: Labeled for use as service equipment.

2.2 NONFUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.
- B. Type HD, Heavy Duty, Single Throw, 240 or 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Type HD, Heavy Duty, Double Throw, 240 or 600-V ac, 1200A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- D. Accessories:
 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 3. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.3 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1 unless otherwise noted.
 2. Outdoor Locations: NEMA 250, Type 3R.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- B. Install fuses in fusible devices.
- C. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Acceptance Testing Preparation:
 - 1. Test continuity of each circuit.
- D. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

3.5 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

END OF SECTION 26 2816

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**SECTION 26 2913
ENCLOSED CONTROLLERS**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes ac, enclosed controllers rated 600 V and less, of the following types:
 - 1. Across-the-line, manual and magnetic controllers.

1.3 SUBMITTALS

- A. Product Data: For each type of enclosed controller. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each enclosed controller.
 - 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Each installed unit's type and details.
 - b. Nameplate legends.
 - c. Short-circuit current rating of integrated unit.
 - d. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices in combination controllers.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - 1. Routine maintenance requirements for enclosed controllers and all installed components.
 - 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
- E. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

- F. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain enclosed controllers of a single type through one source from a single manufacturer. Manufacturer shall be the same as the panelboards, etc.
- 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.
- C. Comply with NFPA 70.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.6 COORDINATION

- A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate features of enclosed controllers and accessory devices with pilot devices and control circuits to which they connect.
- C. Coordinate features, accessories, and functions of each enclosed controller with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.
 - 2. Danfoss Inc.; Danfoss Electronic Drives Div.
 - 3. Eaton Corporation; Cutler-Hammer Products.
 - 4. General Electrical Company; GE Industrial Systems.
 - 5. Rockwell Automation; Allen-Bradley Co.; Industrial Control Group.

6. Siemens/Furnas Controls.
7. Square D.

2.2 ACROSS-THE-LINE (ACL) ENCLOSED CONTROLLERS

- A. Magnetic Controller: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.
 1. Control Circuit: 120 V; obtained from integral control power transformer with a control power transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.
 2. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 20 tripping characteristic. Provide with heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle. Install on motors 5 hp and less.
- B. Combination Magnetic Controller: Factory-assembled combination controller and disconnect switch.
 1. Nonfusible Disconnecting Means: NEMA KS 1, heavy-duty, nonfusible switch. For starters of 10KAIC and under.
- C. Controller Size: Minimal of 0.

2.3 ENCLOSURES

- A. Description: Flush- or surface-mounting cabinets as indicated. NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at installed location.
 1. Outdoor Locations: NEMA 250, Type 3R.

2.4 ACCESSORIES

- A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.
- B. Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type. Provide red running pilot light and HOA.
- C. Auxiliary Contacts: two N.O and one N.C. auxiliary contacts.

2.5 FACTORY FINISHES

- A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested enclosed controllers before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and surfaces to receive enclosed controllers for compliance with requirements, installation tolerances and other conditions affecting performance.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Select features of each enclosed controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, controller, and load; and configuration of pilot device and control circuit affecting controller functions.
- B. Select horsepower rating of controllers to suit motor controlled.

3.3 INSTALLATION

- A. For control equipment at walls, bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."

3.4 IDENTIFICATION

- A. Identify enclosed controller, components, and control wiring according to Division 26 Section "Identification for Electrical Systems."

3.5 CONTROL WIRING INSTALLATION

- A. Install wiring between enclosed controllers according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect hand-off-automatic switch and other automatic-control devices where applicable.
 - 1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
 - 2. Connect selector switches with enclosed controller circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.6 CONNECTIONS

- A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

- B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.7 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test continuity of each circuit.
- B. Motor Phase Rotation:
 - 1. Verify proper motor rotation by “bumping” the motor. Coordinate this test with Divisions 21, 22, 23, and 26. Modify circuiting if phase rotation is not correct.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
 - 1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
 - 2. Report results in writing.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 26 2913

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**SECTION 26 5100
INTERIOR LIGHTING**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Interior lighting fixtures.
 - 2. Lighting fixture supports.

1.3 DEFINITIONS

- A. CRI: Color-rendering index.
- B. CU: Coefficient of utilization.
- C. LED: Light Emitting Diode.
- D. LER: Light Fixture efficacy rating.
- E. Light Fixture: Complete lighting fixture, including ballast housing if provided.
- F. RCR: Room cavity ratio.

1.4 SUBMITTALS

- A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
 - 1. Physical description of lighting fixture including dimensions.
 - 2. Energy-efficiency data.
 - 3. LED Fixture Reports
 - a. IESNA LM-79 Test Reports.
 - b. IESNA LM-80 Test Reports.
 - c. IESNA TM-21 Calculation.
- B. Shop Drawings: Show details for each fixture.

- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.
 - 1. Tabulated list of light fixture types, associated lamps, and associated LED modules.

1.5 QUALITY ASSURANCE

- A. 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.
- B. Comply with NFPA 70.

1.6 COORDINATION

- A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.7 WARRANTY

- A. Special Warranty for LED Modules: Provide all materials and labor necessary to replace components that fail in materials or workmanship, f.o.b. the nearest shipping point to Project site, within specified warranty period indicated below.
 - 1. Warranty Period: Five year(s) from date of Substantial Completion.
- B. Special Warranty for LED Fixtures: Provide all materials and labor necessary to repair or replace components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty to include but not be limited to:
 - a. Fixture finish.
 - b. LED Driver(s)
 - c. LED Modules
 - d. Replacement when more than 10% of LED sources in any module is defective or non-starting.
 - e. Color shift.
 - 2. Warranty Period for Solid State Lighting Fixtures: Five years from date of Substantial Completion.
- C. Provide written copy of manufacturer's warranty with lighting submittals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the manufacturers specified or pre-bid approved equivalent:
 - 1. Light Fixtures:
 - a. Refer to Lighting Fixture Schedule on Drawings.

2.2 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

- A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- B. LED Fixtures: Comply with UL 8750 and UL 1598.
- C. Metal Parts: Free of burrs and sharp corners and edges.
- D. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
- E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- F. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
 - 4. Laminated Silver Metallized Film: 90 percent.
- G. Plastic Diffusers, Covers, and Globes:
 - 1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - a. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless different thickness is indicated.
 - b. UV stabilized.
 - 2. Glass: Annealed crystal glass, unless otherwise indicated.

2.3 LED (LIGHT-EMITTING DIODE)

- A. LEDs, driver, and advanced optical design.
- B. Approximately 96 percent optical efficiency.
- C. Reflector sealed to the LED chip package for uniform illumination. Reflector shall reduce light loss and deliver superior light control. Reflector shall control glare.
- D. High efficiency driver and thermal management system capable of providing total luminaire efficiencies in excess of 50 lumens per watt.
- E. Fixture shall include frame-in kit for construction being installed in.
- F. Proper thermal management with heat sinks.
- G. Fixture shall be Listed with Energy Star or Designlights Consortium.
- H. Drivers: General Requirements:
 - 1. Efficiency per LM-79:
 - a. Drivers capable of 50 watts or greater: 85 percent or higher
 - b. Drivers capable of less than 50 watts less: 80 percent or higher
 - 2. Power Output: UL Class I or II output.
 - 3. Rated Driver Life: Shall match Light Engine Rated Life; 50,000 hours minimum.
 - 4. Operating Frequency: 60 Hz
 - 5. Power Factor: 0.90 or higher.
 - 6. Total Harmonic Distortion Rating: Less than 20 percent.
 - 7. Sound Rating: Class A
 - 8. Hazardous Substances: RoHS compliant.
 - 9. Operations:
 - a. On/Off: Shall be rated for normal 120V or 277V switch operation as indicated on drawings.
 - b. Dimming: Shall be compatible with industry standard dimming protocols.
 - 10. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 - 11. Radio Frequency Interference: Comply with FCC 47 CFR part 15 Class A (commercial).

2.4 LED MODULES

- A. Lumen Output: As indicated on the fixture schedule.
- B. LED Binning: Within a 3-step MacAdam ellipse.
- C. Rated Module Life: Greater than 70 percent of initial lumens at 50,000 hours, per LM-79 and LM-80 testing.
- D. Correlated Color Temperature (CCT): As indicated on the drawings with an allowed plus or minus 5% variance.
- E. Color Rendering Index (CRI): As indicated for the specified CCT:
 - 1. CCT of 3000K to 3500K: Greater than or equal to 80.
 - 2. CCT of 4000K to 6500K: Greater than or equal to 70.

2.5 LIGHTING FIXTURE SUPPORT COMPONENTS

- A. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two, 1/2-inch (13-mm) steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gauge (2.68 mm).
- E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gauge (2.68 mm).
- F. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
- G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.
- B. Support for Lighting Fixtures in or on Grid-Type Suspended Ceilings: The grid shall not be used as a support element. Contractor shall support fixtures independently from structure.

1. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.
 2. Install at least two independent support rods or wires from structure to a tab on lighting fixture at opposite ends of the fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.
- C. Suspended Lighting Fixture Support:
1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
 2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
 3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
- D. Adjust aimable lighting fixtures to provide required light intensities.
- E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- F. Install contactors and low-voltage track lighting transformers in NEMA 1 enclosures.
- G. Light fixtures with the letters NL are to be used as night lights and be unswitched.

3.2 FIELD QUALITY CONTROL

- A. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION 26 5100

**SECTION 26 5600
EXTERIOR LIGHTING**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Exterior luminaires.
 - 2. Poles and accessories.
- B. Related Sections include the following:
 - 1. Division 26 Section "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

1.3 DEFINITIONS

- A. CRI: Color-rendering index.
- B. Luminaire: Complete lighting fixture, including ballast housing if provided.
- C. Pole: Luminaire support structure, including tower used for large area illumination.
- D. Standard: Same definition as "Pole" above.

1.4 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

- A. Wind Load: Pressure of wind on pole and luminaire, calculated and applied as stated below in AASHTO LTS-4.
 - 1. Wind speed for calculating wind load for poles 50 feet (15 m) or less in height is 100 mph (177 km/h).

1.5 SUBMITTALS

- A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:
 - 1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
 - 2. Details of attaching luminaires and accessories.

3. Details of installation and construction.
 4. Luminaire materials.
 5. Photoelectric relays.
 6. Ballasts/drivers, including energy-efficiency data.
 7. Lamps, including life, output, and energy-efficiency data.
 8. Materials, dimensions, and finishes of poles.
 9. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
 10. Anchor bolts for poles.
- B. Shop Drawings:
1. Show details for each fixture.
 2. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For luminaires and poles to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. 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.
- B. Comply with IEEE C2, "National Electrical Safety Code."
- C. Comply with NFPA 70.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Package aluminum poles for shipping according to ASTM B 660.
- B. Store poles on decay-resistant-treated skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
- C. Retain factory-applied pole wrappings on metal poles until right before pole installation.

1.8 WARRANTY

- A. Special Warranty: Provide all materials and labor necessary to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.
 - 1. Warranty Period for Luminaires: Five years from date of Substantial Completion.
 - 2. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
 - 3. Warranty Period for Color Retention: Five years from date of Substantial Completion.
 - 4. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
- B. Subject to compliance with requirements, provide products by one of the manufacturers specified or pre-bid approved equivalent:
 - 1. Light Fixtures:
 - a. Refer to Lighting Fixture Schedule on Drawings.

2.2 LUMINAIRES, GENERAL REQUIREMENTS

- A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.
- B. Metal Parts: Free of burrs and sharp corners and edges.
- C. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.
- D. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
- E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.

- F. Exposed Hardware Material: Stainless steel.
- G. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
- H. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.
- I. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
- J. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- K. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.
- L. Factory-Applied Finish for Steel luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
 - 2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - a. Color: As selected from manufacturer's standard catalog of colors.

2.3 LED

- A. LEDs, driver, and advanced optical design.
- B. Approximately 96 percent optical efficiency.
- C. Direct-contact refractor sealed to the LED chip package for uniform illumination. Refractor shall reduce light loss and deliver superior light control. Refractor shall control glare.
- D. High efficiency driver and thermal management system capable of providing total luminaire efficiencies in excess of 70 lumens per watt.

- E. Modular light bars.
- F. Proper thermal management with heat sinks and vented housing for continual air flow through fixture.

2.4 POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS

- A. Manufacturers:
 - 1. Cooper Industries.
 - 2. Lithonia.
 - 3. GE Lighting.
 - 4. Valmont.
 - 5. Or approved equal.
- B. Structural Characteristics: Comply with AASHTO LTS-4.
 - 1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in Part 1 "Structural Analysis Criteria for Pole Selection" Article, with a gust factor of 1.3.
 - 2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.
- C. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts, unless otherwise indicated.
- D. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
 - 1. Materials: Shall not cause galvanic action at contact points.
 - 2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication, unless stainless-steel items are indicated.
 - 3. Anchor-Bolt Template: Plywood or steel.
- E. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."
- F. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.

- G. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4.

2.5 ALUMINUM POLES

- A. Poles: Seamless, extruded structural tube complying with ASTM B 429, Alloy 6063-T6 with access handhole in pole wall.
- B. Poles: ASTM B 209 (ASTM B 209M), 5052-H34 marine sheet alloy with access handhole in pole wall.
 - 1. Shape: Round, straight.
 - 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- D. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- E. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.
 - 1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.
 - 2. Finish: Same as luminaire.
- F. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
- G. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 - 2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
 - 3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
 - 4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.

- a. Color: As selected by Architect from manufacturer's full range.

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

- A. Install lamps in each luminaire.
- B. Fasten luminaire to indicated structural supports.
 - 1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Adjust luminaires that require field adjustment or aiming.
- D. Exterior building fixtures shall be sealed with weatherproof caulking (color match face of building). Fixture locations and mounting heights shall be coordinated with architectural elevations and details.

3.2 POLE INSTALLATION

- A. Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.
- B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features, unless otherwise indicated on Drawings:
 - 1. Fire Hydrants and Storm Drainage Piping: 60 inches.
 - 2. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet.
 - 3. Trees: 15 feet.
- C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- D. Foundation-Mounted Poles: Mount pole with leveling nuts and tighten top nuts to torque level recommended by pole manufacturer.
 - 1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
 - 2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
 - 3. Install base covers, unless otherwise indicated.
 - 4. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

- E. Raise and set poles using web fabric slings (not chain or cable).

3.3 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
- B. Steel Conduits: Comply with Division 26 Section "Raceway and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.4 GROUNDING

- A. Ground metal poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
 - 1. Install grounding electrode for each pole, unless otherwise indicated.
 - 2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

3.5 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.
 - 1. Verify operation of photoelectric controls.
- C. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain luminaire lowering devices. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 26 5600

**SECTION 31 0519
GEOSYNTHETICS FOR EARTHWORK**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Geotextile for filtration.
- B. Geotextile for protection.

1.2 RELATED REQUIREMENTS

- A. Section 02 4100 - Demolition: Site demolition.
- B. Section 31 1000 - Site Clearing.
- C. Section 31 2200 - Grading.
- D. Section 31 2316 - Excavation.
- E. Section 31 2316.13 - Trenching.
- F. Section 31 2323 - Fill.

1.3 REFERENCE STANDARDS

- A. AASHTO M 288 - Standard Specification for Geosynthetic Specification for Highway Applications 2022.
- B. ASTM D4533/D4533M - Standard Test Method for Trapezoid Tearing Strength of Geotextiles 2015.
- C. ASTM D4632/D4632M - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles 2015a.
- D. ASTM D4873/D4873M - Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples 2017 (Reapproved 2021).
- E. ASTM D5199 - Standard Test Method for Measuring the Nominal Thickness of Geosynthetics 2012 (Reapproved 2019).
- F. ASTM D6241 - Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile- Related Products Using a 50-mm Probe 2014.

1.4 SUBMITTALS

- A. See Section 01 0004 Submittal Procedures for submittal procedures.

- B. Product Data: Manufacturer's data on each product to be used, including physical properties, seaming materials, and installation instructions.
- C. Manufacturer's Certification: Indicating the proposed geosynthetic function meets design requirements supported by applicable testing results.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. See SDSTA Division 1 for additional requirements.
- B. Identify, store, and handle geosynthetic rolls and samples according to ASTM D4873/D4873M.
- C. Protect materials from sunlight and other ultraviolet light sources during storage.
- D. Handle geosynthetics with care and prevent dragging, dropping, or imbalanced lifting.

1.6 FIELD CONDITIONS

- A. Surface Requirements: Do not place geosynthetic when the receiving surface is saturated or has ponded water.
- B. Follow recommendations of geosynthetic manufacturer.

PART 2 PRODUCTS

2.1 GEOSYNTHETIC

- A. Provide geosynthetic in largest size sheets as possible to minimize field joining.
- B. Uniform thickness according to ASTM D5199.

2.2 GEOTEXTILE

- A. General:
 - 1. Material: Polyethylene consisting of 5 percent maximum regrind and free of contaminants.
 - 2. AASHTO M 288.
 - 3. Elongation: 35 percent, minimum, when tested in accordance with ASTM D4632/D4632M.
- B. Geotextile for Protection: Capable of absorbing and dissipating stress.
 - 1. Type: Woven.
 - 2. Seams: Mechanically sewn.
 - a. Overlap: 3 inches (7.6 cm).

- b. Stitch: Flat; continuous; tied off at ends.
 - c. Strength: 85 percent of grab, minimum, according to ASTM D4632/D4632M.
 - d. Limit seams perpendicular to the direction of incline.
 - 3. Grab Strength: 500 lb (2.2 kN), minimum, when tested in accordance with ASTM D4632/D4632M.
 - 4. Puncture Strength: 650 lb (2.9 kN), minimum, when tested in accordance with ASTM D6241.
 - 5. Sewn Seam Strength: 300 lb (1.3 kN), minimum, when tested in accordance with ASTM D4632/D4632M.
 - 6. Trapezoid Tear Strength: 150 lb (0.7 kN), minimum, when tested in accordance with ASTM D4533/D4533M.
- C. Geotextile Accessories:
- 1. Seaming Thread: High-strength; as recommended by manufacturer; contrasting color.
 - 2. Anchoring Pins: As recommended by manufacturer.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify the receiving surface is smooth, without ruts or protrusions, and grades are according to design drawings.
- B. Verify the geosynthetic is free of defects or flaws that may degrade physical performance.

3.2 PREPARATION

- A. Remove vegetation, boulders, and rocks larger than 3/4 inch (20 mm) in size and other sharp objects in accordance with Section 31 1000.
- B. Remove unsuitable materials in accordance with Section 31 2316.
- C. Fill in holes, including stake holes, backfill, and fill in accordance with Section 31 2323.
- D. Grade as indicated on drawings in accordance with Section 31 2200.
- E. Compact smooth as indicated on drawings in accordance with Section 31 2323.

3.3 INSTALLATION

- A. General:

1. Notify Architect a minimum of 24 hours prior to installation.
2. Prevent surface drainage from eroding under geosynthetic. Repair undermined areas prior to backfill.
3. Position geosynthetic smooth and wrinkle free on prepared surface; unroll or unfold carefully, avoiding stretching.
4. Secure geosynthetic to prevent movement or damage during installation.
5. Perform seaming in adequate lighting. Seam each geosynthetic member immediately after final placement. Clean sheets of dust, dirt, and other foreign matter prior to seaming.
6. Follow manufacturer's recommended installation procedures.

B. Filtration:

1. Install geotextile according to manufacturer's recommendations.
2. Lay sheets in the direction of construction.
3. Repairs: Remove damaged portion of geotextile and seam an additional layer to cover the affected area in all directions. Replace geotextile where surface runoff contamination has occurred.

C. Protection:

1. Install geotextile according to manufacturer's recommendations.
2. Lay sheets in the direction of incline.
3. Place adjacent geotextile and loosely fasten until seamed.
4. Place terminal ends within anchor trench and secure with backfill.
5. Repairs: Remove damaged portion of geotextile and seam an additional layer to cover the affected area in all directions.

3.4 BACKFILL

- A. Obtain approval for geosynthetic sheet installation from Architect before placing fill.
- B. Backfill in a manner to prevent damage to geosynthetic. Repair geosynthetic damaged during backfill operations.
- C. Cover geosynthetic in the installed direction in accordance with Section 31 2323.

3.5 PROTECTION

- A. Do not exceed geosynthetic manufacturer's recommended exposure to UV radiation.
- B. Prevent surface water runoff from contaminating geosynthetic.
- C. Do not use pins or staples where risk of damaging underlying geosynthetic layer is present.
- D. Erect barricades to prevent traffic over geosynthetic before it is filled.

END OF SECTION 31 0519

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**SECTION 31 1000
SITE CLEARING**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Removal of existing debris.

1.2 RELATED REQUIREMENTS

- A. Section 01 0001 - Summary of Work: Limitations on Contractor's use of site and premises.
- B. Section 01 0006 - Temporary Facilities and Controls: Site fences, security, protective barriers, and waste removal.
- C. Section 01 0007 - Closeout Submittals: Project conditions; protection of bench marks, survey control points, and existing construction to remain; reinstallation of removed products.
- D. Section 31 2200 - Grading: Topsoil removal.
- E. Section 31 2200 - Grading: Fill material for filling holes, pits, and excavations generated as a result of removal operations.
- F. Section 31 2323 - Fill: Filling holes, pits, and excavations generated as a result of removal operations.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Fill Material: As specified in Section 31 2200 - Grading

PART 3 EXECUTION

3.1 SITE CLEARING

- A. Minimize production of dust due to clearing operations; do not use water if that will result in ice, flooding, sedimentation of public waterways or storm sewers, or other pollution.

3.2 EXISTING UTILITIES AND BUILT ELEMENTS

- A. Coordinate work with utility companies; notify before starting work and comply with their requirements; obtain required permits.
- B. Protect existing utilities to remain from damage.
- C. Do not disrupt public utilities without permit from authority having jurisdiction.
- D. Protect existing structures and other elements that are not to be removed.

3.3 DEBRIS

- A. Remove debris, junk, and trash from site.
- B. Leave site in clean condition, ready for subsequent work.
- C. Clean up spillage and wind-blown debris from public and private lands.

END OF SECTION 31 1000

**SECTION 31 2200
GRADING**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Removal and storage of topsoil.
- B. Rough grading the site for site structures.
- C. Finish grading.

1.2 RELATED REQUIREMENTS

- A. Section 31 1000 - Site Clearing.
- B. Section 31 2316 - Excavation.
- C. Section 32 9219 - Seeding: Finish ground cover.

1.3 SUBMITTALS

- A. Project Record Documents: Accurately record actual locations of utilities remaining by horizontal dimensions, elevations or inverts, and slope gradients.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Topsoil: Topsoil excavated on-site.
 - 1. Graded.
 - 2. Free of roots, rocks larger than 2 inch (50 mm), subsoil, debris, large weeds and foreign matter.
- B. Topsoil: Imported
 - 1. Friable clay loam surface soil free of subsoil, clay lumps, stones and other objects over 2 inches (50 mm) in diameter, and without weeds, roots, and other objectionable material.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that survey bench mark and intended elevations for the Work are as indicated.
- B. Verify the absence of standing or ponding water.

3.2 PREPARATION

- A. Identify required lines, levels, contours, and datum.
- B. Stake and flag locations of known utilities.
- C. Locate, identify, and protect from damage above- and below-grade utilities to remain.
- D. Provide temporary means and methods to remove all standing or ponding water from areas prior to grading.
- E. Protect site features to remain, including but not limited to bench marks, survey control points, existing structures, and fences, from damage by grading equipment and vehicular traffic.

3.3 ROUGH GRADING

- A. Remove topsoil from areas to be further excavated, re-landscaped, or re-graded, without mixing with foreign materials.
- B. Do not remove topsoil when wet.
- C. Remove subsoil from areas to be further excavated, re-landscaped, or re-graded.
- D. Do not remove wet subsoil , unless it is subsequently processed to obtain optimum moisture content.
- E. Benching Slopes: Horizontally bench existing slopes greater than 1:4 to key fill material to slope for firm bearing.
- F. Stability: Replace damaged or displaced subsoil to same requirements as for specified fill.
- G. Remove and replace soils deemed unsuitable by classification and which are excessively moist due to lack surface water control.

3.4 SOIL REMOVAL

- A. Stockpile excavated subsoil on site.
- B. Stockpile subsoil to be re-used on site; remove remainder from site.
- C. Stockpiles: Use areas designated on site; pile depth not to exceed 8 feet (2.5 m); protect from erosion.

3.5 FINISH GRADING

- A. Before Finish Grading:
 - 1. Verify building and trench backfilling have been inspected.

2. Verify subgrade has been contoured and compacted.
- B. Remove debris, roots, branches, stones, in excess of 1/2 inch (13 mm) in size. Remove soil contaminated with petroleum products.
- C. In areas where vehicles or equipment have compacted soil, scarify surface to depth of 3 inches (75 mm).
- D. Place topsoil in areas where seeding are indicated.
- E. Place topsoil to the following compacted thicknesses:
 1. Areas to be Seeded with Grass: 4 inches (100 mm).
- F. Place topsoil during dry weather.
- G. Remove roots, weeds, rocks, and foreign material while spreading.
- H. Fine grade topsoil to eliminate uneven areas and low spots. Maintain profiles and contour of subgrade.
- I. Lightly compact placed topsoil.
- J. Maintain stability of topsoil during inclement weather. Replace topsoil in areas where surface water has eroded thickness below specifications.

3.6 REPAIR AND RESTORATION

- A. Existing Facilities, Utilities, and Site Features to Remain: If damaged due to this work, repair or replace to original condition.

3.7 FIELD QUALITY CONTROL

- A. See Section 31 2323 for compaction density testing.

3.8 CLEANING

- A. Remove unused stockpiled topsoil and subsoil. Grade stockpile area to prevent standing water.
- B. Leave site clean and raked, ready to receive landscaping.

END OF SECTION 31 2200

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**SECTION 31 2316
EXCAVATION**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Excavating for building volume below grade, footings, pile caps, slabs-on-grade, paving, site structures, and utilities within the building.
- B. Trenching for utilities outside the building to utility main connections.

1.2 RELATED REQUIREMENTS

- A. Document 221198-Geotechnical Evaluation for SURF WWTP Improvements (FMG Engineering, October 6, 2022: Geotechnical report; bore hole locations and findings of subsurface materials. Available upon request.
- B. Section 02 4100 - Demolition: Shoring and underpinning existing structures.
- C. Section 31 1000 - Site Clearing: Vegetation and existing debris removal.
- D. Section 31 2200 - Grading: Grading.
- E. Section 31 2316.13 - Trenching: Excavating for utility trenches outside the building to utility main connections.
- F. Section 31 2316.26 - Rock Removal: Removal of rock during excavating.
- G. Section 31 2323 - Fill: Fill materials, backfilling, and compacting.
- H. Section 33 4100 - Subdrainage: Filter aggregate and filter fabric for foundation drainage systems.

1.3 REFERENCE STANDARDS

- A. 29 CFR 1926 - Safety and Health Regulations for Construction Current Edition.

1.4 SUBMITTALS

- A. See Section 01 0004 Submittal Procedures, for submittal procedures.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Bedding and Fill to Correct Over-Excavation:
 - 1. See Section 31 2323 for bedding and corrective fill materials at general excavations.
 - 2. See Section 31 2316.13 for bedding and corrective fill materials at utility trenches.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that survey bench mark and intended elevations for the work are as indicated.

3.2 PREPARATION

- A. Identify required lines, levels, contours, and datum locations.
- B. See Section 31 1000 for clearing, grubbing, and removal of existing debris.
- C. See Section 31 2200 for topsoil removal.
- D. Locate, identify, and protect utilities that remain and protect from damage.
- E. Protect bench marks, survey control points, existing structures, fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.
- F. Grade top perimeter of excavation to prevent surface water from draining into excavation. Provide temporary means and methods, as required, to maintain surface water diversion until no longer needed, or as directed by Architect.

3.3 EXCAVATING

- A. Excavate to accommodate new structures and construction operations.
 - 1. Excavate to the specified elevations.
 - 2. Excavate to the length and width required to safely install, adjust, and remove any forms, bracing, or supports necessary for the installation of the work.
 - 3. Cut utility trenches wide enough to allow inspection of installed utilities.
 - 4. See Section 31 2316.26 for required excavation clearances for pipes in utility trenches.
- B. Notify Architect of unexpected subsurface conditions and discontinue affected Work in area until notified to resume work.
- C. Do not interfere with 45 degree bearing splay of foundations.
- D. Provide temporary means and methods, as required, to remove all water from excavations until directed by Architect. Remove and replace soils deemed suitable by classification and which are excessively moist due to lack of dewatering or surface water control.

3.4 FILLING AND BACKFILLING

- A. Do not fill or backfill until all debris, water, unsatisfactory soil materials, obstructions, and deleterious materials have been removed from excavation.

- B. See Section 31 2316.13 for fill, backfill, and compaction requirements at utility trenches.

3.5 CLEANING

- A. Remove excavated material that is unsuitable for re-use from site.
- B. Remove excess excavated material from site.

3.6 PROTECTION

- A. Divert surface flow from rains or water discharges from the excavation.
- B. Prevent displacement of banks and keep loose soil from falling into excavation; maintain soil stability.
- C. Protect open excavations from rainfall, runoff, freezing groundwater, or excessive drying so as to maintain foundation subgrade in satisfactory, undisturbed condition.
- D. Protect bottom of excavations and soil adjacent to and beneath foundation from freezing.
- E. Keep excavations free of standing water and completely free of water during concrete placement.

END OF SECTION 31 2316

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**SECTION 31 2316.13
TRENCHING**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Backfilling and compacting for utilities outside the building to utility main connections.

1.2 RELATED REQUIREMENTS

- A. Document 221198-Geotechnical Evaluation for SURF WWTP Improvements (FMG Engineering, October 6, 2022: Geotechnical report; bore hole locations and findings of subsurface materials. Available upon request.
- B. Section 03 3000 - Cast-in-Place Concrete.
- C. Section 31 0519 - Geosynthetics for Earthwork.
- D. Section 31 2200 - Grading: Site grading.
- E. Section 31 2316 - Excavation: Building and foundation excavating.
- F. Section 31 2316.26 - Rock Removal: Removal of rock during excavating.
- G. Section 31 2323 - Fill: Backfilling at building and foundations.
- H. Section 33 4100 - Subdrainage: Filter aggregate and filter fabric for foundation drainage systems.

1.3 REFERENCE STANDARDS

- A. AASHTO T 180 - Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18 in.) Drop 2021, with Errata (2022).
- B. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³)) 2012 (Reapproved 2021).
- C. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³)) 2012 (Reapproved 2021).

1.4 SUBMITTALS

- A. 01 0004 - Submittal Procedures for submittal procedures.
- B. Fill Composition Test Reports: Results of laboratory tests on proposed and actual materials used.
- C. Compaction Density Test Reports.

PART 2 PRODUCTS

2.1 FILL MATERIALS

- A. General Fill: Subsoil excavated on-site.
 - 1. Graded.
 - 2. Free of lumps larger than 3 inches (75 mm), rocks larger than 2 inches (50 mm), and debris.
- B. Granular Fill: Free-draining gravel containing less than 5 percent passing the No. 200 sieve and no more than 20 percent passing the No. 4 sieve and have a maximum particle size of 1 inch.
- C. Topsoil: See Section 31 2200.

2.2 ACCESSORIES

- A. Geotextile: See Section 31 0519.

2.3 SOURCE QUALITY CONTROL

- A. See Section 01 0005 Quality Control, for general requirements for testing and analysis of soil material.
- B. Where fill materials are specified by reference to a specific standard, test and analyze samples for compliance before delivery to site.
- C. If tests indicate materials do not meet specified requirements, change material and retest.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that survey bench marks and intended elevations for the work are as indicated.

3.2 TRENCHING

- A. Notify Architect of unexpected subsurface conditions and discontinue affected Work in area until notified to resume work.
- B. Slope banks of excavations deeper than 4 feet (1.2 meters) to angle of repose or less until shored.
- C. Do not interfere with 45 degree bearing splay of foundations.
- D. Cut trenches wide enough to allow inspection of installed utilities.
- E. Hand trim excavations. Remove loose matter.

- F. Remove large stones and other hard matter that could damage piping or impede consistent backfilling or compaction.
- G. Remove lumped subsoil, boulders, and rock up to 1/3 cubic yard (0.25 cu m) measured by volume. See Section 31 2316.26 for removal of larger material.
- H. Remove excavated material that is unsuitable for re-use from site.
- I. Remove excess excavated material from site.
- J. Provide temporary means and methods, as required, to remove all water from trenching until directed by the Architect. Remove and replace soils deemed unsuitable by classification and which are excessively moist due to lack of dewatering or surface water control.
- K. Determine the prevailing groundwater level prior to trenching. If the proposed trench extends less than 1 foot (305 mm) into the prevailing groundwater, control groundwater intrusion with perimeter drains routed to sump pumps, or as directed by the Architect.

3.3 PREPARATION FOR UTILITY PLACEMENT

- A. Cut out soft areas of subgrade not capable of compaction in place. Backfill with general fill.
- B. Compact subgrade to density equal to or greater than requirements for subsequent fill material.
- C. Until ready to backfill, maintain excavations and prevent loose soil from falling into excavation.

3.4 BACKFILLING

- A. Backfill to contours and elevations indicated using unfrozen materials.
- B. Employ a placement method that does not disturb or damage other work.
- C. Systematically fill to allow maximum time for natural settlement. Do not fill over porous, wet, frozen or spongy subgrade surfaces.
- D. Maintain optimum moisture content of fill materials to attain required compaction density.
- E. Slope grade away from building minimum 2 inches in 10 feet (50 mm in 3 m), unless noted otherwise. Make gradual grade changes. Blend slope into level areas.
- F. Correct areas that are over-excavated.
 - 1. Other areas: Use general fill, flush to required elevation, compacted to minimum 97 percent of maximum dry density.
- G. Compaction Density Unless Otherwise Specified or Indicated:
- H. Reshape and re-compact fills subjected to vehicular traffic.

3.5 BEDDING AND FILL AT SPECIFIC LOCATIONS

- A. Use general fill unless otherwise specified or indicated.
- B. Utility Piping, Conduits, and Duct Bank:
 - 1. Compact in maximum 8 inch (200 mm) lifts to 95 percent of maximum dry density.

3.6 FIELD QUALITY CONTROL

- A. See Section 01 0005 Quality Control, for general requirements for field inspection and testing.
- B. Evaluate results in relation to compaction curve determined by testing uncompacted material in accordance with ASTM D1557 ("modified Proctor"), AASHTO T 180, or ASTM D698 ("standard Proctor").
- C. If tests indicate work does not meet specified requirements, remove work, replace and retest.
- D. Frequency of Tests: One test for every two feet of backfill per 150 lineal feet..

END OF SECTION 31 2316.13

**SECTION 31 2316.26
ROCK REMOVAL**

PART 1 GENERAL

PART 3 EXECUTION

2.1 EXAMINATION

- A. Verify site conditions and note subsurface irregularities affecting work of this section.

2.2 PREPARATION

- A. Identify required lines, levels, contours, and datum.

2.3 ROCK REMOVAL

- A. Form level bearing at bottom of excavations.
- B. Remove shaled layers to provide sound and unshattered base for footings.
- C. In utility trenches, excavate to 6 inches (150 mm) below invert elevation of pipe and 24 inches (600 mm) wider than pipe diameter.
- D. Remove excavated materials from site.
- E. Correct unauthorized rock removal in accordance with backfilling and compacting requirements of Section 31 2323.

2.4 FIELD QUALITY CONTROL

- A. Independent agency field inspection will be provided under provisions of Section 01 0005 Quality Control for Construction.

END OF SECTION 31 2316.26

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**SECTION 31 2323
FILL**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Filling, backfilling, and compacting for building volume below grade, footings, slabs-on-grade, and utilities within the building.
- B. Backfilling and compacting for utilities outside the building to utility main connections.
- C. Filling holes, pits, and excavations generated as a result of removal (demolition) operations.
- D. Lightweight concrete fill.

1.2 RELATED REQUIREMENTS

- A. Document Geotechnical Evaluation Sanford Underground Research Facility (SURF) Wastewater Treatment Plant (WWTP) Improvements, Lead, South Dakota, October 6, 2022: Geotechnical report; bore hole locations and findings of subsurface materials. Available upon request.
- B. Section 31 2200 - Grading: Removal and handling of soil to be re-used.

1.3 DEFINITIONS

- A. Finish Grade Elevations: Indicated on drawings.

1.4 REFERENCE STANDARDS

- A. ASTM C136/C136M - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates 2019.
- B. ASTM D1556/D1556M - Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method 2015, with Editorial Revision (2016).
- C. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³)) 2012 (Reapproved 2021).

1.5 SUBMITTALS

- A. See Section 01 0004 Submittal Procedures for submittal procedures.
- B. Product Data for Manufactured Fill.
- C. Soil Samples: 10 pounds (4.5 kg) sample of each type of fill; submit in air-tight containers to testing laboratory.
- D. Materials Sources: Submit name of imported materials source.

- E. Compaction Density Test Reports.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Independent firm specializing in performing testing and inspections of the type specified in this section.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. When necessary, store materials on site in advance of need.
- B. When fill materials need to be stored on site, locate stockpiles where designated.
 - 1. Separate differing materials with dividers or stockpile separately to prevent intermixing.
 - 2. Prevent contamination.
 - 3. Protect stockpiles from erosion and deterioration of materials.

PART 2 PRODUCTS

2.1 FILL MATERIALS

- A. General Fill - Fill Type - Imported: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
 - 1. Satisfactory Soils: ASTM D2487 Soil Classification Groups GW, GPP, GM, SW, SP, SM, and CL or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.
 - 2. Unsatisfactory Soils: Soil Classification Groups GC, SC, ML, OL, CH, MH, OH, and PT according to ASTM D 2487, or a combination of the groups.
 - a. Unsatisfactory soils also include satisfactory soils not maintained between -1 percent and 3 percent of optimum moisture content at time of compaction.
- B. General Fill: Subsoil excavated on-site.
 - 1. Graded.
 - 2. Free of lumps larger than 3 inches (75 mm), rocks larger than 2 inches (50 mm), and debris.
- C. Structural Fill:
 - 1. Engineered Fill: Non-expansive, well-graded natural or crushed gravel with 100% passing the 3-inch sieve and between 8% and 20% passing the #200 sieve. The engineered fill material should also have a liquid limit less than 30. The engineered fill

material must be approved by the Geotechnical Engineer prior to transport to the site.

2. Stabilization Rock: Clean rock with 100% passing the 3-inch sieve, 0 to 15% passing the 1-inch sieve, and 0 to 8% passing the #4 sieve. The stabilization rock must be approved by the Geotechnical Engineer prior to transport to the site.

- D. Topsoil: See Section 31 2200.

2.2 SOURCE QUALITY CONTROL

- A. See Section 01 0005 Quality Control for Construction, for general requirements for testing and analysis of soil material.
- B. Where fill materials are specified by reference to a specific standard, testing of samples for compliance will be provided before delivery to site.
- C. If tests indicate materials do not meet specified requirements, change material and retest.
- D. Provide materials of each type from same source throughout the Work.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Identify required lines, levels, contours, and datum locations.
- B. See Section 31 2200 for additional requirements.
- C. Verify subdrainage, dampproofing, or waterproofing installation has been inspected.
- D. Verify structural ability of unsupported walls to support imposed loads by the fill.
- E. Verify areas to be filled are not compromised with surface or ground water.

3.2 PREPARATION

- A. Scarify and proof roll subgrade surface to a depth of 8 inches (200 mm mm) to 12 inches (300 mm) to identify soft spots.
- B. Cut out soft areas of subgrade not capable of compaction in place. Backfill with general fill.
- C. Compact subgrade to density equal to or greater than requirements for subsequent fill material.
- D. Until ready to fill, maintain excavations and prevent loose soil from falling into excavation.

3.3 FILLING

- A. Fill to contours and elevations indicated using unfrozen materials.
- B. Employ a placement method that does not disturb or damage other work.

- C. Systematically fill to allow maximum time for natural settlement. Do not fill over porous, wet, frozen or spongy subgrade surfaces.
- D. Maintain optimum moisture content of fill materials to attain required compaction density.
- E. Slope grade away from building minimum 2 inches in 10 feet (50 mm in 3 m), unless noted otherwise. Make gradual grade changes. Blend slope into level areas.
- F. Correct areas that are over-excavated.
 - 1. Load-bearing foundation surfaces: Fill with concrete.
 - 2. Load-bearing foundation surfaces: Use structural fill, flush to required elevation, compacted to 100 percent of maximum dry density.
 - 3. Other areas: Use general fill, flush to required elevation, compacted to minimum 97 percent of maximum dry density.
- G. Compaction Density Unless Otherwise Specified or Indicated:
 - 1. Under paving, slabs-on-grade, and similar construction: 92 percent of maximum dry density, ASTM D-1557.
 - 2. At Site Grading 15 feet from structures: 85 percent of maximum dry density, ASTM D-1557.
- H. Reshape and re-compact fills subjected to vehicular traffic.
- I. Maintain temporary means and methods, as required, to remove all water while fill is being placed as required, or until directed by the Architect. Remove and replace soils deemed unsuitable by classification and which are excessively moist due to lack of dewatering or surface water control.

3.4 FILL AT SPECIFIC LOCATIONS

- A. Over Buried Utility Piping, Conduits, and Duct Bank in Trenches:
 - 1. Compact in maximum 8 inch (200 mm) lifts to 92 percent of maximum dry density.

3.5 CLEANING

- A. Remove unused stockpiled materials, leave area in a clean and neat condition. Grade stockpile area to prevent standing surface water.
- B. Leave borrow areas in a clean and neat condition. Grade to prevent standing surface water.

END OF SECTION 31 2323

**SECTION 32 1123
AGGREGATE BASE COURSES**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Aggregate base course.

1.2 RELATED REQUIREMENTS

- A. Section 31 2200 - Grading: Preparation of site for base course.

1.3 REFERENCE STANDARDS

- A. ASTM C136/C136M - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates 2019.
- B. ASTM D1556/D1556M - Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method 2015, with Editorial Revision (2016).
- C. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³)) 2012 (Reapproved 2021).
- D. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method 2015.
- E. ASTM D2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) 2017, with Editorial Revision (2020).
- F. ASTM D4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils 2017, with Editorial Revision (2018).
- G. ASTM D6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth) 2017a, with Editorial Revision (2021).

1.4 SUBMITTALS

- A. See Section 01 0004 Submittal Procedures for submittal procedures.
- B. Materials Sources: Submit name of imported materials source.
- C. Aggregate Composition Test Reports: Results of laboratory tests on proposed and actual materials used.
- D. Compaction Density Test Reports.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. When necessary, store materials on site in advance of need.

- B. When aggregate materials need to be stored on site, locate where directed by Owner.
- C. Aggregate Storage, General:
 - 1. Separate differing materials with dividers or stockpile separately to prevent intermixing.
 - 2. Prevent contamination.
 - 3. Protect stockpiles from erosion and deterioration of materials.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Coarse Aggregate Type Base Course: Coarse aggregate, complying with State of South Dakota Highway Department standard specifications Section 882 for Base Course.

2.2 SOURCE QUALITY CONTROL

- A. See Section 01 0005 Quality Control for Construction for general requirements for testing and analysis of aggregate materials.
- B. Where aggregate materials are specified using ASTM D2487 classification, testing of samples for compliance will be provided before delivery to site.
- C. If tests indicate materials do not meet specified requirements, change material and retest.
- D. Provide materials of each type from same source throughout the Work.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that survey bench marks and intended elevations for the work are as indicated.
- B. Verify substrate has been inspected, gradients and elevations are correct, and is dry.

3.2 PREPARATION

- A. Correct irregularities in substrate gradient and elevation by scarifying, reshaping, and re-compacting.
- B. Do not place aggregate on soft, muddy, or frozen surfaces.

3.3 INSTALLATION

- A. Spread aggregate over prepared substrate to a total compacted thickness of 8 inches (200 mm).
- B. Place aggregate in maximum 4 inch (100 mm) layers and roller compact to specified density.

- C. Level and contour surfaces to elevations and gradients indicated.
- D. Add water to assist compaction. If excess water is apparent, remove aggregate and aerate to reduce moisture content.
- E. Use mechanical tamping equipment in areas inaccessible to compaction equipment.

3.4 TOLERANCES

- A. Scheduled Compacted Thickness: Within 1/4 inch (6.4 mm).
- B. Variation From Design Elevation: Within 1/2 inch (12.8 mm).

3.5 FIELD QUALITY CONTROL

- A. See Section 01 0005 Quality Control for Construction for general requirements for field inspection and testing.
- B. Compaction density testing will be performed on compacted aggregate base course in accordance with ASTM D1556, ASTM D2167, or ASTM D6938.
- C. If tests indicate work does not meet specified requirements, remove work, replace and retest.
- D. Frequency of Tests: One test for every 1000 SF, minimum of 2 tests..

3.6 CLEANING

- A. Leave unused materials in a neat, compact stockpile.
- B. Leave borrow areas in a clean and neat condition. Grade to prevent standing surface water.

END OF SECTION 32 1123

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**SECTION 32 1313
CONCRETE PAVING**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Concrete sidewalks, stair steps, and parking areas.

1.2 RELATED REQUIREMENTS

- A. Section 03 1000 - Concrete Forming and Accessories.

1.3 REFERENCE STANDARDS

- A. ACI 211.1 - Selecting Proportions for Normal-Density and High Density-Concrete - Guide 2022.
- B. ACI 301 - Specifications for Concrete Construction 2020.
- C. ACI 304R - Guide for Measuring, Mixing, Transporting, and Placing Concrete 2000 (Reapproved 2009).
- D. ACI 305R - Guide to Hot Weather Concreting 2020.
- E. ACI 306R - Guide to Cold Weather Concreting 2016.
- F. ASTM A1064/A1064M - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete 2022.
- G. ASTM C33/C33M - Standard Specification for Concrete Aggregates 2018.
- H. ASTM C39/C39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens 2021.
- I. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete 2022a.
- J. ASTM C150/C150M - Standard Specification for Portland Cement 2022.
- K. ASTM C173/C173M - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method 2016.
- L. ASTM C260/C260M - Standard Specification for Air-Entraining Admixtures for Concrete 2010a (Reapproved 2016).
- M. ASTM C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete 2019.
- N. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete 2019, with Editorial Revision (2022).

- O. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete 2022.
- P. ASTM D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types) 2018.

1.4 SUBMITTALS

- A. See Section 01 0004 Submittal Procedures for submittal procedures.
- B. Product Data: Provide data on joint filler, admixtures, and curing compound.

PART 2 PRODUCTS

2.1 FORM MATERIALS

- A. Form Materials: As specified in Section 03 1000, comply with ACI 301.
- B. Wood form material, profiled to suit conditions.
- C. Joint Filler: Preformed; non-extruding bituminous type (ASTM D1751).
 - 1. Thickness: 1/2 inch (12 mm).

2.2 REINFORCEMENT

- A. Steel Welded Wire Reinforcement: Plain type, ASTM A1064/A1064M; in flat sheets; unfinished.

2.3 CONCRETE MATERIALS

- A. Obtain cementitious materials from same source throughout.
- B. Cement: ASTM C150/C150M, Type I/II Portland cement, gray color.
- C. Fine and Coarse Mix Aggregates: ASTM C33/C33M.
- D. Fly Ash: ASTM C618, Class C or F.
- E. Water: Clean, and not detrimental to concrete.
- F. Air-Entraining Admixtures: ASTM C260/C260M.
- G. Chemical Admixtures: ASTM C494/C494M, Type A - Water Reducing, Type C - Accelerating, and Type G - Water Reducing, High Range and Retarding.
 - 1. Do not use chemicals that will result in soluble chloride ions in excess of 0.1 percent by weight of cement.

2.4 ACCESSORIES

- A. Curing Compound: ASTM C309, Type 1, Class A.

2.5 CONCRETE MIX DESIGN

- A. Proportioning Normal Weight Concrete: Comply with ACI 211.1 recommendations.
- B. Concrete Strength: Establish required average strength for each type of concrete on the basis of field experience or trial mixtures, as specified in ACI 301.
 - 1. For trial mixtures method, employ independent testing agency acceptable to Architect for preparing and reporting proposed mix designs.
- C. Admixtures: Add acceptable admixtures as recommended in ACI 211.1 and at rates recommended by manufacturer.
- D. Concrete Properties:
 - 1. Compressive strength, when tested in accordance with ASTM C39/C39M at 28 days; 4000 psi (27.58 MPa).
 - 2. Fly Ash Content: Maximum 15 percent of cementitious materials by weight.
 - 3. Water-Cement Ratio: Maximum 40 percent by weight.
 - 4. Total Air Content: 4 percent, determined in accordance with ASTM C173/C173M.
 - 5. Maximum Slump: 4 inches (100 mm).
 - 6. Maximum Aggregate Size: 1.5" inch (38 mm).

2.6 MIXING

- A. Transit Mixers: Comply with ASTM C94/C94M.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify compacted subgrade is acceptable and ready to support paving and imposed loads.
- B. Verify gradients and elevations of base are correct.

3.2 SUBBASE

- A. See Section 32 1123 for construction of base course for work of this Section.

3.3 PREPARATION

- A. Moisten base to minimize absorption of water from fresh concrete.

3.4 FORMING

- A. Place and secure forms to correct location, dimension, profile, and gradient.
- B. Assemble formwork to permit easy stripping and dismantling without damaging concrete.
- C. Place joint filler vertical in position, in straight lines. Secure to formwork during concrete placement.

3.5 REINFORCEMENT

- A. Place reinforcement as indicated.

3.6 COLD AND HOT WEATHER CONCRETING

- A. Follow recommendations of ACI 305R when concreting during hot weather.
- B. Follow recommendations of ACI 306R when concreting during cold weather.
- C. Do not place concrete when base surface temperature is less than 40 degrees F (4 degrees C), or surface is wet or frozen.

3.7 PLACING CONCRETE

- A. Place concrete in accordance with ACI 304R.
- B. Do not place concrete when base surface is wet.
- C. Ensure reinforcement, inserts, embedded parts, formed joints are not disturbed during concrete placement.
- D. Place concrete continuously over the full width of the panel and between predetermined construction joints. Do not break or interrupt successive pours such that cold joints occur.

3.8 JOINTS

- A. Provide scored joints.
 - 1. At 5 feet (1.52 m) intervals.

3.9 FINISHING

- A. Area Paving: Light broom, texture perpendicular to pavement direction.

- B. Sidewalk Paving: Light broom, texture perpendicular to direction of travel with troweled and radiused edge 1/4 inch radius (6 mm radius).
- C. Place curing compound on exposed concrete surfaces immediately after finishing. Apply in accordance with manufacturer's instructions.

3.10 TOLERANCES

- A. Maximum Variation of Surface Flatness: 1/4 inch (6 mm) in 10 ft (3 m).

3.11 FIELD QUALITY CONTROL

- A. An independent testing agency will perform field quality control tests, as specified in Section 01 0005 Quality Control for Construction.
 - 1. Provide free access to concrete operations at project site and cooperate with appointed firm.
 - 2. Submit proposed mix design of each class of concrete to inspection and testing firm for review prior to commencement of concrete operations.
- B. Compressive Strength Tests: ASTM C39/C39M; for each test, mold and cure three concrete test cylinders. Obtain test samples for every 100 cu yd (76 cu m) or less of each class of concrete placed.
 - 1. Take one additional test cylinder during cold weather concreting, cured on job site under same conditions as concrete it represents.
 - 2. Perform one slump test for each set of test cylinders taken.

3.12 PROTECTION

- A. Immediately after placement, protect pavement from premature drying, excessive hot or cold temperatures, and mechanical injury.
- B. Do not permit pedestrian traffic over pavement for 7 days minimum after finishing.
- C. Do not permit pedestrian traffic over pavement until 75 percent design strength of concrete has been achieved.

END OF SECTION 32 1313

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**SECTION 32 9219
SEEDING**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Preparation of subsoil.
- B. Placing topsoil.
- C. Hydroseeding, mulching and fertilizer.
- D. Maintenance.

1.2 RELATED REQUIREMENTS

- A. Section 31 2200 - Grading: Topsoil material.
- B. Section 31 2200 - Grading: Preparation of subsoil and placement of topsoil in preparation for the work of this section.

1.3 DEFINITIONS

- A. Weeds: Include Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

1.4 SUBMITTALS

- A. Certificate: Certify seed mixture approval by authority having jurisdiction.
- B. Maintenance Data: Include maintenance instructions, cutting method and maximum grass height; types, application frequency, and recommended coverage of fertilizer .

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable. Deliver seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, and location of packaging.

PART 2 PRODUCTS

2.1 SEED MIXTURE

- A. Seed Mixture (Slope west side of sight):
 - 1. Crested Wheat Grass: 40 percent.

2. Perennial Ryegrass: 30 percent.
 3. Hard Fescue: 20 percent.
 4. Annual Ryegrass: 10 percent.
 5. Rate of Application - 100# per acre
- B. Seed Mixture (Interior Areas and Areas around Blower Building)
1. Blue Fescue: 20%
 2. Chewings Fescue: 20%
 3. Creeping Red Fescue: 20%
 4. Hard Fescue: 20%
 5. Perennial Rye Grass: 10%
 6. NuBlue Kentucky Bluegrass: 10%
 7. Rate of Application - 200# per acre
- C. Alternate Seed Mixtures may be submitted by the Contractor for approval by and Owner and Engineer.

2.2 SOIL MATERIALS

- A. Topsoil: Type as specified in Section 31 2200.

2.3 ACCESSORIES

- A. Mulching Material: Oat or wheat straw, free from weeds, foreign matter detrimental to plant life, and dry. Hay or chopped cornstalks are not acceptable.
1. Apply mulching material at 2 tons per acre.
- B. Fertilizer: Recommended for grass, slow release nitrogen, biological materials, and biostimulant materials; of proportion necessary to eliminate deficiencies of topsoil.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that prepared soil base is ready to receive the work of this Section.

3.2 PREPARATION

- A. Prepare subgrade in accordance with Section 31 2200.

- B. Place topsoil in accordance with Section 31 2200.

3.3 FERTILIZING

- A. Apply fertilizer at a rate of 200 pounds per acre.
- B. Apply after smooth raking of topsoil and prior to roller compaction.
- C. Do not apply fertilizer at same time or with same machine as will be used to apply seed.
- D. Mix thoroughly into upper 2 inches (50 mm) of topsoil.
- E. Lightly water to aid the dissipation of fertilizer.

3.4 SEEDING

- A. Apply seed at rates, noted in Section 2.1 above, evenly in two intersecting directions. Rake in lightly.
- B. Do not seed areas in excess of that which can be mulched on same day.
- C. Do not sow immediately following rain, when ground is too dry, or during windy periods.
- D. Immediately following seeding and compacting, apply mulch to a thickness of 1/8 inches (3 mm). Maintain clear of shrubs and trees.
- E. Apply water with a fine spray immediately after each area has been mulched. Saturate to 4 inches (100 mm) of soil.
- F. Following germination, immediately re-seed areas without germinated seeds that are larger than 4 by 4 inches (100 by 100 mm).

3.5 HYDROSEEDING

- A. Apply seeded slurry with a hydraulic seeder at rates noted above.
- B. Do not hydroseed area in excess of that which can be mulched on same day.
- C. Immediately following seeding, apply mulch to a thickness of 1/8 inches (3 mm). Maintain clear of shrubs and trees.
- D. Apply water with a fine spray immediately after each area has been mulched. Saturate to 4 inches (100 mm) of soil.
- E. Following germination, immediately re-seed areas without germinated seeds that are larger than 4 by 4 inches (100 by 100 mm).

3.6 MAINTENANCE

- A. Provide maintenance at no extra cost to Owner; Owner will pay for water.
- B. See Section 01 7000 - Execution Requirements, for additional requirements relating to maintenance service.
- C. Maintain seeded areas immediately after placement until grass is well established and exhibits a vigorous growing condition.
- D. Mow grass at regular intervals to maintain at a maximum height of 2-1/2 inches (65 mm). Do not cut more than 1/3 of grass blade at any one mowing.
- E. Neatly trim edges and hand clip where necessary.
- F. Immediately remove clippings after mowing and trimming.
- G. Water to prevent grass and soil from drying out.
- H. Roll surface to remove minor depressions or irregularities.
- I. Control growth of weeds. Apply herbicides in accordance with manufacturer's instructions. Remedy damage resulting from improper use of herbicides.
- J. Immediately reseed areas that show bare spots.
- K. Protect seeded areas with warning signs during maintenance period.

END OF SECTION 32 9219

**SECTION 33 0110.58
DISINFECTION OF WATER UTILITY PIPING SYSTEMS**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Disinfection of site domestic water lines specified in Section 33 1416.

1.2 RELATED REQUIREMENTS

- A. Section 33 1416 - Site Water Utility Distribution Piping.

1.3 REFERENCE STANDARDS

- A. AWWA B300 - Hypochlorites 2018.
- B. AWWA B301 - Liquid Chlorine 2018.
- C. AWWA B302 - Ammonium Sulfate 2016.
- D. AWWA B303 - Sodium Chlorite 2018.
- E. AWWA C651 - Disinfecting Water Mains 2014, with Addendum (2020).

1.4 SUBMITTALS

- A. See Section 01 0004 Submittal Procedures for submittal procedures.
- B. Test Reports: Indicate results comparative to specified requirements.
- C. Certificate: From authority having jurisdiction indicating approval of water system.
- D. Bacteriological report:
 - 1. Date issued, project name, and testing laboratory name, address, and telephone number.
 - 2. Time and date of water sample collection.
 - 3. Name of person collecting samples.
 - 4. Test locations.
 - 5. Initial and 24 hour disinfectant residuals in ppm for each outlet tested.
 - 6. Coliform bacteria test results for each outlet tested.
 - 7. Certification that water complies, or fails to comply, with bacterial standards of State of South Dakota DANR..

1.5 QUALITY ASSURANCE

- A. Submit bacteriologist's signature and authority associated with testing.

PART 2 PRODUCTS

2.1 DISINFECTION CHEMICALS

- A. Chemicals: AWWA B300 Hypochlorite, AWWA B301 Liquid Chlorine, AWWA B302 Ammonium Sulfate, and AWWA B303 Sodium Chlorite.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that piping system and water well has been cleaned, inspected , and pressure tested.
- B. Schedule disinfecting activity to coordinate with start-up, testing, adjusting and balancing, demonstration procedures, including related systems.

3.2 DISINFECTION

- A. Use method prescribed by the applicable state or local codes, or health authority or water purveyor having jurisdiction, or in the absence of any of these follow AWWA C651.
- B. Provide and attach equipment required to perform the work.
- C. Inject treatment disinfectant into piping system.
- D. Maintain disinfectant in system for 24 hours.
- E. Flush, circulate, and clean until required cleanliness is achieved; use municipal domestic water.
- F. Replace permanent system devices removed for disinfection.

3.3 FIELD QUALITY CONTROL

- A. Perform field inspection and testing in accordance with Section 01 0005.

END OF SECTION 33 0110.58

**SECTION 33 1416
SITE WATER UTILITY DISTRIBUTION PIPING**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Water pipe for site conveyance lines.
- B. Pipe valves.

1.2 RELATED REQUIREMENTS

- A. Section 31 2316.13 - Trenching: Excavating, bedding, and backfilling.
- B. Section 33 0110.58 - Disinfection of Water Utility Piping Systems: Disinfection of site service utility water piping.

1.3 REFERENCE STANDARDS

- A. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300 2021.
- B. ASME B16.4 - Gray Iron Threaded Fittings: Classes 125 and 250 2021.
- C. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless 2022.
- D. AWWA C111/A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings 2017.
- E. AWWA C500 - Metal-Seated Gate Valves for Water Supply Service 2019.
- F. AWWA C600 - Installation of Ductile-Iron Mains and Their Appurtenances 2017.
- G. AWWA C800 - Underground Service Line Valves and Fittings 2021.
- H. AWWA M11 - Steel Pipe - A Guide for Design and Installation 2016, with Addendum (2019).

1.4 SUBMITTALS

- A. See SDSTA Division 1 for submittal procedures.
- B. Product Data: Provide data on pipe materials, pipe fittings, valves and accessories.
- C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- D. Project Record Documents: Record actual locations of piping mains, valves, connections, thrust restraints, and invert elevations. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with Owner requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store valves in shipping containers with labeling in place.

1.7 WARRANTY

- A. See Section SDSTA Division 1 for additional warranty requirements.

PART 2 PRODUCTS

2.1 WATER PIPE

- A. Steel Pipe and Fittings:
 - 1. Pipe: Standard weight, zinc-coated complying with ASTM A53/A53M.
 - 2. Fittings: Comply with ASME B16.4, Class 125, zinc-coated or ASME B16.3, Class 150, zinc-coated, threaded, hot dipped galvanized.

2.2 VALVES

- A. Valves: Manufacturer's name and pressure rating marked on valve body.
- B. Ball Valves Up To 2 Inches (50 mm):
 - 1. Ball Valves for Tunnel rated to 250 psi
 - 2. Curb Stop Drain Back Ball Valve for buried piping rated to 250 psi
 - 3. Valve Box: 1.5-inch Curb Box
 - a. Provide one and a half inch (1.5") diameter curb box on ball valve as shown on the Drawings. Curb box shall be constructed of brass and have the word "WATER" stamped on the lid. Curb box shall be attached to the PVC riser using a gule-on schedule 40 MIP adapter.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that building service connection and municipal utility water main size, location, and invert are as indicated.

3.2 PREPARATION

- A. Cut pipe ends square, ream pipe and tube ends to full pipe diameter, remove burrs.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare pipe connections to equipment with flanges or unions.

3.3 TRENCHING

- A. See the sections on excavation and fill for additional requirements.
- B. Hand trim excavation for accurate placement of pipe to elevations indicated.
- C. Form and place concrete for pipe thrust restraints at each change of pipe direction. Place concrete to permit full access to pipe and pipe accessories. Provide 2 square feet (0.6 sq m) thrust restraint bearing on subsoil.
- D. Backfill around sides and to top of pipe with cover fill, tamp in place and compact, then complete backfilling.

3.4 INSTALLATION - PIPE

- A. Maintain separation of water main from sewer piping in accordance with SD DANR code.
- B. Group piping with other site piping work whenever practical.
- C. Install ductile iron piping and fittings to AWWA C600.
- D. Route pipe in straight line.
- E. Install pipe to allow for expansion and contraction without stressing pipe or joints.
- F. Slope water pipe and position drains at low points.

3.5 INSTALLATION - VALVES AND HYDRANTS

- A. Set valves on solid bearing.
- B. Center and plumb valve box over valve. Set box cover flush with finished grade.

END OF SECTION 33 1416

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**SECTION 33 4100
SUBDRAINAGE**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Building Perimeter Drainage Systems.
- B. Filter aggregate and fabric and bedding.

1.2 RELATED REQUIREMENTS

- A. Section 31 0519 - Geosynthetics for Earthwork.
- B. Section 31 2316 - Excavation: Excavating for subdrainage system piping and surrounding filter aggregate.
- C. Section 31 2316.13 - Trenching: Excavating and backfilling for site subdrainage systems.
- D. Section 31 2323 - Fill: Backfilling over filter aggregate, up to subgrade elevation.

1.3 REFERENCE STANDARDS

- A. ASTM D2729 - Standard Specification for Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings 2021.
- B. ASTM D4355/D4355M - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon Arc-Type Apparatus 2021.

1.4 SUBMITTALS

- A. See Section 01 0004 Submittal Procedures for submittal procedures.
- B. Product Data: Provide data on pipe drainage products and pipe accessories.
- C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- D. Project Record Documents: Record location of pipe runs, connections, cleanouts and principal invert elevations.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

- A. Comply with applicable code for materials and installation of the work of this section.

2.2 PIPE MATERIALS

- A. Manufacturers:

1. Variations: 01 0004 Submittal Procedures.
- B. Polyvinyl Chloride Pipe: ASTM D2729; plain end, 4 inch (100 mm) inside diameter; with required fittings.
- C. Use perforated pipe at subdrainage system; unperforated for outfall.

2.3 AGGREGATE AND BEDDING

- A. Filter Aggregate and Bedding Material: Granular fill as specified in Section 31 2323.
- B. Impervious Fill Material: As specified in Section 31 2323.

2.4 ACCESSORIES

- A. Pipe Couplings: Solid plastic.
- B. Geotextile Fabric: As specified in Section 31 0519.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that trench cut is ready to receive work and excavations, dimensions, and elevations are as indicated on layout drawings.

3.2 PREPARATION

- A. Hand trim excavations to required elevations. Correct over-excavation with filter aggregate rock.
- B. Remove large stones or other hard matter that could damage drainage piping or impede consistent backfilling or compaction.

3.3 INSTALLATION

- A. Place drainage pipe on clean cut subsoil or filter aggregate on concrete foundation footing.
- B. Lay pipe to slope gradients noted on drawings; with maximum variation from true slope of 1/8 inch (3 mm) in 10 feet (3 m).
- C. Place pipe with perforations facing down.
- D. Install filter aggregate at sides, over top of pipe. Provide top cover compacted thickness of 12 inches (300 mm).
- E. Place filter fabric over levelled top surface of aggregate cover prior to subsequent backfilling operations.

- F. Place aggregate in maximum 4 inch (100 mm) lifts, consolidating each lift.
- G. Refer to Section 31 2323 for compaction requirements. Do not displace or damage pipe when compacting.
- H. Place impervious fill over drainage pipe aggregate and filter fabric cover and compact.
- I. Connect to storm sewer system with unperforated pipe .

3.4 FIELD QUALITY CONTROL

- A. Section 01 0005 Quality Control for Construction: Field inspection and testing.
- B. Request inspection prior to and immediately after placing aggregate cover over pipe.

3.5 PROTECTION

- A. Protect pipe and aggregate cover from damage or displacement until backfilling operation begins.

END OF SECTION 33 4100

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**SECTION 33 4211
STORMWATER GRAVITY PIPING**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Stormwater drainage piping.
- B. Stormwater pipe accessories.

1.2 RELATED REQUIREMENTS

- A. Section 31 2316 - Excavation: Excavating of trenches.
- B. Section 31 2316.13 - Trenching: Excavating, bedding, and backfilling.
- C. Section 31 2323 - Fill: Bedding and backfilling.

1.3 REFERENCE STANDARDS

- A. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120 2021a.
- B. ASTM D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications 2020.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination: Coordinate the installation of stormwater gravity piping with size, location and installation of stormwater drains according to Plans and Details.
- B. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.5 SUBMITTALS

- A. See Section 01 0004 Submittal Procedures for submittal procedures.
- B. Product Data: Provide data indicating pipe and pipe accessories.
- C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- D. Project Record Documents:
 - 1. Record location of pipe runs, connections, and invert elevations.
 - 2. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

PART 2 PRODUCTS

2.1 STORMWATER PIPE MATERIALS

- A. Provide products that comply with applicable code(s).
- B. Plastic Pipe: ASTM D1785, Schedule 40, Poly Vinyl Chloride (PVC) material; inside nominal diameter of 8 inches (200 mm), bell and spigot style solvent sealed joint end.
- C. Coupling Bands: Galvanized steel, 0.052 inches (1.3 mm) thick x 10 inches (250 mm) wide; connected with two neoprene "O" ring gaskets and two galvanized steel bolts.

2.2 PIPE ACCESSORIES

- A. Fittings: PVC fittings and specials furnished for installation on this project shall be of the size and type shown on the Drawings.
 - 1. General Requirements:
 - a. All tees, wyes, bends, etc. shall be elastomeric gasket type.
 - b. All PVC fittings and specials shall be Schedule 40.
 - c. All gasketed specials and fittings shall be installed in accordance with the manufacturer's recommendations.
- B. Trace Wire: Magnetic detectable conductor, clear plastic covering, imprinted with "Stormwater Service" in large letters.

2.3 BEDDING AND COVER MATERIALS

- A. Bedding: As specified in Section 31 2316.13.
- B. Cover: As specified in Section 31 2316.13.

PART 3 EXECUTION

3.1 TRENCHING

- A. See Section 31 2316 - Excavation and Section 31 2323 - Fill for additional requirements.
- B. Hand trim excavation for accurate placement of pipe to elevations indicated.
- C. Backfill around sides and to top of pipe with cover fill, tamp in place and compact, then complete backfilling.

3.2 INSTALLATION

- A. Verify that trench cut is ready to receive work and excavations, dimensions, and elevations are as indicated on layout drawings.
- B. Install pipe, fittings, and accessories in accordance with manufacturer's instructions. Seal watertight.
 - 1. Plastic Pipe: Also comply with ASTM D2321.
- C. Lay pipe to slope gradients noted on layout drawings; with maximum variation from true slope of 1/8 inch (3 mm) in 10 feet (3 m).
- D. Connect to building storm drainage system, foundation drainage system, and utility/municipal system.
- E. Install continuous trace wire 6 inches (150 mm) above top of pipe; coordinate with Section 31 2316.13.

3.3 FIELD QUALITY CONTROL

- A. Perform field inspection in accordance with Section 01 0005 Quality Control for Construction.

END OF SECTION 33 4211

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**SECTION 33 4213
STORMWATER CULVERTS**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Pipe culvert, joints and accessories.
- B. Bedding.

1.2 RELATED REQUIREMENTS

- A. Section 31 2316 - Excavation: Excavating of trenches.
- B. Section 31 2323 - Fill: Bedding and backfilling.

1.3 REFERENCE STANDARDS

- A. ASTM A929/A929M - Standard Specification for Steel Sheet, Metallic-Coated by the Hot-Dip Process for Corrugated Steel Pipe 2018.

1.4 SUBMITTALS

- A. See Section 01 0004 Submittal Procedures for submittal procedures.
- B. Product Data: Provide data on pipe, fittings and accessories.

PART 2 PRODUCTS

2.1 CULVERT PIPE, GENERAL

- A. Regulatory Requirements: Comply with applicable code for materials and installation of the work of this section.

2.2 STEEL CULVERT PIPE

- A. Corrugated Steel Pipe: Fabricated of ASTM A929/A929M galvanized steel sheet:
 - 1. Shape: Circular, with nominal diameter of 8 inches.
- B. Tapered Ends: Same material as pipe, machine cut, for joining to pipe end.
- C. Coupling Bands: Galvanized steel, 0.052 inches (1.3 mm) thick x 10 inches (250 mm) wide; connected with two neoprene "O" ring gaskets and two galvanized steel bolts.

2.3 BEDDING AND COVER MATERIALS

- A. Bedding: As specified in Section 31 2316.13.
- B. Cover: As specified in Section 31 2316.13.

PART 3 EXECUTION

3.1 EXCAVATING

- A. See Section 31 2316 - Excavation and Section 31 2323 - Fill for additional requirements.
- B. Excavate culvert trench to 12 inches (300 mm) below pipe invert. Hand trim excavation for accurate placement of pipe to elevations indicated.

3.2 INSTALLATION - PIPE

- A. Verify that trench cut is ready to receive work and excavations, dimensions, and elevations are as indicated on layout drawings.
- B. Install pipe and accessories in accordance with manufacturer's instructions
- C. Lift or roll pipe into position. Do not drop or drag pipe over prepared bedding.
- D. Shore pipe to required position; retain in place until after compaction of adjacent fills. Ensure pipe remains in correct position and to required slope.
- E. Repair surface damage to pipe protective coating with two coats of compatible bituminous paint coating.

3.3 PIPE ENDS

- A. Place fill at pipe ends, at embankment slopes.

3.4 TOLERANCES

- A. Lay pipe to alignment and slope gradients noted on layout drawings; with maximum variation from true slope of 1/8 inch (3 mm) in 10 feet (3 m).
- B. Maximum Variation From Intended Elevation of Culvert Invert: 1/2 inch (12 mm).
- C. Maximum Offset of Pipe From True Alignment: 1 inch (25 mm).
- D. Maximum Variation in Profile of Structure From Intended Position: 1 percent.

3.5 PROTECTION

- A. Protect pipe and bedding from damage or displacement until backfilling operation is in progress.

END OF SECTION 33 4213

**SECTION 40 0552
PROCESS VALVES**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Ball valves - metal body.
- B. Butterfly valves - metal body.
- C. Gate valves - metal body.
- D. Plug valves.
- E. Rubber Check Valve
- F. Valve operators.
- G. Electric valve operators.

1.2 RELATED REQUIREMENTS

- A. Section 33 4211 Stormwater Gravity Piping
- B. Section 40 2340 Process Piping
- C. Section 40 6900 Process Integration
- D. Section 43 2313 Pumps
- E. Section 46 0043 Unit Process - Moving Bed Biofilm Reactor System

1.3 REFERENCE STANDARDS

- A. ASME B1.20.1 - Pipe Threads, General Purpose, Inch 2013 (Reaffirmed 2018).
- B. ASME B1.20.2M - Pipe Threads, 60 Deg, General Purpose 2006 (Reaffirmed 2011).
- C. ASME B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard 2020.
- D. ASME B16.11 - Forged Fittings, Socket-Welding and Threaded 2021.
- E. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings 2021.
- F. AWWA C110/A21.10 - Ductile-Iron and Gray-Iron Fittings 2021.
- G. AWWA C111/A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings 2017.
- H. AWWA C509 - Resilient-Seated Gate Valves for Water Supply Service 2015.

- I. AWWA C550 - Protective Interior Coatings for Valves and Hydrants 2017.
- J. AWWA C606 - Grooved and Shouldered Joints 2015.
- K. MSS SP-25 - Standard Marking System for Valves, Fittings, Flanges and Unions 2018.
- L. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.

1.4 SUBMITTALS

- A. See Section 01 0004 - Submittal Procedures
- B. Product Data: Manufacturer's data sheets for each valve and accessory, showing compliance with requirements; include materials, pressure ratings, valve operators, seats and seals, clearances for operation and maintenance, and other characteristics.
 - 1. Identify data sheets using the valve identification scheme used on drawings.
 - 2. For electric actuators, show electrical characteristics.
- C. Shop Drawings: Custom-prepared piping diagrams showing location of each valve and drain, whether or not indicated in Contract Documents; this shop drawing may be combined with other piping shop drawings.
- D. Valve Schedule: Custom-prepared schedule of valves, showing:
 - 1. Valve identifying number; cross-reference to product data sheets and to process
 - 2. Manufacturer and model name/number.
 - 3. Valve type using specification terminology (e.g. gate, metal body, over 2 inch).
 - 4. Application (direct-buried or exposed).
 - 5. Piping Service (e.g. air piping, influent piping, effluent piping).
 - 6. Installation orientation (horizontal or vertical pipe, stem vertical or horizontal).
 - 7. Size and dimensions.
 - 8. Flow coefficient Kv (Cv).
 - 9. Pressure rating and pressure drop at specified flow rate.
 - 10. Spring range.
 - 11. Valve end type (e.g. flanged, threaded, socket-welded).
 - 12. Manual operator type.

13. Automatic operator type, where applicable, and identifying number.
 14. Accessories (e.g. extension stem, floor stand, extension bonnet).
 15. Access and clearance requirements.
- E. Automatic Operator Schedule: Custom-prepared schedule of automatic valve operators, showing:
1. Valve and operator identifying numbers.
 2. Operator manufacturer and model number.
 3. Positive positioner range.
 4. Close-off pressure to torque.
 5. Actuator type (electric).
 6. Electric Actuators: Input and output contacts.
 7. Access and clearance requirements.
- F. Automatic Valve Operator Calculations: For each remote-controlled valve, submit calculations supporting selection of actuator, including calculations of the force required to move and seal the valve.
- G. Field Quality Control Reports: Records of valve demonstrations.
- H. Project Record Documents: Approved shop drawings and schedules modified to show actual as-constructed conditions.
- I. Operating and Maintenance Data: See Section 01 0008.
- J. Maintenance Materials:
1. For Each Type and Size of Valve:
 - a. Lubricator, lubricant of appropriate temperature rating, lubricator/isolating valve.
 - b. Gaskets; 2 each.
 - c. O-ring seals; 2 each.
 - d. Diaphragms (molded); 2 each.
 - e. All other parts made of elastomeric materials; 2 each.
 - f. Stem packing; 2 each.

- g. Seat rings; 2 each and seat ring pulling tool.
- 2. Operating Key for Cross Handled Valves: Galvanized.
- 3. One set of any other special tools necessary for adjustment, operation, maintenance and disassembly, for each valve type and appurtenance.

1.5 WARRANTY

- A. See Section 01 0008 Operation and Maintenance Data

PART 2 PRODUCTS

2.1 VALVE APPLICATIONS

- A. Valve Applications: Provide valves as follows whether shown on drawings or not.
- B. Do not direct-bury flanged valves; provide valve pit or manhole.

2.2 REQUIREMENTS APPLICABLE TO ALL VALVES

- A. See drawings for valve sizes, valve ratings, operator types, and piping types and sizes.
- B. Provide valves suitable for the service indicated and coordinated to piping system.
 - 1. Provide valves that will withstand working pressure indicated or working pressure of pipe to which valve is connected, whichever is greater.
 - 2. Provide valves of sizes indicated or of port diameter/area equal to that of pipe to which valve is connected, whichever is larger.
 - 3. Provide valves that open by turning counterclockwise, with direction of opening integrally marked on operating nut or operator.
 - 4. Valve End Connections: As indicated; if not indicated, provide end connections of the same type as indicated for joints in pipe to which valve is connected.
 - 5. Factory install operators and accessories.
- C. Identification and Tagging: Mark valves in accordance with MSS SP-25 using identification tags securely attached; on tags show the service, valve identification number from drawings, manufacturer's name and model number.
 - 1. Identification Tags: 1.375 inches (35 mm) diameter, minimum; engraved laminated plastic with black lettering.
 - 2. Attachment: No. 12 AWG copper wire.

2.3 REQUIREMENTS APPLICABLE TO METAL-BODY VALVES

- A. Valve End Connections:
 - 1. Flanged Ends: In accordance with ASME B16.5; Class 125 pound (56 kg) unless otherwise indicated.
 - 2. Socket-Welding Ends: In accordance with ASME B16.11.
 - 3. Threaded Ends: In accordance with ASME B16.11.
 - 4. Threaded Ends: In accordance with ASME B1.20.1/ ASME B1.20.2M.
 - 5. Solder Joint Ends: In accordance with ASME B16.18.
 - 6. Grooved Joint Ends: In accordance with AWWA C606.
 - 7. Mechanical Joint Ends: Styrene butadiene rubber (SBR) or vulcanized SBR gasketed type, in accordance with AWWA C111/A21.11 and AWWA C110/A21.10.
 - 8. Push-On Joint Ends: Styrene butadiene rubber (SBR) or vulcanized SBR gasketed type, in accordance with AWWA C110/A21.10 and AWWA C111/A21.11.
- B. Valve Exterior Finish: Factory-applied epoxy coating complying with AWWA C550; either two-part liquid material or heat-activated material.
 - 1. Where valve is indicated to have fusion bonded epoxy finish, provide only heat-activated material.
 - 2. Coating Thickness: 7 mils (0.18 mm), minimum, dry film thickness.
- C. Valve Lining: Where valves are indicated to be lined, provide factory-applied factory-applied lining; use epoxy lining unless other material is indicated.
 - 1. Epoxy Lining: AWWA C550; either two-part liquid material or heat-activated material except provide only heat-activated material when lining is indicated as fusion bonded.
 - 2. Epoxy Lining Thickness: 7 mils (0.18 mm), minimum, dry film thickness, except where thickness is limited by valve operating tolerances.

2.4 BALL VALVES - METAL-BODY

- A. Ball Valves - Sizes 2.5 inch (65 mm) and larger: End entry one-piece body type.
 - 1. Rating: 400 psig (2.76 MPa) at 150 degrees F (66 degrees C).
 - 2. Body: Bronze, with full bore ports.
 - 3. Seat: Polytetrafluoroethylene (PTFE) seats and packing.

4. Ball: Chrome plated steel.
5. End Connections: Grooved

2.5 BUTTERFLY VALVES - METAL BODY

- A. Butterfly Valves: Grooved style.
 1. Body: ASTM A126 cast iron.
 2. Disc: Contoured ASTM A436 Type 1 Ni-resist cast iron with maximum lead content of 0.003 percent.
 3. Valve Shafts: Carbon steel with self-lubricating, corrosion-resistant sleeve type bearings.
 4. Seats for Valves 24 inch (600 mm) and Smaller: Attached to either valve body or disc; chloroprene.
 5. Seats for Valves Larger Than 30 inch (750 mm): Field replaceable.
 6. Manual Operator: Hand wheel or L

2.6 GATE VALVES - METAL BODY

- A. Manufacturers:
- B. Gate Valves - Sizes 2-1/2 inches (65 mm) and Larger: Solid wedge type with clear waterway equal to full diameter of valve.
 1. Rating: 200 psig (1.38 MPa).
 2. Body: AWWA C509, resilient-seated; Ni-resistant.
 3. Trim: Iron.
 4. Bonnet: OS&Y, bolted type.
 5. Disc: Iron; with non rising stems with backseats.

2.7 PLUG VALVES

- A. Manufacturers:
 1. DeZurik: www.dezurik.com
 2. Milliken Valve: www.millikenvalve.com/#sle.
 3. Henry Pratt Company: www.henrypratt.com/#sle.
 4. Val-Matic Valve & Manufacturing Corporation: www.valmatic.com/#sle.

- B. Plug Valves - Sizes 3 inches (80 mm) through 54 inch (1350 mm): Eccentric type.
 - 1. Rating: 175 psig (1.2 MPa) at 140 degrees F (60 degrees C).
 - 2. Body: Nonlubricated type; ductile iron; drip-tight shutoff with pressure from either direction.
 - 3. Plugs: Ductile iron, with round ports.
 - 4. Ports: Regular, with open area minimum 80 percent of connecting pipe area.
 - 5. Seats: Stainless steel.
 - 6. Stem Bearings: Self-lubricating stainless steel.
 - 7. End Connections: Grooved.
 - 8. Manual Operator for Valves 8 inches (200 mm) and Larger: Totally enclosed, geared; with chain wheel.

2.8 RUBBER CHECK VALVE

- A. Manufacturers: Rubber Check Valve shall be rubber duckbill type check valve as manufactured by Proco or Red Valve or Owner approved equal.
- B. Valve shall be flanged type with an encapsulated retaining ring, Proco Style 710EE or equal, as shown on the plans.
- C. Valve shall have EPDM construction for cover and tube elastomer materials, FSA Material Class Std. III.

2.9 VALVE OPERATORS

- A. Operator Types:
 - 1. For each valve controlled by process control system, provide remote-controlled automatic operator, electric type.
 - 2. For each valve not controlled by process control system, provide a manual operator, except for self-actuated valves.
- B. Operators: Sized to operate valve for full range of pressures and velocities and of the type specified for application:
 - 1. Maximum Force to Operate: Not more than 39.3 pounds-force (175 N) under any operating condition including initial breakaway; provide gear reduction where necessary to reduce force to operate.

2. Locking: Self-locking or equipped with self-locking device; padlock eyes on valve handles; wheels lockable with chain and padlock.
 3. Quarter Turn Valves: Provide position indicator.
 4. Direct-Buried Quarter-Turn Valves: Operator designed to withstand input torque of 450 foot-pounds (610 N-m) at fully open or fully closed positions; grease packed and gasketed to withstand submersion in water to 10.2 psig (70 kPa).
- C. Automatic Operators: Actuator, valve stem coupling, gearing if required, size and configuration to suit full range of valve operation, and additional requirements as indicated.
1. Totally enclosed valve actuating mechanism with adjustable travel stops and valve position indicator.
 2. For Quarter Turn Valves: Reversing, bi-directional operation.
 3. Provide manual override mechanism unless specifically indicated as "no manual override"; with lockable motor de-clutch mechanism.
 4. On loss of control signal, maintain valve in last position, unless otherwise indicated.
 5. Housing: NEMA 250 Type 4X enclosure.
- D. Manual Operators:
1. Direct-Buried Valves Larger Than 2-1/2 inches (65 mm): 2 inch (50 mm) operating nut.
 2. Direct-Buried Valves 2 inches (50 mm) and Smaller: Cross handle for operation by forked key.
 3. Exposed Valves: Hand wheel type operator except where other type is permitted or required.
 4. Hand Wheels: Galvanized and painted.
 5. Lever handles are allowed on quarter-turn valves 8 inches (200 mm) and smaller.

2.10 ELECTRIC VALVE OPERATORS

- A. Manufacturers:
1. Auma: www.auma.com/#sle.
 2. Rotork: www.rotork.com/#sle.
- B. Electric Operators: Motor-operated.

1. Gearing: Two-stage, planetary, permanently lubricated self-locking gear train with self-lubricating bearings; connections via male output shaft.
 2. Start-up Torque: 120 foot-pound (163 N-m).
 3. Stall Torque: 150 foot-pound (203 N-m).
 4. Duty Cycle: 75 percent.
 5. Equipped with AC thermal overload protector with automatic reset or non-overloading under normal operating conditions.
 6. See Plans for electrical requirements.
- C. Positioners: For modulating actuators provide positioner controlling the valve position as function of input signals; direct acting; with corrosion-resistant, splash- and moisture-proof enclosure with gasketed cover.

2.11 VALVE ACCESSORIES

- A. Extension Bonnets: Provide as necessary, with stem and accessories applicable to specific valve and operator.
- B. Direct-Buried Valves: Provide extension stem enclosed in cast iron, concrete, or polyethylene valve box housing to prevent contact with soil.
1. Length: Sufficient to bring operating nut to a point 6 inches (150 mm) or less below grade.
 2. Diameter: Sufficient to completely cover valve.
 3. Cast Iron Valve Boxes: Extension type with slide or screw vertical adjustment and flared base; minimum metal thickness of 3/16 inch (5 mm).
- C. Manual Valves Below Operating Personnel Floor Level: Where depth of valve centerline is more than 36 inches (915 mm) below floor level, provide extension stem and floor stand.

PART 3 EXECUTION

3.1 PREPARATION

- A. Prior to installation, clean debris and foreign material out of valve openings and seats, check operating mechanisms for ease of operation and proper functioning, and check nuts and bolts for tightness.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.

- B. Install valves as nearly as possible in position indicated on drawings, located and oriented to provide easy access to valve operator and to avoid interference with other equipment.
- C. Install valves without exerting distortion or strain on appurtenances.
- D. Flanged Connections:
 - 1. Install flanged valve bolt holes so as to straddle vertical centerline of pipe.
 - 2. Clean flanged faces prior to inserting gasket and bolts.
 - 3. Tighten nuts progressively and uniformly.
- E. Threaded Connections: Clean threads by wire brushing or swabbing prior to installation.
- F. Manual Valve Orientation in Horizontal Runs of Pipe:
 - 1. Where pipe centerline elevation is 54 inches (1,370 mm) or less above finished floor, install valve with operating stem in vertical position, unless otherwise indicated.
 - 2. Where pipe centerline elevation is between 54 inches (1,370 mm) and 81 inches (2,057 mm) above finish floor, install valve with stem in horizontal position, unless otherwise indicated.

3.3 FIELD QUALITY CONTROL - PRIOR TO STARTUP

- A. Demonstrate proper valve operation while testing pipelines or as a separate step.
 - 1. Show that valves open and close smoothly with operating pressure on one side and atmospheric pressure on the other, and in both directions for two-way valve applications.
 - 2. Count and record the number of turns required to open and close each valve, and account for any discrepancies from manufacturer's data.
- B. Isolation Valve Leak Check:
 - 1. With full pressure in the system, command valve closed.
 - 2. Use an ultra-sonic flow meter to detect flow or leakage.
- C. Actuator Range Check: Verify proper operation of actuators and positioners.
 - 1. Verify that actuator extreme positions are correct.
 - 2. Apply a signal to actuator through its controller.
 - 3. Record the signal levels for the extreme positions.
 - 4. Vary the signal over its full range and verify that actuators travel in the correct direction and from one extreme position to the other.

D. Valve Stroke Setup and Check:

1. Verify the actual positions against the control system readout.
2. Set pump to normal operating mode.
3. Command valve closed; visually verify that valve is closed and adjust output zero signal as required.
4. Command valve to open; verify position is full open and adjust output signal as required.
5. Command valve to a few intermediate positions.
6. If actual valve position does not reasonably correspond, replace actuator or add pilot positioner (for pneumatics).

END OF SECTION 40 0552

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**SECTION 40 0559
HYDRAULIC GATES**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Upward sliding gates, for opening and closing wall openings in MBBR Basins.

1.2 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete: Concrete for upward sliding gates and weir gates wall construction.
- B. Section 05 5000 - Metal Fabrications.
- C. Section 40 2340 – Wastewater Process Piping

1.3 REFERENCE STANDARDS

- A. AWWA C562 - Fabricated Aluminum Slide Gates 2021.

1.4 SUBMITTALS

- A. See SDSTA Division 1 - Submittal Procedures.
- B. Product Data: Manufacturer's data on products, showing composition, dimensions, accessories, and anchorage.
- C. Shop Drawings: Detailed fabrication and installation drawings showing materials, fabrication, tolerances, connections, seals, and anchorages.
- D. Operating and Maintenance Data: See SDSTA Division 1
- E. Field Quality Control Test Reports.

1.5 WARRANTY

- A. See SDSTA Division 1 for closeout submittals and for additional warranty requirements.
- B. The Manufacturer shall guarantee the slide gates, when installed and operated as recommended by the Manufacturer, trouble-free operation for a period of ten (10) years. If the Owner or Engineer is not completely satisfied with the performance of the product, the manufacturer shall remedy the problem at no cost or refund the materials and installation cost upon the return of the equipment. The Manufacturer shall guarantee the following:
 - 1. Leakage shall be no more than that allowed by the AWWA C563 and AWWA C562 Standard during the guarantee period

2. Door (disc) shall be free of sticking or binding as judged by the Owner/Engineer (move freely via operator provided) with no exercising required. Gate operators are to be warranted by the operator manufacturer per their standard warranty
3. No exception or revision shall be taken to the warranty

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Whipps, Inc: www.whipps.com Model 824 Self Contained, Wall Mounted Slide Gates, sizes shown in plans
- B. Rodney Hunt, Orange, Massachusetts www.rodneyhunt.com
- C. R.W. Gate Company Troy, New York www.rwgate.com
- D. Engineer/Owner Approved Equal

2.2 GATES - GENERAL

- A. The contractor shall provide all labor, materials, equipment, and incidentals required to furnish and install slide gates, operating stems, and operating floor stands, complete and operational with all necessary accessories as shown on the Contract Drawings, as specified herein, or as required for complete operation.
- B. Aluminum Gates: Comply with AWWA C562.
- C. Gate type, lift type, frame type, size, seating head, and bottom-closure type is indicated in the gate schedule. Schedule as indicated on drawings.
- D. Design and fabricate gates to withstand the design head.
- E. Gate Leaf:
 1. Completely assemble gate leaf, including the attachment of all components and accessories, prior to placing in frame.
 2. Avoid distortion of the gate leaf and attached components during installation.
 3. Fasten rubber seals securely to metal retainers.
 4. Apply a suitable lubricant to the rubber seal rubbing plates to protect rubber seals before operating gate.
- F. Unless otherwise specified, all stainless steel parts, including fasteners shall be Duplex 2205 Stainless Steel.
- G. Seals:

1. Ultra High Molecular Weight (UHMW) polyolefin.

H. Leakage Rate:

1. Leakage rates shall not exceed 0.1 gallons per minute per foot of wetted perimeter.

2.3 SLIDE GATE LEAF:

- A. Single-component structural fabrication, shop fabricated and provided complete with gate stem, stem guides, leaf nut, leaf nut spanner wrench, bar seals, seal collars, lock assembly, and other appurtenant items as required for installation.
- B. Slide Gates shall be comprised of Aluminum
1. Aluminum: Slide Gate Leafs shall be constructed of Aluminum, ASTM B209, Alloy 6061, or ASTM B308, Alloy 6061.
 - a. Aluminum construction, reinforced with angle, channel, or plate stiffeners as required to limit the deflection at maximum specified head to 1/8" and the maximum stress to 7,600 PSI.
 - b. Minimum material thickness will be 1/4 inch.
 - c. Stem connectors for all non handpull shall consist of two vertical members welded to the slide. Each stem shall be bolted to the stem connector with a minimum of two stainless steel attachment bolts.
 - d. Edge of slide shall be 1/2" thick minimum when 1/4" is the specified minimum material thickness and 3/4" thick minimum when 3/8" is the minimum material thickness.
 - e. Reinforcing stiffeners shall be welded to the slide and mounted horizontally. Two vertical stiffeners shall be welded on the outside of the horizontal stiffeners for additional reinforcement.

2.4 SLIDE GATE FRAME:

- A. Materials
1. For Aluminum Slide Gate: Aluminum, ASTM B209, Alloy 6061, or ASTM B308, Alloy 6061. Extruded aluminum construction shall be provided consisting of guides, invert, and top member. Suitable reinforcements shall be provided to resist all operating loads. Minimum material thickness shall be 1/4 inch.
- B. Frame design shall allow for mounting directly to a wall with duplex stainless steel anchor bolts and grout. Mounting style shall be as show on the Contract Drawings.

- C. The frame guides shall have a minimum weight of 4 lbs per foot of length for wall mounted gates.
- D. The frame guides shall extend to accommodate the entire height of the slide when the slide is in the fully opened position on upward opening slide gates.
- E. A rigid aluminum invert member shall be provided across the bottom of the opening. The invert member shall be of the flushbottom type on upward opening gates and shall have a minimum weight of 4 lbs per foot of length for wall mounted gates.
- F. A rigid extruded aluminum top seal member shall be provided across the top of the submerged opening.
- G. A self-contained frame shall be provided with a support yoke for mounting the operator.
 - 1. The support yoke shall be designed to allow removal of the slide.
 - 2. The support yoke shall be located as required to provide full travel of the slide gate.
 - 3. The yoke shall be designed so that the maximum deflection is limited to $L/360$ of the span when operating at maximum specified head.

2.5 SEALS:

- A. The frames shall be equipped with seats/seals to prevent metal-to-metal contact and restrict leakage.
 - 1. The guides of all gates shall incorporate ultra-high molecular weight polyethylene (UHMW) seat/seals on both the upstream and downstream sides of the slide. Each seat/seal will be shaped to act as both a bearing surface and a seal. Gates that cover submerged openings shall have UHMW seats/seals on both sides and top of gate opening in addition to reopen invert seals. The top seal shall be mounted on the frame and be of low friction polymer construction.
 - 2. All gates shall contain a replaceable, flush bottom neoprene invert seal, mounted on the frame.
 - 3. All seals shall be attached to the frame with duplex stainless steel retainers and/or duplex stainless steel bolts.

2.6 STEMS:

- 1. The entire stem shall be from solid duplex stainless steel rod.
- 2. The stem shall have a minimum diameter of 1-1/2".
- 3. The stem shall be threaded to allow full travel of the slide unless the travel distance is otherwise shown on the Contract Drawings.

4. The threaded portion of the stem shall have rolled or machine cut acme threads polished to a 63 microinch finish.
5. The stem shall be of size to safely with stand without buckling or permanent distortion the stresses induced by normal operating forces.
6. The stem shall be designed to transmit in compression at least 2.5 times the output of the manual actuator with an 80 lb. effort or 1.43 times the stall thrust on electric motor actuators.
7. A field adjusted threaded cast aluminum stop collar shall be provided on all stems with manual actuators to limit downward travel of the slide.
8. A field adjusted aluminum split upstop collar shall be provided on all non-handpulled gates to limit the upward travel of the slide.

2.7 STEM GUIDES:

- A. Provide integral frame mounted stem guides or wall mounted stem guides to limit the L/r ratio of the operating stem to 200 or less, on all non-handpull operated gates.
- B. Stem guides shall be bronze bushed and adjustable in two directions.

2.8 STEM COVERS:

- A. All rising stem gates shall be provided with clear lexan or butyrate stem covers.
- B. The stem covers shall be properly vented and closed at the top with a plastic cap.
- C. The stem covers shall be provided with field mounted mylar travel indicator strips.

2.9 ANCHOR BOLTS:

- A. Provide duplex stainless steel adhesive anchors equal to all Ramset/Red head Epcon System or Hilti HIT System.
- B. Provide anchor bolts of no less than 1/2" diameter.
- C. Provide all anchor bolts with ample cross section to withstand the force created by operation of the gate.
- D. Install anchor bolts per manufacturer's instruction.

2.10 PAINTING:

- A. All aluminum parts in contact with concrete shall be shop coated as specified in Section 09 9600.

2.11 MANUAL OPERATORS:

A. General

1. The operator shall be as shown in the Contract Drawings.
2. All manual operators will be enclosed in a high-strength cast aluminum or stainless steel housing.
3. An arrow with the word "OPEN" shall be permanently attached or cast onto the operator to indicate the direction or rotation to open the gate.
4. The operator shall be mounted to the gate yoke on self-contained gates

B. Handwheel Operators:

1. Roller-type bearings shall be provided above and below the bronze operating nut.
2. Mechanical seals shall be provided above and below the bronze operating nut.
3. The handwheel shall have a diameter of 18".
4. Shall be rising stem type gate.
5. The height of the handwheel above the operating floor shall be as shown in the Contract Drawings.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Thoroughly clean bearing surfaces requiring lubrication; lubricate with an manufacturer's approved lubricant before assembly and installation.
- B. Install anchors as indicated on drawings.
- C. Frames and guides shall be installed in a true vertical plane with 90-degree corners.
- D. Gate Frame and Guides:
 1. Test gate frame and guides for proper alignment and clearances prior to installation on concrete, by lowering and raising the gate leaf through the full operating range.
- E. Concrete and Concrete Grout Placement:
 1. Embed gate frame and other components in concrete in an approved manner to fill all voids, secure anchorage, prevent seepage, and provide uniform finish surfaces.
 2. Inspect embedment concrete after curing for at least 7 days; fill any voids around embedded components by pumping concrete grout to full embedment.

3. Inspect pumped grout after curing for at least 7 days, and use hammer blows to the components to detect any remaining voids.
4. Where remaining voids are located, drill 1 inch (25 mm) diameter grout holes in the components and the voids and fill by pressure grouting through the grout holes.
5. Plug grout holes by welding openings in the components and grinding welds flush.

3.2 ACCEPTANCE TRIAL OPERATION AND TEST

- A. After the gate assembly has been installed, including operating machinery, the Owner and Engineer will examine the complete system for final acceptance.
- B. Operate the gate throughout its full operating range a sufficient number of times to demonstrate proper operation.
- C. Furnish the services of a factory representative for one (1) day who has complete knowledge of proper operation and maintenance to inspect the final installation and supervise a test run of the equipment
- D. Maximum gate leakage shall be as defined in the General Design Criteria of this Specification, herein. If gates, operators, and appurtenances do not meet specified requirements, corrective measures shall be taken by the Contractor, or the equipment shall be removed and replaced with equipment that satisfies the conditions specified.

END OF SECTION 40 0559

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**SECTION 40 2340
PROCESS PIPING**

PART 1 GENERAL

1.1 DESCRIPTION

- A. This section covers furnishing and installing all process piping including piping under structures and air systems and all work incidental thereto, as shown on the Contract Drawings and as specified herein.
- B. Piping shall be furnished and installed as shown on the Contract Drawings. The Contractor shall be responsible for coordinating the fabrication of pipe to correct lengths and conditions with respect to valve and other equipment laying dimensions. Pipe, valves, and fittings have been shown on the Contract Drawings to assist the Contractor, however, the Contractor shall verify all dimensions and quantities. Where pipe is not specifically located on the Contract Drawings, it shall be installed on lines parallel and/or perpendicular to wall and/or floor surfaces and shall be securely fastened in a workmanlike manner.

1.2 RELATED REQUIREMENTS

- A. Section 099600 High Performance Coatings
- B. Section 31 2316.13 - Trenching: Trenching for piping installation.

1.3 SUBMITTALS

- A. See SDSTA Division 1 - Submittal Procedures.
- B. Product Data: Manufacturer's descriptive and technical literature for each material and component, showing compliance with requirements and installation instructions.
- C. Shop Drawings:
 - 1. List of piping systems, indicating application, material, size, and pressure rating.
 - 2. Detailed drawings of piping systems, showing locations of valves, expansion joints, specialties, and instrument connections.
- D. Waste Water Disposal: Before starting operations that require a temporary water supply submit the method proposed for disposal of waste water; for information; where regulatory permits are required, submit evidence that permits have been obtained.
- E. Pipe Testing Plan.
- F. Field Quality Control Reports.
- G. Operation and Maintenance Data: See Section 01 0008.

- H. Project Record Documents: Record actual locations of pipe anchors and guides and layout of piping systems relative to other parts of the work including clearances for maintenance and operation.

1.4 QUALITY ASSURANCE

- A. Plastic Piping Manufacturer Qualifications: Submit documentation certifying that the manufacturer of each thermoplastic piping system is listed with the Plastic Pipe Institute as meeting the recipe and mixing requirements of the resin manufacturer for the resin used to manufacture each of the respective thermoplastic pipe systems.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Plastic Pipe: Package, pack, and mark in accordance with manufacturer's recommendations.
- B. Gaskets: Store rubber gaskets not to be installed immediately under cover, out of direct sunlight.

1.6 FIELD CONDITIONS

- A. Existing Conditions:
 - 1. Verify existing piping and penetrations.
 - 2. Prior to ordering materials, expose all existing pipes which are to be connected to new pipelines.
 - 3. Verify size, material, joint types, elevation, horizontal location, and pipe service of existing pipes.
 - 4. Inspect size and location of structure penetrations to verify adequacy of wall sleeves and other openings before installing connecting pipes.

1.7 MANUFACTURER'S CERTIFICATION LETTER

- A. A letter from the pipe and fitting manufacture's stating the product(s) are supplied new from the manufacturer and is covered by the manufacturer's warranty shall be supplied to the Engineer.

PART 2 PRODUCTS

2.1 PIPING APPLICATIONS

- A. MBBR Influent Process Piping
 - 1. Above Grade: Cement-lined ductile iron, Grooved connections
 - 2. Below Grade: C900 PVC, Ductile Iron Restrained Joint Fittings
- B. MBBR Effluent Process Piping

1. C900 PVC, Ductile Iron Restrained Joint Fittings
- C. MBBR Series Operation Piping
 1. Schedule 80 PVC, Flanged
- D. Air Process Piping
 1. Above Grade: Schedule 40 hot dipped galvanized steel, galvanized grooved fittings.
 2. Below Grade: Unlined ductile iron, MJ fittings
- E. Influent Building
 1. Schedule 40 hot dipped galvanized steel, galvanized grooved fittings

2.2 C900 PVC PROCESS PIPING

- A. General: Pipe furnished for installation on this project shall be of the size and type shown on the Drawings. The pipe shall be manufactured from one of the materials designated for the specified line and application as described in the following subsections.
- B. Class 235, C900 PVC Pipe:
 1. Polyvinyl chloride pressure pipe and fittings shall conform to the requirements of AWWA C900 "Poly Vinyl Chloride (PVC) Pressure Pipe", Class 235 meeting the requirements of DR18.
 2. Outside pipe diameter shall be the same as that of cast iron pipe of similar nominal size.
 3. Pipe materials shall conform to "Standard Specification for Rigid Poly (Vinyl Chloride) Compounds and Chlorinated Poly (Vinyl Chloride) Compounds" (ASTM D-1784).
 4. The pipe shall bear the National Sanitation Seal for potable water pipe.
 5. Provisions must be made for expansion and contraction at each joint with an elastomeric ring.
 6. The bell shall consist of an integral wall section with a solid cross-section elastomeric ring which meets the requirements of ASTM D1869. The bell section shall be designed to be at least as strong as the pipe wall.
 7. Each length of pipe, including integral bell, shall be pressure tested in accordance with AWWA C900 Standards.
 8. Pipe and fittings must be assembled with a non-toxic lubricant.
 9. Standard lengths shall be 20 feet for all sizes.

10. Pipe may be furnished with separate couplings in lieu of integral bell to achieve high deflection.
11. Separate couplings shall pass a hydrostatic integrity test at the factory in accordance with AWWA C900 Standards.
12. Restraint:
 - a. Mechanical joint connections shall use megalug joint restraints with Corblu T-Bolts and nuts.
 - b. All pipe bells within 15 ft of a fitting shall utilize a bell restraint.

2.3 DUCTILE IRON LIQUID PROCESS PIPING

- A. Piping shall be of the material as shown on the Plans. The piping system shall be drip-tight and capable of withstanding 250 psi operation pressure. Unless specified otherwise elsewhere, all flanges shall conform to ANSI B16.1 Class 125.
- B. Ductile Iron Process Piping:
 1. Ductile iron pipe shall conform to the requirements of ANSI A21.50 (AWWA C150) and ANSI A21.51 (AWWA C151). Flanged ductile iron pipe shall conform to ANSI A21.15 (AWWA C115). Flanged ductile iron piping shall be rated for a maximum working pressure of 250 psi.
 2. Pipe shall be provided with a double thickness cement-mortar lining per AWWA C104.
 3. Flanged and mechanical joint fittings for use on ductile iron pipe shall be ductile iron and shall be rated for 250 psi working pressure.
 4. Certification of inspection and testing shall be provided by the manufacturer.
 5. Pipe Connections: Ductile iron pipe connections shall be grooved, flanged, or sleeve type couplings as shown on the Plans. Grooved couplings shall be in conformance with Federal Specifications QQ-I-666C, Grade II and shall be similar and equal to Victaulic or Aeroquip. Flanges shall conform to ANSI B16.1 Class 125 and AWWA C110. Blind flanges shall be installed where shown on the Plans.
 6. Fittings: The Drawings show size and general location of fittings required to make up the piping system. Fittings shall be flanged or grooved to match the pipe connection system selected. Fittings shall be ductile iron fittings meeting the ANSI standard dimensions for ANSI Class 125 flanged fittings or Federal Specification QQ-I-666C Grade II grooved couplings.
 7. Exterior Pipe Coatings: Pipe shall not be bituminous coated.

- a. Buried: Pipe exterior shall be coated with an active layer of 200 g/m² or more pure metallic zinc in accordance with ISO 8179-1 with an asphaltic coating over the zinc.
 - b. Above Finished Floor Level: Pipe exterior shall be prepared and coated in accordance with Section 099600 of these Specifications.
- 8. Ductile iron process piping shall be as manufactured by American, McWane, U.S. Pipe, or equal.
- 9. Restraint:
 - a. Mechanical joint connections shall use megalug joint restraints with Corblu T-Bolts and nuts.
 - b. All pipe bells within 15 ft of a fitting shall utilize a bell restraint.

2.4 DUCTILE IRON AIR PIPING:

- A. Ductile iron pipe shall conform to the requirements of ANSI A21.50 (AWWA C150) and ANSI A21.51 (AWWA C151). Flanged ductile iron pipe shall conform to ANSI A21.15 (AWWA C115). Flanged ductile iron piping shall be minimum Class 53. All iron piping and fittings beneath concrete slabs shall be encased in minimum 6" concrete. Grooved and mechanical joint fittings for use on ductile iron pipe shall be cast iron and shall be rated for 250 psi working pressure. Mechanical joint pipe shall use megalug joint restraints with Corblu T-Bolts and nuts. In order to assure delivery times and better assured control over the manufacturing process associated with fittings, these products must be manufactured in plants located within the Continental United States.
- B. Gaskets shall be rated for 250 degree F operating temperature.
- C. Exterior pipe Coatings:
 - 1. Buried: Pipe shall not be bituminous coated. Pipe exterior shall be coated with an active layer of 200 g/m² or more pure metallic zinc in accordance with ISO 8179-1 with an asphaltic coating over the zinc.
 - 2. Above Finished Floor Level: Pipe exterior shall be prepared and coated in accordance with Section 099600 of these Specifications.
- D. Certification of inspection and testing shall be provided by the manufacturer.
- E. The Drawings show size and general arrangement of the piping system. Responsibility for furnishing exact length of pipe for proper make-up rests with the Contractor.
- F. Restraint:

1. Mechanical joint connections shall use megalug joint restraints with Corblu T-Bolts and nuts.
2. All pipe bells within 15 ft of a fitting shall utilize a bell restraint.

2.5 GALVANIZED CARBON STEEL PIPING

- A. Steel Pipe: Schedule 40 ASTM A53/A53M, seamless, Grade A, galvanized
1. Interior/Exterior Galvanized Finish: Hot-dipped galvanized in accordance with ASTM A153/A153M; electroplated zinc or cadmium plating not permitted.
 2. Galvanized steel pipe fittings and joints shall be grooved.
 3. Gaskets for air service shall be rated for 250 degree F operating temperature.
 4. Gaskets for liquid service shall be rated for 250 psi operating pressure.

2.6 SCHEDULE 80 POLY (VINYL CHLORIDE) (PVC) PROCESS PIPE

- A. Schedule 80 PVC Pipe shall conform to the requirements Type 1, Grade 1 Poly Vinyl chloride as outlined in ASTM D-1784. Pipe shall conform to ASTM D-1785 and applicable sections of AWWA C-900. Schedule 80 PVC pipe diameters shall conform to the diameters for steel pipe of the same nominal size. PVC pipe used for interior process piping be attached using flanged connections. Solvent welding shall be compatible with water service.

2.7 PIPE SYSTEM APPURTENANCES

- A. Flexible Connections: Flexible expansion joints on intake and discharge sides of pumps and in other locations shown on the Contract Drawings shall be of the reinforced rubber type with minimum elongation of 1/2" and minimum compression of 3/4". Coupling shall allow ease of installation by the means of a floating pipe flange or compression bolt. Flexible expansion joint shall be designed for operation on air lines with operating temperatures of up to 300 degrees F. Flexible expansion joints shall be similar and equal to Proco Products, Inbc, Invincible as manufactured by Mercer Rubber Co., Flex/Pard/R as manufactured by ThermoTech, or Spanflex by Holz Rubber Co. Stainless Steel Tie bolts shall be provided at joints to reduce excessive expansion.
- B. Pipe Hangers and Supports:
1. It shall be the responsibility of the Contractor to provide the pipe support system adequate to properly support the size and type of pipe installed. Pipe supports and hangers shall be designed and spaced in accordance with the design procedures recommended in AWWA M11.
 2. Pipe supports of the adjustable type shall be similar and equal to Clow, Carpenter and Patterson, Inc. or Grinnell. Pipe supports, anchors, and appurtenances shall be stainless

steel.

3. Pipe hangers shall be the adjustable clevis type and shall be similar and equal to Grinnell or Carpenter and Patterson, Inc. Pipe hangers and appurtenances shall be stainless steel unless noted otherwise on the plans. All threaded rod for pipe hangers shall be stainless steel unless noted otherwise on the plans.
- C. Wall Sleeves: Wall sleeves for pipe penetrations shall be cast iron or steel with a water seal collar and equipped with link seals or equal. The link seals shall be supplied with stainless steel hardware, (bolts, nuts, washers, etc.). Wall sleeves passing through walls of basins containing water shall be equipped with double sets of link seals to provide pipe support at the wall penetration and additional protection against leakage.
- D. Adapter Flanges: Adapter flanges shall be installed at the locations shown on the Contract Drawings and as needed for complete piping system. Flange material shall be manufactured from ductile iron ASTM A536, Grade 60-42-10. Gaskets shall be suitable for use with wastewater and treated, chlorinated water. Flange adapters for grooved piping shall be flat face, ductile iron housings with elastomer pressure responsive gaskets for connection to ANSI Class 125 or 150 flanged components.
- E. Restrained Joints: All buried mechanical joint fittings below floor slabs shall be restrained with retainer glands. Glands shall be manufactured of ductile iron conforming to ASTM A536, grade 60-42-10. Set screws shall be of hardened ductile iron. Straight runs of pipe shall be equipped with gaskets w/stainless steel grips similar to Fast-Grip gaskets by American Ductile Iron Pipe.
- F. Sleeve Type Coupling - Sleeve type couplings shall be installed where shown on the Contract Drawings or as approved by the Engineer. Sleeve-type couplings shall be Dresser Style 38 or 40 or Romac 501. Joint harnesses for sleeve type couplings shall be provided as required. All lugs and bolts located in water holding basins, below floor slabs, and in open rooms used for pipe/fitting connections shall be stainless steel. Joint harnesses shall be sized per AWWA M11 manual for the pressure encountered. Sleeve type couplings shall be supplied with a factory applied fusion bonded epoxy coating.
- G. Foster Mechanical Joint Adaptor – All buried mechanical joint fittings connected to another mechanical joint shall be joined together using a foster adaptor as required.

2.8 PIPE INSULATION AND JACKETING

- A. Insulation and jacketing shall be furnished and installed for pipe and fittings in the following locations:
 1. Exposed 3 inch pipe and conduit between the Influent Building (Area 1) and Influent Filter Building (Area 2)
 2. All interior air piping and fittings in Blower Building (Area 4). Valves shall not be insulated. Ensure termination points at valves are sealed and finished completely

- B. Exterior piping shall be provided with Aluminum Jacket: ASTM B 209M formed aluminum sheet.
 - 1. Thickness: 0.016 inch sheet
 - 2. Finish: Smooth
 - 3. Joining: Longitudinal slip joints and 2 inch laps.
 - 4. Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner.
 - 5. Metal Jacket Bands: 3/8 inch wide; 0.010 inch thick stainless steel.
- C. Interior piping shall be provided with PVC Jacket
- D. Flexible Elastomeric Cellular Insulation
 - 1. Manufacturer:
 - a. These specifications are based on products and data of Armacell and designate the type and quality of work intended under this section. Products of other manufacturers proposed as equivalent must be submitted for written approval by the specifying engineer ten days prior to the bid date. Supporting technical data, samples, published specifications and the like must be submitted for comparison. The contractor should warrant that proposed substitutions, if accepted, will provide performance equal to the materials specified herein.
 - b. Insulation material shall be a flexible, closed-cell elastomeric insulation in tubular or sheet form:
 - 1) APArmaflex, APArmaflex W, APArmaflex SS, or APArmaflex SA.
 - 2. Insulation: This product meets the requirements as defined in ASTM C 534, "Specification for preformed elastomeric cellular thermal insulation in sheet and tubular form."
 - a. Insulation materials shall have a closed-cell structure to prevent moisture from wicking which makes it an efficient insulation.
 - b. Insulation material shall be manufactured without the use of CFC's, HFC's or HCFC's. It is also formaldehyde free, low VOC's, fiber free, dust free and resists mold and mildew.
 - c. Materials shall have a flame spread index of less than 25 and a smoke-developed index of less than 50 when tested in accordance with ASTM E 84, latest revision. In addition, the product, when tested, shall not melt or drip flaming particles, the flame shall not be progressive and all materials shall pass simulated end-use fire tests.

- d. Materials shall have a maximum thermal conductivity of 0.27 Btu-in./h-ft²- °F at a 75°F mean temperature when tested in accordance with ASTM C 177 or ASTM C 518, latest revisions.
 - e. Materials shall have a maximum water vapor transmission of 0.08 perm-inches when tested in accordance with ASTM E 96, Procedure A, latest revision.
 - f. The material shall be manufactured under an independent third party supervision testing program covering the properties of fire performance, thermal conductivity and water vapor transmission.
3. Adhesives and Finishes
- a. Adhesive shall be the insulation manufacturer's recommended contact adhesive: Armaflex 520, Armaflex 520 BLV or Armaflex HT 625 Adhesive.
 - b. Insulation finish shall be the insulation manufacturer's recommended finish: Armaflex WB Finish.
 - c. Accessories such as adhesives, mastics and cements shall have the same properties as listed above and shall not detract from any of the system ratings as specified above.

PART 3 EXECUTION

3.1 TRENCHING

- A. Perform trenching for piping installation in accordance with Section 31 2316.13.
- B. Do not backfill until piping testing is complete.

3.2 PREPARATION

- A. Keep Interior of Pipes Clean:
 - 1. Prevent accumulation of weld rod, weld spatter, pipe cuttings and filings, gravel, cleaning rags, and other foreign material inside piping sections during fabrication.
 - 2. Close pipe openings with caps or plugs before, during, and after installation.
 - 3. Remove foreign objects and dirt prior to assembly and installation.
- B. Protect pipe coatings from chemical and mechanical damage; do not install damaged products.
- C. Before field fabrication of pipe or fittings, notify Engineer at least 2 weeks prior to date of starting fabrication.
- D. Before field coating of pipe or fittings, notify Engineer at least 3 days prior to date of starting any surface preparation or coating work.

3.3 INSTALLATION - GENERAL

- A. Install piping and appurtenances in compliance with ASME B31.3, reviewed shop drawings, if any, and manufacturer's instructions, with all joints tight and no undue marring of finishes.
 - 1. Install piping to accurate lines and grades.
 - 2. Run piping as straight as practical in alignment shown with minimum of joints.
 - 3. Maintain required upstream and downstream clearances.
 - 4. At flow measuring devices, provide straight runs of piping upstream and downstream as indicated.
 - 5. Install piping without springing or forcing pipe to fit.
 - 6. Pitch piping toward low points and provide a valved drain at each low point.
 - 7. Provide a sufficient number of unions or flanges to allow for dismantling of pipe, valves, and equipment.
 - 8. Where temporary supports are used, make them sufficiently rigid to prevent shifting or distortion of pipe.
 - 9. Make installed piping, valves, and fittings free from strain and excessive stresses caused by weight or misalignment.
- B. Provide isolation valves and miscellaneous devices as required for an operable installation.
- C. Pipe Jointing: Clean the ends of pipes thoroughly, remove foreign matter and dirt from inside of pipes, and keep piping clean during and after installation.
- D. Thermal Expansion and Contraction: Install piping to allow for thermal expansion and contraction resulting from difference between temperature during installation and during operation.
 - 1. Anchors: Locate as indicated on drawings and reviewed shop drawings, if any, to withstand expansion thrust loads and to direct and control thermal expansion.
 - 2. Intermediate Pipe Alignment Guides:
 - a. Install adjacent to pipe expansion joints and within four pipe diameters each side.
 - b. At pipe mounted on metal channel framing, install intermediate pipe guide at each metal channel framing support not carrying an anchor or alignment guide.
- E. Flexible Couplings and Expansion Joints: Install in accordance with manufacturer's instructions, at connections to equipment and where shown on drawings and reviewed shop drawings, if any.

- F. Pipe Tap Connections: Taps direct to pipe barrels are prohibited; make taps as follows:
 - 1. Ductile Iron Piping: Use service saddle or tapping boss of a fitting, valve body, or equipment casting.
- G. Buried Pipe Installation:
 - 1. Carry pipe to the trench; do not drag it.
 - 2. Exercise care when lowering pipe into trench to prevent damage and twisting of pipe.
 - 3. At valves and connections, excavate trench bottom to sufficient length, width, and depth to ensure clearance between undisturbed trench bottom and bottom of valves and connections.
- H. Joints at Rigid Structures:
 - 1. Provide flexible joints at face of rigid structures, whether or not shown on drawings.
 - 2. Flexible jointing methods include, but are not limited to, rubber ring joints, mechanical joints, flexible couplings, and proprietary restrained ductile iron pipe joints; welded joints are not considered flexible.
 - 3. Joint Location: Flush with structure face or up to one (1) pipe diameter from face; maximum distance from face:
 - a. Pipe Diameter Over 18 inches (450 mm): First joint within one (1) pipe diameter from face.
 - b. Smaller Diameters: 18 inches (450 mm) from face.
- I. Identify exposed piping as specified in Section 46 0500.

3.4 METALLIC PIPE JOINTING

- A. Connecting Dissimilar Metallic Pipe and Appurtenances: Use isolation devices as specified and as required to separate different materials to avoid galvanic action; install in accordance with manufacturer's instructions.

3.5 PLASTIC PIPE INSTALLATION

- A. Cut, fabricate, and install plastic pipe in accordance with pipe manufacturer's instructions and recommendations.
- B. Install pipe only when ambient temperature is above 40 degrees F (4.5 degrees C) and below 90 degrees F (32 degrees C) and not exposed to direct sunlight.
- C. Plastic Pipe Jointing: Follow manufacturer's instructions.

1. Heat Jointing: Comply with ASTM D2657.
 2. Electrofusion Jointing: Comply with ASTM F1290.
 3. Solvent-Cemented Jointing: Comply with ASTM D2855.
 4. Push-On Joints: Lubricate gaskets to prevent displacement; take care to ensure that gasket remains in proper position in bell or coupling.
 5. Do not thread Schedule 40 pipe; where connecting pipe to threaded valves or fittings, use Schedule 80 threaded nipples.
 6. Use strap wrenches for tightening threaded plastic joints, taking care not to over-tighten fittings.
 7. Shield pipe ends from direct sunlight prior to and during installation.
 8. Provide adequate ventilation when working with pipe joint solvent cement; comply with ASTM F402 for handling of solvent cements, primers and cleaners.
- D. Use expansion joints and offset piping arrangements to accommodate thermal expansion and contraction.
1. Make offset loops from pipe centerline as recommended by manufacturer based on maximum temperature difference between pipe temperature at time of jointing and operating temperature.
 2. For pipe exposed to outside air or in which the temperature variation of the contents is substantial, make provisions for movement due to thermal expansion and contraction in accordance with PPI (PE); Material Properties; Coefficient of Expansion/Contraction.

3.6 FIELD QUALITY CONTROL - GENERAL

- A. Test all parts of piping systems using clean water and hydrostatic pressure and leakage tests, unless otherwise indicated.
- B. Leakage Testing: Perform after pressure tests have been satisfactorily completed, unless otherwise approved by Owner.
- C. Water: Provide clean test water of such quality to avoid corrosion of piping system materials.

3.7 FIELD QUALITY CONTROL - HYDROSTATIC PRESSURE TESTING

- A. Perform hydrostatic testing in accordance with ASME B31.3 under normal service conditions.
- B. Maximum Velocity During Filling: 0.25 fps (0.075 m/s) applied over full area of pipe or as recommended by pipe manufacturer, whichever is lesser.

- C. Venting Air While Filling: Purge all air in system; open air release vents to purge air pockets; venting may also be provided by loosening minimum of four bolts of flanges or by use of equipment vents.
- D. Valves: Include each valve in at least one piping section tested; open and close valves several times during test.
- E. Rigid Piping Test Procedure:
 - 1. Maintain test pressure continuously for minimum of 30 minutes and during examinations for leakage.
 - 2. Leave piping system full of water after leaks are repaired, unless otherwise directed by Owner.
- F. Non-Rigid, Non-Metallic Piping and Metallic Piping With Non-Metallic Liner Test Procedure:
 - 1. Raise pressure to 50 percent of normal service pressure.
 - 2. Inspect pipe, fittings, joints and connections, and valves for visible leakage; correct leaks and continue test.
 - 3. Raise pressure to test pressure and add small amounts of test liquid as required hourly for maximum of 3 hours as required to maintain test pressure.
 - 4. After 4 hours, lower test pressure by 10.2 psi (70 kPa).
 - 5. If pressure remains steady for one (1) hour, no leakage is indicated.
 - 6. Before retesting, allow piping system to relax for 8 hours.
- G. Inspect pipe, fittings, joints and connections, and valves for visible leakage; correct leaks and re-test until results are satisfactory.

3.8 FIELD QUALITY CONTROL - PIPE LEAKAGE TESTING

- A. Test piping for leakage by filling with water, or other appropriate test liquid, applying specified test pressure, and measuring amount of additional liquid is necessary to maintain the specified pressure for the specified duration.
- B. Maximum Allowable Leakage: As determined by following formula, whichever is greater:
 - 1. L (allowable leakage) = $C_f \times N \times D \times P^{0.5}$, in gallons per hour (cubic mm per hour).
 - 2. C_f = conversion factor = 0.0001351 (10.786)
 - 3. N = number of joints in the length of piping tested.
 - 4. D = nominal pipe diameter, inch (mm)

- 5. P = average test pressure during the test, psig (MPa).
- C. Duration of Leakage Test: At least 2 hours after piping has been filled and air has been expelled.
- D. Test Pressure: 150 psig plus/minus 5 psig (34.5 kPa).
- E. Locate leaks, repair, and re-test until leakage is within specified limits.

3.9 CLEANING PIPING - PRIOR TO STARTUP

- A. After testing, flush piping with water to remove accumulated construction debris and other foreign matter; continue flushing until no foreign matter exits the pipe.
- B. Install cone strainers in connections of attached equipment and leave in place until flushing is completed. Remove accumulated debris through drains or by removing spools or valves.
- C. Minimum Flushing Velocity: 2.5 feet per second (0.76 m/s).
- D. For large diameter pipe impractical to flush at minimum flushing velocity, clean pipe in place from inside by brushing and sweeping, then flush at a lower velocity.

END OF SECTION 40 2340

**SECTION 40 6113
– INTEGRATOR COORDINATION**

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Definition of the various “integrators” and their responsibilities
- B. Related Sections include but are not necessarily limited to:
 - 1. Division 1 – General Requirements
 - 2. Division 23 – Mechanical
 - 3. Division 26 – Electrical
 - 4. Division 40 - Process Integration, Instrumentation and Control for Process Systems
 - 5. Divisions 43 and 46 for equipment requirements and control

1.2 SYSTEM DESCRIPTION

- A. The control system shall be the result of the combined efforts of the Control System Integrator, Electrical Sub-Contractor, Instrumentation Supplier and Equipment Supplier. Descriptions are provided as follows:
 - 1. Control System Integrator – The Control System Integrator shall be responsible for the development of the local Control System for the process improvements within this project, including the new RTU and new instruments and processes. Control System Integrator shall provide required data output capabilities for future integration into the Treatment Facility SCADA (by others).
 - a. Pre-Submittal Site Visit and Documentation – The Control System Integrator shall be responsible for visiting the site prior to submittal of instrumentation and line diagram documents. Integrator shall use this time to verify measurements, locations, lay lengths, diameters, and connection style of instruments, and other relevant information prior to ordering instruments, mounting hardware, and building panels. Control System Integrator shall also familiarize themselves with the existing SCADA system in order to provide a user interface that is consistent with the existing system. An ISA Form S20.26 or S20.40a shall be provided and filled out for each piece of equipment existing and new. In addition, the Control System Integrator shall be responsible for the following:
 - 1) The hardware design of all RTU (PLC) panels and miscellaneous panels not provided by Process Equipment suppliers.

- 2) Purchasing of all RTU (PLC) panel materials and construction of RTU (PLC) panels.
 - 3) Hardware testing of all RTU (PLC) control panels.
 - 4) Overseeing and verifying the communications cabling, fiber optic cabling, and all communication terminations required for operation of the RTU (PLC) control system.
 - 5) Overseeing and verifying the field connections and functionality of all sensors and devices connected to the RTU (PLC) system.
 - 6) Work with Electrical Sub-Contractor to install an Ethernet Network that is a “Fault Tolerant Ring” design.
 - 7) Development of modern SCADA System incorporating new processes.
 - 8) Define and refine the control loop requirements with the Engineer and/or Owner.
 - 9) Purchase of the HMI and RTU (PLC) programming software.
 - 10) Develop and test PLC programs for the RTU (PLC) Control System.
 - 11) Develop HMI software interface screens and reports.
 - 12) Assisting with the start-up and field verification of the various control loops in the system.
 - 13) Generate the O&M Manuals regarding all equipment supplied for the RTU (PLC) control system and provide complete system documentation.
 - 14) Maintaining full functionality of the Wastewater Treatment Facility during the development of the new SCADA System.
 - 15) Disconnection and removal any portion of the existing SCADA System which will no longer used and all associated wiring, cabling, hardware, process instrumentation, computer systems, and hardware. Coordinate with the owner regarding the storing locations or equipment to be discarding.
2. Electrical Sub-Contractor – The Electrical Sub-Contractor shall be a sub-contractor of the General Contractor for this project and shall provide the installation and wiring of the PLC Control System. All of the signal wiring, communications wiring, coaxial cable, fiber optic cable terminations, T1 cable terminations, and all other terminations will be provided by the Electrical Sub-Contractor.
- a. Work with Control System Integrator to install an Ethernet Network that is a “Fault Tolerant Ring” design.

- b. Electrical Sub-Contractor shall be responsible for providing and installing all conduit and wire as shown on the electrical and controls plan sheets and required for a complete and functional control system.
- 3. Process Equipment Suppliers – The Process Equipment Suppliers (MBBR and Blower System) are the equipment suppliers that are providing control panels, equipment, and/or signals that must interface as specified in 40 6900. The Process Equipment Suppliers shall provide the following:
 - a. Furnish Control Panels, as applicable, that strictly adhere to the Division 40 specifications.
 - b. Information on signal types and related scaling.
 - c. Documentation on communications registers required to interface with the Plant Control System including control and status registers, analog signal registers, and setpoint registers as needed.
 - d. Work with the Control System Integrator to develop Operator Interface Screens on HMI devices included with their equipment.
 - e. Work with the Control System Integrator to develop the logic for an integrated control system.
- 4. Instrumentation Supplier – If the Instrumentation Supplier providing the “Instrumentation and Control for Process Systems” in Section 40 7000 is different from the Control System Integrator, the Instrumentation Supplier shall be responsible for the overseeing the installation and field calibration of all items supplied. Field calibration shall be witnessed by the Owner or Control System Integrator and require a signed “calibration” sheet for each instrument prior to acceptance of the equipment.
- B. The Control System Integrator, Electrical Sub-Contractor, Process Equipment Suppliers, and Instrumentation Suppliers shall meet in person with the Engineer and/or Owner prior to the start of construction to go through the above responsibilities and submittal process for the project.

1.3 SUBMITTALS

- A. See Section 01 0004 “Submittals Procedures” for requirements for the mechanics and administration of the submittal process.
- B. Operation and Maintenance Manuals:
 - 1. See Section 01 0004 “Submittal Procedures” for requirements for:
 - a. The mechanics and administration of the submittal process
 - b. The content of Operation and Maintenance Manuals

PART 2 PRODUCTS - (NOT APPLICABLE TO THIS SECTION)

PART 3 EXECUTION - (NOT APPLICABLE TO THIS SECTION)

END OF SECTION 40 6113

**SECTION 40 6900
– PROCESS INTEGRATION**

PART 1 GENERAL

1.1 DESCRIPTION

- A. This Work shall consist of performing all labor and furnishing all material to provide a complete and functioning local control system for the Sanford Underground Research Facility Improvements including control panels, instruments, equipment and processes. This section includes specifications for the control panels, appurtenances, and associated materials and equipment. This section also defines responsibilities and requirements for coordination of the Work, shop drawing submittals, operator training, system checkout, spare parts, and warranty.
1. The instrument and control system consist of all primary elements, transmitters, switches, controllers, relays, computers, recorders, indicators, panels, signal converters, signal boosters, amplifiers, special power supplies, special or shielded cable, special grounding or isolation, auxiliaries, software, wiring, and other devices required to provide complete control of the systems as specified in the Contract Documents.
 2. Unless otherwise required for instrument compatibility, electric control signals shall be 4 to 20 mA, 24 Vdc, and pneumatic signals shall be 3 to 15 psi. Control System Integrator shall verify signals of existing equipment to remain in-place prior to Control Panel construction.
 3. All signals shall be directly linearly proportional to measured variable unless specifically noted otherwise.

1.2 CONDITIONS AND SYSTEMS RESPONSIBILITY

- A. The Control System Integrator shall be responsible for coordination of all aspects of work including:
1. Installation of a new RTU for process improvements
 2. Integration process improvements into new local control SCADA system.
 3. Coordinating with the Electrical Sub-Contractor, Instrumentation Supplier, and Equipment Suppliers.
 4. Coordination with the Owner and/or Engineer,
 5. Disconnection and discarding of replaced equipment.
 6. Testing of control systems.
 7. Provide all necessary Operator Training.
 8. Provide system checkout and repair during the warranty period.

9. Provide complete system documentation.
- B. The Control System Integrator shall be responsible for working closely with the Instrumentation Suppliers, General Contractor, and Electrical Sub-Contractors to join all the individual processes into a system that is integrated and appears to be seamless to the Owner.
1. It shall be the responsibility of the Control System Integrator to closely schedule his work so that his work will be installed at the proper time and without delaying the completion of the entire project. The plan for the sequence of operations shall be reviewed with the Owner, Engineer, and General Contractor prior to starting installation of the equipment to minimize impact on project schedule.
 2. It is the responsibility of the Contractor to install all controls equipment in strict accordance with manufacturer's recommendations, with adequate on-site supervision being provided by the manufacturer of the equipment or his authorized representative.
 3. The software packages furnished as a part of the control and telemetry system shall be licensed to the Owner. Software shall be fully documented and a backup copy of the software shall be provided on a USB Drive or equivalent long-term storage medium. Software license shall be a run-time license.
 4. The authorized representative of the manufacturers supplying equipment shall notify the Engineer that the equipment has been satisfactorily installed and is ready for operation. No form of energy shall be turned on to any part of the control and monitoring system prior to receipt by the Engineer of a statement of approval of the installation from the Contractor containing his Supplier's authorization for turning on energy to the system.

1.3 RELATED WORK SPECIFIED ELSEWHERE

- A. The following items of related work are specified and included in other sections of these Specifications:
1. Division 1 – General Requirements
 2. Division 23 – Mechanical
 3. Division 26 – Electrical
 4. Division 40 –
 - a. “Integrator Coordination” for coordination requirements between Control System Integrator, suppliers, and electricians to create a fully functioning control system
 - b. “Instrumentation and Control for Process Systems” for general requirements for hardware products and integration.
 5. Divisions 43 and 46 for equipment requirements and control

- B. The materials specifications for wire, appurtenances, and equipment apply to the materials required for the control system. The Control System Integrator shall coordinate control and monitoring system wiring requirements.

1.4 QUALITY ASSURANCE

- A. Referenced Standards:
 - 1. Canadian Standards Association (CSA)
 - 2. FM Global (FM)
 - 3. The Instrumentation, Systems, and Automation Society (now International Society of Automation, ISA):
 - a. S5.1, Instrumentation Symbols and Identification
 - b. S5.2, Binary Logic Diagrams for Process Operations
 - c. S5.3, Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Systems
 - d. S5.4, Standard Instrument Loop Diagrams
 - e. S20, Standard Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves
 - f. RP7.1-56, Pneumatic Control Circuit Pressure Test
 - 4. National Electrical Manufacturers Association (NEMA)
 - 5. National Institute of Standards and Technology (NIST)
 - 6. Underwriters Laboratories, Inc. (UL)
- B. Miscellaneous:
 - 1. Comply with electrical classifications and NEMA enclosure types shown on Drawings.

1.5 QUALIFICATIONS OF CONTROL SYSTEM INTEGRATORS

- A. Control System Integrators proposing to bid the work specified herein shall be approved by the Owner and the Engineer. In addition to the system specifications, the following minimum requirements shall be met by the Contractor:
 - 1. At least five (5) years of experience in design and installation of control systems for water and/or wastewater treatment plants.
 - 2. Demonstrated ability to serve as Control System Integrator.

3. List of Names and qualifications of individuals to be assigned to the job.
- B. The following Control System Integrators are approved for this Contract:
1. Sweeney Controls – Fargo, ND; (701) 232-3644
 2. Dakota Pump Inc. – Mitchell, SD (605) 996-6636
 3. Micro Comm Inc.- Olathe, KS (913) 390-4500
 4. Automatic Systems Co. – St. Paul, MN (651) 631-9005
 5. In Control – Fridley, MN (763) 783-9500
 6. Direct Companies – Sioux Falls, SD (866) 583-3377
 7. Or Owner Approved Equal

1.6 SHOP DRAWINGS REQUIREMENTS

- A. Submit copies of shop drawings in accordance with Division 1 for all hardware items and software products listed under “Products”. Shop drawings shall include all catalog cuts, descriptive data, and drawings for the entire control system. If catalog cuts are furnished, the specific model number, color, and all requirements shall be indicated on each copy of the shop drawings.
- B. Submit copies of the proposed method of control system expansion, including a listing of additional hardware required, additional software required, and implementation requirements. The data acquisition and monitoring system supplier shall also submit a detailed explanation of the procedure for integrating the Work process controls into the existing facilities.
- C. Submit system documentation as described in paragraphs 3.1 of this Specification.
- D. Submittals shall be prepared from original printed material or clear unblemished photocopies of original printed material. Facsimile information is not acceptable.
- E. Product technical data including:
1. Acknowledgement that products submitted meet requirements of standards referenced
 2. Equipment catalog cut sheets
 3. Instrument data sheets:
 - a. ISA S20 or Engineer approved equal
 - b. Separate data sheet for each instrument
 4. Materials of construction

5. Minimum and maximum flow ranges
 6. Pressure loss curves
 7. Physical limits of components including temperature and pressure limits
 8. Size and weight
 9. Electrical power requirements and wiring diagrams
 10. NEMA rating of housing
 11. Submittals shall be marked with arrows to show exact features to be provided.
- F. Loop diagrams per ISA S5.4.
1. Each loop diagram on a separate sheet
 2. Each sheet shall contain the following minimum information:
 - a. All loop devices clearly identified
 - b. Identification of the loop and each loop component, including connections to such things as recorders and computers. Numbering and tagging must agree with the P&ID.
 - c. All interconnections with identifying numbers for:
 - 1) Electrical cables
 - 2) Conductor pairs
 - 3) Pneumatic or hydraulic tubing
 - d. Identification of connections including:
 - 1) Junction boxes
 - 2) Terminals
 - 3) Bulkheads
 - 4) Ports
 - 5) Computer input/output connections
 - 6) Grounding systems
 - e. Signal levels and ranges
 - f. Device location

- g. Energy sources designating voltage, pressure, and other applicable requirements
 - h. Enough process lines and equipment to clearly show the process side of the loop and provide clarity of control action. This includes:
 - 1) What is being measured
 - 2) What is being controlled
 - 3) Other information required to complete the process loop
 - i. Reference to supplementary records and drawings to show inter-relation to other control loop.
 - j. Controller action
 - k. Control valve action upon electronic, hydraulic, or pneumatic failure
- G. Process connected instrument installation details containing the following minimum information:
 - 1. Bill of materials providing as a minimum the following information:
 - a. Tube material and size
 - b. Connection size
 - c. Fitting size, material, and rating
 - d. Valve type and material
 - e. Instrument description
 - f. Pipe stand size and material
 - g. Tube slope requirements
 - 2. Required elevations and dimensions
- H. Comprehensive set of point-to-point wiring diagrams showing all interconnections between packaged systems or equipment control panels, motor control centers, instrumentation, and all other electrical equipment as required to depict a complete and functional electrical control system. Instrumentation wiring already shown on loop diagrams need not be included on point-to-point wiring diagrams.
 - 1. Diagrams shall provide the following minimum information:
 - a. Terminal block identification (includes terminals on remote equipment furnished by Others)

- b. Wire identification number.
 - c. Wire size
 - d. Wire type
 - e. Wire color
 - f. Wire shielding and insulation type
 - g. Conductor quantities and associated conduit size
 - h. Ground points
 - i. Interconnection requirements to existing systems or equipment furnished by Others
- 2. Diagrams shall be provided on Drawings of sufficient size so as to minimize the number of drawings.
 - a. Drawing size: 11 x 17 IN
- I. Electrical schematic control diagrams. Diagrams shall include:
 - 1. Terminal identification
 - 2. Unique identification of all control devices and contacts
 - a. Utilize Owner's device identification numbers where applicable
 - 3. Wire identification
 - 4. Equipment identification
 - 5. Indication of remote and local devices and wiring
 - 6. Overcurrent protection indication
 - 7. Voltage
 - 8. All control logic
- J. Panel fabrication drawings
- K. PLC/DCS equipment drawings
- L. Graphic layouts
- M. Graphic component construction
- N. Nameplate layout drawing

- O. Drawings, systems, and other elements are represented schematically in accordance with ISA S5.1 and ISA S5.3.
 - 1. The nomenclature, tag numbers, equipment numbers, panel numbers, and related series identification contained in the Contract Documents shall be employed exclusively throughout submittals.
- P. Certifications:
 - 1. Documentation verifying that calibration equipment is certified with NIST traceability.
 - 2. Approvals from independent testing laboratories or approval agencies, such as UL, FM, or CSA. Certification documentation is required for all equipment for which the specifications require independent agency approval.
- Q. Testing reports:
 - 1. Source quality control reports
- R. Warranties: Provide copies of warranties and list of factory authorized service agents.

PART 2 PRODUCTS

2.1 GENERAL

- A. Coordinate with Control System Integrator(s) to ensure that necessary wiring, conduits, contacts, relays, converters, and incidentals are provided in order to transmit, receive, and control necessary signals to other control elements, to control panels, and to receiving stations.
 - 1. Control system wiring shall comply with applicable NEC and UL standards. Standards shall govern in the case of a conflict.
 - a. Discrete signal wiring shall be a minimum of a 16-gauge pair for panel and field wiring.
 - b. Analog signal wiring shall be minimum 18-gauge twisted, shielded pair for panel and field wiring.
 - c. Ground Wires for field wiring (analog and discrete) shall be 12-gauge.
 - d. Ground Wires for panel wiring (analog and discrete) shall be per UL 508A and manufacturer requirements.
 - e. Ethernet cables shall be a minimum of Cat-6.
 - 2. Control system conduit shall be RMC Steel Conduit per Specification 26 0533.
- B. The functions and features specified herewith are the minimum acceptable requirements for the SCADA system. The provided system shall equal or exceed each requirement.

- C. In some cases, the specifications may allow the accomplishing of certain functions by means of more than one hardware/firmware/software approach. Any approach that is proposed shall equal or exceed all functional, operational, convenience, and maintenance aspects of the one described.
- D. Major equipment, component, and software items are specified; however, the Contractor shall provide all appurtenant items necessary to achieve the required operation as hereinafter specified.

2.2 PERFORMANCE AND DESIGN REQUIREMENTS

- A. System Operating Criteria:
 - 1. Stability: After controls have taken corrective action, as result of a change in the controlled variable or a change in setpoint, oscillation of final control element shall not exceed two cycles per minute or a magnitude of movement of 0.5 percent full travel.
 - 2. Response: Any change in setpoint or change in controlled variable shall produce a corresponding corrective change in position of final control element and become stabilized within 30 seconds.
 - 3. Agreement: Setpoint indication of controlled variable and measured indication of controlled variable shall agree within 3 percent of full scale over a 6:1 operating range.
 - 4. Repeatability: For any repeated magnitude of control signal, from either an increasing or decreasing direction, the final control element shall take a repeated position within 0.5 percent of full travel regardless of force required to position final element.
 - 5. Sensitivity: Controls shall respond to setpoint deviations and measured variable deviations within 1.0 percent of full scale.
 - 6. Performance: All instruments and control devices shall perform in accordance with manufacturer's specifications.

2.3 DESCRIPTION OF WORK

- A. General: The scope of Work under this Contract includes connecting and configuring of new equipment that is installed under this Contract and development of the appropriate displays, reports, and logs to record the information generated by the new equipment and instruments. All wiring and appurtenances required for a complete and functional system shall be provided under this Contract. The monitoring and control functions are described in the functional description of the control system. The control equipment and material specifications are described in the Specifications for control system hardware and materials.
- B. The following subsections define the Work that will be completed under this Contract.
 - 1. General:

- a. It shall also be the responsibility of the project awarded Control System Integrator to visit the site for investigation of existing system prior to panel and SCADA design. While no existing equipment shall be incorporated into the local SCADA system, it is the responsibility of the Control System integrator to provide a system that is consistent in function and usability to the existing system(s).
- b. Full functionality of the wastewater treatment process shall be maintained during construction and handoff to the new SCADA System and shall be responsible for coordinating times with Owner for any disturbances to the process that may be necessary.
- c. A new RTU (RTU-2) shall be installed in the Existing Pressure Filter Building (Area 2). All new instrumentation, processes, and equipment installed under this contract shall be controlled through RTU-2. The new control system shall utilize PLC's and OIT's on the panels as shown on the Plans. The new control panel(s) shall utilize Ethernet/IP protocol or direct signals for in-house communication with the devices as shown in the Plans. New control panel(s) shall provide Ethernet/IP output for future connection and communication with the panels on other parts of the site. Control System Integrator shall develop and integrate adequate number of graphic screens on the HMI software to accurately show the operation of the processes and equipment.
- d. The Control System Integrator shall incorporate the instrumentation and I/O as specified and required for the proposed upgrades, as described in the Specifications, and shown on the Y Series Plan Sheets. The new RTU (RTU-2) shall monitor and control the new devices.
- e. Switches, buttons, and lights shall be wired to provide a means of manual control in the event of a PLC failure.
- f. All existing and new alarm conditions shall report to the new RTU-2. In the future (N.I.C.) RTU-2 shall be integrated into a facility wide SCADA system, which will provide remote alarming.
- g. Control System Integrator shall be responsible for the removal and discarding of all replaced equipment. Coordinate with Owner for any equipment to be salvaged.

2.4 PROCESS CONTROL FUNCTIONS

- A. Summary Listing of Points: The point list provided in the plans indicates the number of new inputs and outputs to and from the control system. The number of wires and terminations will vary with configuration of the control system. The list of points is provided as a reference list for the functional specifications. The control system shall monitor and control the Analog/Discrete inputs and outputs summarized on the plan sheets.

- B. The lists do not include the contact closure points required to drive status and alarm lights and horns on the control panels. The analog output lists do not include the outputs required to drive displays. The outputs necessary to drive the displays, indicators, and recorders are described in the functional specifications.
- C. Operational Description – General Control Functions:
 - 1. General: It is intended that the new RTU-2 provide a system for monitoring the new treatment process and equipment in the treatment plant. The work in this contract will include installing and connecting the panels and equipment furnished under this contract, connecting signals from new instruments and equipment. The control and monitoring requirements for each major piece of process equipment connected to the system are listed in the functional descriptions of the controls.
 - a. General Requirements: The control and monitoring system uses a Programmable Logic Controller based system sized to handle all analog and contact closure signals necessary for the monitoring and control functions specified. Two modes of control shall be available to the Operator.
 - 1) Operator Setpoint Control: In this mode, the Operator shall set desired flow, level, and time interval setpoints as required by the various control loops. Adjustment of a setpoint shall not hinder the operation of other control loops. The control loop shall operate the system within the setpoint limits if the controlled equipment is in the automatic mode. Dead bands, signal averaging, and signal damping will be necessary to prevent unnecessary and too frequent control adjustments. Signal averaging shall be operator-adjustable over a span of 0 to 30 minutes. The Operator shall be able to override the automatic control from the local control panels by using the “HAND” control or “OPEN/CLOSE” controls for valves.
 - 2) Manual Control: In this mode, the Operator shall be able to take direct control of any device connected to a “HAND-OFF-AUTO” switch or “OPEN-CLOSE-AUTO” switch on the switchgear, MCC, control panel, VFD, valve actuator or which is remotely mounted. The manual mode of control shall be completely independent of the programmable controller and failure of the programmable controller shall in no way limit manual control functions. The “OFF” position of the manual control switch will override all other controls. The “HAND” position will permit control of the unit operation from either the switch on the MCC or the process control panel. The “AUTO” position will permit control of the unit operation from the PLC.
 - 3) Alarm logic shall be equipped with time delays to prevent nuisance alarms. Alarms shall be annunciated by the alarm annunciation system in the process control panel.

- b. Operator Interface Requirements:
 - 1) An Operator Interface on RTU-2 shall provide the means for monitoring the new equipment in the wastewater treatment plant.
 - c. Records of Run Time:
 - 1) The process monitoring and control system shall maintain run time records for each piece of process equipment connected to the control and monitoring system. The run time records shall be maintained by non-resetting counters within the PLC system. Displays of accumulated run time for each item of equipment shall be available through the operator interface displays at each RTU panel.
 - d. Status and Alarm Monitoring: Equipment alarms shall be designed to inform the Operator of any un-commanded change of status. Equipment failure alarm logic shall include adjustable time delays to prevent nuisance alarms due to time delays in the starting controls. The motor starter controls for process equipment generally include time delay relays to sequence restart after power failure. The time delays for the alarms shall be set longer than the time delay for start to prevent nuisance alarms.
 - 1) Analog input alarms shall be annunciated when a setpoint limit is violated or a signal is lost AND an operator selected timer expires. Zero flow signals on flow meters will not necessarily be an alarm condition; setpoints for low flow must be adjustable to prevent nuisance alarms at zero flow. Operator shall enter alarm limits using the keyboard for the process control interface.
 - 2) Status inputs shall be used as a means for recording run time on all motors connected to the process monitoring and control system. The motor run time meters shall be non-resetting. The data shall be accumulated in the data base maintained in the process control system and shall be displayed on operator interface screens at the human machine interface.
 - 3) Status and alarm engraving is shown on the Plans. The engraving schedules and arrangements shown are intended as a guide for control panel layouts. Variations to the shown arrangements will be reviewed at the time of shop drawing submittal.
 - e. Remote Access: The Control System Integrator shall provide the Owner with remote access to all controls. The interface shall be the same as the HMI on the main plant computer system.
2. Functional Description of Process Controls: The following is a narrative of the normal operation procedures for each major piece of equipment in the Wastewater Treatment Facility. The parameters in brackets are initial setpoints for operator selected variables.

All operator selected setpoints shall allow the Operator to change or modify variables in the control of the equipment.

- a. It shall be the responsibility of the Control System Integrator to investigate all existing process devices associated with the Wastewater Treatment Facility in order to create a local SCADA system that feels seamlessly to the plant operators. The Control System Integrator shall work closely with the Operators when developing local SCADA system in order to reflect the desired operation. The following is a narrative of the normal operation procedures for the improvements of the Wastewater Treatment Facility Improvements project. The functional descriptions included in this specification are not intended to be a complete functional description of the entire wastewater treatment facility. The parameters in brackets are initial setpoints for operator selected variables. All operator selected setpoints shall allow the Operator to change or modify variables in the control of the equipment. Equipment, instrumentation, and panel tags listed in the Plans and Specifications for this project reflect only new or revised instrumentation and are not intended to be used for final tags. The Controls System Integrator shall be responsible for revising instrumentation, equipment and panel tags to seamlessly integrate them into the existing system. Revised identification tags shall be provided to the Engineer and Owner in the Construction Plans of Record Documents.
- b. Panel Locations:
 - 1) A process monitoring and control panel, RTU-2, shall be installed in the Existing Pressure Filter Building (Area 2), as shown on the plans. The panel shall include an operator interface screen which will permit monitoring and control of all analog outputs throughout the plant improvements. The panel shall be equipped with an uninterruptible power supply. Status and alarm signals and flow proportioning signals from the control system furnished under this section of the specifications will generally be connected to the equipment at either the motor control center or the panel furnished with the equipment.
- c. Area 1:
 - 1) Side Stream Holding Tank Level: The side stream holding tank will be equipped with a pressure transmitter (PIT-101) which will output a signal proportional to the liquid level in the tank. Low tank level [1.0 ft] and high tank level [6.0 ft] events shall generate alarm conditions and shall be annunciated when temperature drops below or rises above an operator selected setpoint.
 - 2) Side Stream Pump Control: the side stream pump (SSP-1) will be installed to pump wastewater from the side stream holding tank to the MBBR

influent. The pump shall be called to operate based on the liquid level in the side stream holding tank as determined by PIT-101. The pump shall be called to start when the tank level is [5.0 ft] and to stop when the level is [2.0 ft]. A local HOA switch (HS-101) shall be located at the pump and allow for manual control of SSP-1.

d. Area 2:

- 1) Existing Pressure Filter Flow Meter: An existing flow meter (FIT-201) is installed in Area 2 to monitor the flow into the Yardney Pressure Filters. This meter communicates with the existing RTU-1. A 4-20 mA flow signal from RTU-1 shall be brought to RTU-2 proportional to the instantaneous flow through FIT-201 in order to operate the new Pressure Filter Effluent Control Valve (CV-201) installed in this project and controlled through RTU-2. A high flow event [1900 gpm] events shall generate an alarm condition and shall be annunciated when flow exceeds an operator selected setpoint.
- 2) Existing Pressure Filter Effluent Pressure Transmitter: The existing Pressure Filter Effluent Pressure Transmitter (PIT-201) shall be reinstalled where shown on the plans and rewired as necessary. PIT-201 communicates with the existing RTU-1 and shall continue to operate based on the existing RTU-1 programming.
- 3) Pressure Filter Effluent Control Valve: The Pressure Filter Effluent Control Valve (CV-201) shall modulate based on the flow from FIT-201 to match an operator set flow rate [1500 gpm]. A local switch (HS-201) located at the valve actuator shall allow for manual operation of the valve.

e. Area 3 and Area 4: The MBBR System (Area 3) shall have two modes of operation, Series Mode and Parallel Mode. The operator shall use manual valving to switch between operating modes. In Series Mode the south basin will be used as the first basin in series, depending manual valve positions. Additionally, the operator shall manually throttle air valves to the second basin in series as necessary to achieve desired operation.

- 1) Normal MBBR Operation: The control function of the MBBR basin and blowers shall be the same regardless of which mode of operation is being used.
- 2) Aeration System Blowers for MBBR System: The treatment facility is equipped with three blowers located in the Blower Building. The blowers will provide air for the MBBR System. Each of the blowers is equipped with an integral variable frequency drive (VFD-401, VFD-402, VFD-403).

- a) The control for each blower shall include Manual-Off-Auto control at the integral VFD (HS-401, HS-402, HS-403). The Auto position shall be used to permit control of the operating speed of the blowers to maintain an operator selected DO concentration in the MBBR basins [2.0 mg/L]. Blowers shall operate based on the lower DO concentration of the two basin (AE-301 or AE-302). The Aeration Blowers shall provide a minimum airflow of [220 SCFM] at all times to maintain media suspension in the MBBR basins.
- b) One blower (“LEAD”) will be used to meet oxygen demands in the aeration system during most air demand scenarios. The “LEAD” blower will be used to constantly provide air to the aeration basins. When conditions exist that require a second blower to start, this blower will act as the “LAG” blower in the system. The third blower shall serve as a “STANDBY” blower. Under no control scenario shall all three blowers operate.
- c) If the “LEAD” or “LAG” blower fails to start when called for, an alarm condition shall be generated and annunciated on the SCADA system.
- d) Blower Effluent Header Pressure Transmitter: The header pressure is monitored by a pressure transmitter (PIT-401). Pressure shall be displayed on the operator interface screens to provide process operating data. The anticipated pressure in the discharge pipe is between 0 and 10 psi.
- e) A blower alternating sequence shall be programmed into RTU-2 for blower operation. The blowers shall be alternated so that upon operating for [7 days], the “LEAD” blower’ will be called to shutdown (“STANDBY”) and the “LAG” blower will become the “LEAD” blower and the “STANDBY” blower shall become the “LAG” blower. The alternating sequence shall be used to help balance the number of run hours between the blowers. The speed of the blowers while running shall be controlled by RTU-2. The VFDs installed in the blowers will be used to speed up and slow down the blowers to maximize sustainable operation of the blowers and ensure the flowrate of air being provided during the transition of the blowers remains constant.
- f) When the “LEAD” and “LAG” blower are operating together in the AUTO mode, the speed of both blowers shall be adjusted in parallel so that both blowers are providing similar contributions of air flow.

- g) Under no conditions shall the blowers be allowed to operate outside of an operator selected range. The blower speed shall not be allowed to drop below the low speed setpoint [50% Speed] and not above the high speed setpoint [100% Speed].
 - h) The control logic in RTU-2 shall include alarms in the event of a low discharge pressure (PIT-401) [7.0 psi] or a high discharge pressure (PIT-401) [11 psi] in the blower discharge header piping.
- 3) High Level Floats: Each MBBR basin shall be equipped with a high-level float (FLS-301 and FLS-302) which shall be triggered when the level in the basin rises above the trip elevation of the switch [5119.5 FT / 2 FT below the top of the basin wall]. Float trip elevations shall be manually adjustable.
 - 4) pH Analyzer: A pH analyzer (AE-303) installed in the MBBR effluent shall monitor the pH of the process and report the value back to RTU-2 for trending and monitoring.
 - 5) Ammonia Analyzer: An ammonia analyzer (AE-304) installed in the MBBR effluent shall monitor the ammonia concentration of the process and report the value back to RTU-2 for trending and monitoring.
 - 6) DO/Temp Probe: A combination DO/temperature probe shall be installed at both the north (AE-301) and south (AE-302) MBBR basins. The probes shall monitor the DO and temperature of the process and report the value back to RTU-2 for trending and monitoring.
 - 7) Blower Building Temperature Transmitters: The blower building shall be furnished with temperature transmitters (TT-401) where shown on the Plan Sheets. Low temperature [40 OF] and high temperature [90 OF] events shall generate alarm conditions and shall be annunciated when temperature drops below or rises above an operator selected setpoint.

2.5 MONITORING AND CONTROL SYSTEM HARDWARE AND MATERIALS

- A. General: The monitoring and control system work under this Contract shall consist of the following major items:
 - 1. Control System Integrator shall furnish and install new RTU;
 - 2. Integrate the I/O addresses for the HMI system to include all the new input/output signals;
 - 3. Provide system to include automatic and manual capabilities to monitor and control the processes.

- B. The control panel shall also contain the power supplies necessary to power the field transmitters requiring 12 VDC and 24 VDC power. Terminals shall be supplied for all input signals, in addition to the signals necessary to support the control system, and a connection to the communications network. Electrical circuits for instrumentation shall be separate from the electrical circuit for the process control system even if they are located within the same process control panel.
- C. Control switches and push buttons shall be furnished and installed to provide the functions necessary to provide a fully functioning RTU. All switches and pushbuttons shall be labeled with appropriate nameplates. Switches and pushbuttons shall be suitable for installation in a high humidity and corrosive environment.
- D. The new panel(s) shall be completely factory or shop wired. New panel(s) shall be placed where shown on the Plans. Final location shall be coordinated with Engineer and Owner. Main groups of wire shall be routed in plastic nonflammable wiring duct. Smaller groups of wires shall be secured with nylon cable clamps and ties or plastic spiral wraps. Terminal blocks shall be used for all external wiring connections. Field wiring to terminal strips shall be routed through non-flammable wiring duct.
- E. Equipment connections shall be made with screw-type connections torqued to the manufacturer's recommended tightness except where devices specified are available only with solder-type terminals. Connections shall be made as recommended by the manufacturer.
- F. The complete installation shall be done such that all relays, control devices, and panel instruments are completely accessible without major dismantling of panel equipment.
- G. Relays, timers, and other control panel mounted control devices shall be plug-in design for convenient maintenance. All relays and timers for similar use shall be identical and interchangeable.
- H. Condensation protection and panel ventilation: Provide a properly sized heating and ventilation system for the panel, as required, to provide the proper operating environment for panel components and prevent condensation build-up. A freeze protection shall also be provided at those outdoor locations containing hydraulics or sensitive electronic equipment subject to freezing conditions. System shall include a 120 VAC fan-driven condensation heater system, ventilation fan(s), and thermo-switch. System shall have an adjustable thermostat control and heater shall be Hoffman or equal (Minimum 200 watt).
- I. Enclosures: The controls furnished and installed under this Contract shall be backplane mounted in the control panel enclosures. The new process control panel front may include the following; operator interface (size as indicated on the plans), an intrusion horn, indication lights, keypad, and switches as required to facilitate the control sequences specified herein. PLCs, OI, and backplane equipment shall be installed. See plans for panel front device layout.
 - 1. Enclosures shall be corrosion resistant NEMA Type 4X Stainless Steel for outdoor locations and NEMA Type 4 painted carbon for indoor locations. The panels shall be

fabricated with front access doors. Each door shall be equipped with a three-point latching mechanism and non-locking handle. Doors shall be constructed of 14-gauge structural steel (minimum) with a baked enamel finish in the manufacturer's standard color. Rear access to the panel is not available. A chrome trim strip shall be provided to cover any shipping splits.

2. Serialized UL Label Requirement (508A)
 - a. Panels provided under this section shall be constructed in compliance with Underwriter's Laboratories Inc 508A - Standard for Industrial Control panels. The control panel(s) shall bear the label/ marking of an OSHA-approved Nationally Recognized Testing Laboratory (NRTL) as an Industrial Control Panel.
 - b. While the use of NRTL- listed components is encouraged, their use alone will not be considered an acceptable or satisfactory alternative to the Industrial Control Panel label specified above. Upon request from the Engineer, the panel manufacturer shall supply documentation to the Owner proving they are a NRTL-certified manufacturing facility for the type of equipment required recognized manufacturing facility for the type of equipment required. Only the assemblies that have been labeled by an NRTL- certified industrial control panel manufacturer shall be considered acceptable for use on this project.
 - c. Control panel enclosure shall be a NRTL-listed panel as manufactured by Hoffman Engineering Company, EQUIPTO Enclosures, Rittal North America, Saginaw Control & Engineering (SCE), Wiegmann Enclosures, Hammond Enclosures, or an Owner approved equal.
3. All interior and exterior surfaces shall be sandblasted prior to painting. Interior and exterior surfaces shall be primed with lacquer metal primer 3/4 to 1 mil dry. Interior finish coat shall be white low-gloss industrial lacquer 1 mil dry with a smooth texture. Exterior finish coat shall be low-gloss industrial lacquer 1 mil dry of a color to be selected by the Owner.
4. Arc Flash: An "Arc Flash" warning sticker shall be applied to the control panel in accordance with SDSTA Arc Flash requirements as listed in Section 26 0553 and 26 0573.
5. Interior brackets, hinged equipment racks, and mounting pans shall be provided for mounting panel equipment. Temporary equipment bracing shall be provided to allow the panel sections to be turned on their side for moving into the control room.
6. Nameplates and Signs: Nameplates and signs shall be engraved as shown on the Plans. Nameplates for the control panel front shall be made of a phenolic laminate with satin black surface and white core. Engraving shall be done in a manner which exposes the white core. The edges of nameplates shall be beveled to expose the color of the core. The nameplates shall be 0.040 inch thick.

- a. Lettering on nameplates shall be a minimum of 3/8" in height for capital letters. Engraving schedules shall be approved by the Engineer prior to engraving the nameplates.
- b. Nameplates shall be attached to the panel by adhesive and a mechanical fastener. Screws or rivets shall be brass, stainless steel, or chromium plated steel.

J. Control and Wiring Devices and Appurtenances:

1. Conductors: All conductors shall be identified at both ends with wire tags. Wire ferrules shall be used.
2. Terminal Blocks: Terminal blocks for all external connections shall be rated at 600 VAC. Terminal blocks for internal panel connections of AWG No. 14 conductor and smaller shall be rated at 300 VAC. White terminal marking strips indicating point identification and diode or capacitor polarity shall be installed on each terminal block. Terminal blocks shall include disconnect switch terminal block sections suitable for interrupting control voltages where a control voltage source enters the enclosure from a remote location.
3. Fused Terminal Blocks: Fused terminal blocks shall be used for all analog input and output signals. The fused terminal blocks shall be provided with an indicator light. Fused terminal blocks shall be Allen Bradley 1492-H5 or Owner approved equal.
4. Receptacles: A duplex receptacle shall be mounted inside the panels. Duplex receptacles shall be of the 20 ampere, 125 VAC, 2 pole, 3 wire, grounding type complete with box. The receptacle shall have integral GFCI protection.
5. Interior Illumination: Interior illumination shall be installed inside the control panel with a door switch that will turn the light on when the enclosure door is opened. Control panel interior lighting fixtures shall be complete with ballast, wiring, and LED lamps. Fixtures shall be controlled by a switch mounted inside the panel.
6. All wiring shall be in complete conformance with the National Electric Code, state, local and NEMA electrical standards. All incoming and outgoing wires shall be connected to numbered terminal blocks and all wiring neatly tied and fastened to chassis as required. For ease of servicing and maintenance, all wiring shall be color coded and uniquely numbered. The wire color code and number shall be clearly shown on the drawings, with each wire's color and number indicated.

- K. Circuit Breaker Protection: Circuit breakers shall be quick-make, quick-break, thermal-magnetic, trip-indicating and have a common trip on all multiple breakers. Provisions for additional breakers shall be such that field addition of connectors or mounting hardware will not be required to add breakers to the panelboards. All instrumentation systems, annunciator panels, lighting circuits, or similar major devices requiring 120 VAC power shall have an individual circuit breaker. Circuit breaker trip ratings shall be as recommended by the

manufacturer of the equipment being protected. Each control panel shall have space provided for a minimum of two additional circuit breakers. Control circuits including flow pacing signals shall be independent and independently-fused so that a circuit problem with one does not interrupt operation of others.

- L. Power Supplies: Constant voltage transformers shall be used to supply power to all equipment requiring a constant voltage supply, which does not have self-contained voltage regulation equipment. AC and DC power supplies shall be furnished for control circuits and indicating lights where not supplied from power supplies furnished as a part of major equipment items.
 - 1. Constant Voltage Transformers: Constant voltage transformers shall be rated as follows:
 - a. Input Voltage: 95-125 VAC.
 - b. Output Voltage: 115 VAC.
 - c. Regulation: +/- 1 percent.
 - d. Size: As Required.
 - e. Constant voltage transformers shall be equipped with surge protection to protect control circuits from voltage spikes.
 - f. Constant voltage transformers shall be as manufactured by Allen Bradley, General Electric, Square D, Sola Electric Company, or an Owner approved equal.
 - 2. AC Power Supplies: AC power supplies shall be rated as follows:
 - a. Primary Voltage: 120 VAC.
 - b. Secondary Voltage: 24 VAC.
 - c. Size: As required.
 - d. AC power supplies shall be as manufactured by General Electric, Square D, Allen Bradley, SOLA Electric Company, or an Owner approved equal.
 - 3. DC Power Supplies: DC power supplies shall be rated as follows:
 - a. Input Voltage: 105-125 VAC.
 - b. Output Voltage: 12-32 VDC adjustable.
 - c. Line Regulation: 50 mV for +/- 10V Line Change.
 - d. Load Regulation: 100 mV for Full Load Current Change.
 - e. Ripple: 35 mV RMS.

- f. Transient Response Time: From 5 to 50 ms; Typical Overshoot between 0.5 and 1.15 volts.
 - g. DC power supplies shall be as manufactured by Allen Bradley, Square D, General Electric, SOLA Electric Company, or an Owner approved equal.
 - 4. Uninterruptible Power Supplies: Uninterruptible power supplies shall be furnished and installed in each new and refurbished PLC enclosure. Provide on-line UPS that will continue to operate flawlessly in the event of a power failure and when the standby generator comes online. UPS shall provide 20 minutes of operation without utility power. UPS shall be manufactured by Eaton, Powerwave, APC or Owner approved equal.
- M. Control Relays: Control relays shall be plug in relays. Relay contacts on 110 VAC circuits shall be rated for 300 VAC and up to 10 amps of load. Coil voltage and contact configuration shall be as required to implement the control and instrumentation loops indicated.
 - 1. Control relays shall be General Electric, Allen Bradley, Square D, IDEC RH series, Potter Brumfield, or an Owner approved equal.
- N. Timing Relays: In general, timer control functions may be provided in the control logic furnished for the type which begins the time delay upon energizing the coil and reset automatically when de-energized. The timing relays shall contain contacts of the voltage and current ratings required to implement the control functions indicated.
 - 1. Timing relays for periods greater than 200 seconds shall utilize solid state electronics. Timers shall have 11 pin base which matches other timers used. Timers shall be ATC 328 Series or an Owner approved equal.
 - 2. Timing relays for periods of 200 seconds and less shall be solid state with adjustable timing ranges of 10-180 seconds, suitable for interior panel mounting. Timers shall have an 11 pin base which matches the other timers used.
 - 3. Timers shall be as manufactured by Allen Bradley, General Electric, Square D, AGASTAT Series 7000, IDEC RTY series, or an Owner approved equal.
- O. Switches and Pushbutton Controls: Sequence selector switches shall be multiple deck, rotary-type detent switches with silver finish phosphor-bronze moveable wiping contacts. The number of decks shall be as required to implement the switching action indicated on the Drawings and/or in the functional description of the controls.
 - 1. Manual-Auto selector switches shall be heavy-duty, oil-tight type switches with maintained contacts.
 - 2. Pushbutton switches shall be heavy-duty, oil-tight switches with momentary contacts.
 - 3. Acceptable Manufacturers:

- a. General Electric Series CR2940,
 - b. Allen Bradley
 - c. Square D
 - d. Owner approved equal
- P. Fuse Holders: Fuse holders for AC and DC instrument systems shall be Buss Snap-Lock Type HLD fuse holders or an Owner approved equal.
1. Each power supply, process instrument, and motor control circuit operating within the panel shall be individually-fused using terminal block fuse connectors installed per the manufacturer's recommendations.
 2. Provide spare fuses for each AC and DC circuit. Spare fuses shall be stored in a spare fuse cabinet located inside the panel enclosure near the fuse holder mounting brackets.
- Q. Process Controllers: The process control and monitoring functions shall be provided by a programmable logic controller. The PLCs shall be used for the process monitoring and control at the locations shown on Plan Sheets. The programmable control system may be used for driving:
1. Control loops
 2. Sequential controls
 3. Status and alarm lights and horns
 4. Digital displays of analog signals
 5. Non-resetting flow totalizer
- a. Manual control for the equipment shall be independent of the programmable control system and wired so that a failure of the programmable control system will not limit the ability of the Operator to control the process.
 - b. Programmable Logic Controllers (PLCs): The PLCs furnished shall be designed for ladder logic control sequence programming using an open architecture software system. The PLCs shall be equipped with input/output boards and terminal strips necessary for the control functions specified. The PLCs shall be the Allen-Bradley CompactLogix Series or Owner approved equal. The number of inputs and outputs shall be determined by the Control System Integrator and will be governed by the control functions required and the configuration of signals within the panel. The system shall be configured with spares of each type of input and output as shown on the plans. All spare I/O shall be wired to terminal blocks located within the enclosure.

- 1) The PLC's shall be rack mounted within the control panel. The controller and I/O boards shall include LED's for status indication and diagnostics. The PLC shall include multiple communication ports. One port shall be for communication with the input/output racks for the master control panel, one port shall be provided for connection of a personal computer system interface, and one port shall be provided for connection of the operator interface.
 - 2) Control loops for the various processes shall be configurable from both a PLC program loading device and a personal computer. The control loop parameters shall be defined by preprogrammed control function blocks of a field proven design demonstrated to have been used successfully on systems of equal or greater complexity. Entry of configuration data for control blocks shall be through operator interface screens similar to spreadsheets and shall use descriptive text.
 - 3) System input/output (I/O) capacity for the control addition shall be provided for the inputs and outputs listed in the plans plus spares of each type as shown on the plans. The (I/O) system shall be constructed using rack mounted modular I/O cards. Rack capacity furnished shall be greater than that required for the number of cards furnished, including spares. The rack capacity shall permit the addition of at least two (2) more cards of the types used in the system. System software shall permit an unlimited number of tags for system input signals
- R. Software: Work under this contract shall include provisions to upgrade existing software to operate the control system. The following is general description of the software available/needed to completely integrate the control system
1. Rockwell FactoryTalk View Site Edition or approved equal: Control System Integrator shall provide one (1) copy of Rockwell FactoryTalk View Site Edition for the developing and testing machine level HMI applications. This software shall be installed on the main personal computer used for the control system.
- S. Operator Interface: Provide 10-inch NEMA 4 front panel mounted touch screen. OIT shall be Allen Bradley PanelView Plus or approved equal.
- T. With the exception of ethernet cables and conduits shown on the Plans, networking components shall be the responsibility fo the Owner. Control system integrator shall provide oversight and verification of the communications.

PART 3 EXECUTION

3.1 CONTROL SYSTEM

- A. General: In addition to the shop drawings and descriptive literature required by the General Requirements, the Control System Integrator shall provide complete system documentation necessary for installation, operation, and maintenance. The documentation shall be provided prior to shipment of hardware. The documentation shall include, but not necessarily be limited to, the following:
1. General description of equipment.
 2. Panel front dimensional drawings.
 3. Panel mounted equipment location map.
 4. Software licenses and documentation identifying the Owner as the holder of the software license. Licenses shall be developer's licenses which permit the Owner to make additions and modifications to the system.
 5. Wiring diagrams for panels and telemetry system.
 - a. Control system documentation listing the control system address for each and every analog and contact closure input and output in the system. Documentation must include an English language descriptor for each input and output and the scale for the analog inputs and outputs.
 - b. Control schematics including field wiring requirements and identification of terminal numbers for both the control panels and the field terminations.
 6. Listing and description of routine maintenance, requirements, and equipment necessary to perform required maintenance. (Include in O&M Manual only).
 7. Specifications and descriptions of panel mounted hardware including lights, switches, annunciators, controllers, displays, and power supplies, etc.
 8. List of spare parts provided.
 9. System Test: Control panels shall be tested prior to delivery to the site. Testing procedures shall be developed by the equipment supplier and approved by the Engineer. Testing shall be open to observation by the Owner and Engineer upon request. The testing shall include, but not necessarily be limited to, the following:
 - a. 48-hour "burn-in" of all panel mounted hardware with no failures.
 - b. Testing of all analog and digital inputs using a signal generator.
 - c. Testing of analog and digital outputs using indicating devices to show output.

- d. Testing of controllers: input, output, operator interface, and accuracy of control loop.
- 10. Installation and Startup: Control panels shall be installed under the direction of the Control System Integrator. Installation shall include, but not necessarily be limited to, setting equipment in place and connection of power and signal wiring. Power wiring shall consist of connecting 120 VAC circuits from distribution panels supplied by the Electrical Sub-Contractor. Connections shall be made to screw-type terminals. The Control System Integrator shall provide terminal to terminal interconnection drawings for all terminations between motor control cabinets and local control panels. The Electrical Sub-Contractor will install wiring between the process control panels and motor control centers and shall make wiring terminations in the motor control cabinets. The Control System Integrator will supervise and approve terminations in the process control and monitoring panels.
- 11. Equipment shall be delivered to the site in undamaged condition. Equipment shall be stored above ground and protected from the weather. Equipment shall be installed in strict accordance with manufacturer's recommendations, the Plans, and Specifications. The Control System Integrator shall supply all materials, labor, and appurtenances to provide a functional Process Instrumentation.
- 12. The control panels shall be installed at the locations shown on the Drawings or as directed by the owner. All panels shall be set plumb and level. After all field connections have been completed, close all openings to prevent debris from entering the panels. Seal all conduits with duct seal. Field connections of power and control wiring shall be made through terminal blocks.
- 13. The Control System Integrator shall provide at least one (1) day system start-up assistance by a team of factory-based engineering and programming personnel after installation and wiring is complete. During this start-up period, the personnel are to thoroughly check all equipment and repeat the factory acceptance test specified earlier.
- 14. Operational Training: Operator training for operation and maintenance of the process control panels shall be provided. The training shall include all instruction necessary to provide operating personnel the ability to perform all control functions, routine periodic maintenance, and light emergency maintenance on the system.
- 15. Operator training for operation, maintenance, and troubleshooting shall be provided. The training shall be conducted at the job site. At least two (2) individuals representing the Owner shall receive the training. The training sessions shall be a minimum of one (1) eight-hour day and shall include "hands-on" training on the system furnished under this Contract. The Owner reserves the right to record the training sessions for future reference.
- 16. The Control System Integrator shall provide:

- a. Programmable Logic Controller and RTU system documentation shall include three (3) copies of descriptions for all loops and the operator's manual describing procedures for routine adjustments to process control and communications loops. Description of control loops shall be copies of printout of the ladder logic diagram used for control with explanatory annotation.
 - b. Two (2) printed copies of the entire documentation package shall be provided along with one (1) electronic copy. One of the hard copies shall be provided for use by the Operator. This copy shall be in loose leaf form bound in ring binders to facilitate modifications and additions. The manual shall detail steps required for operator interface with the process control system.
17. After successful completion of the control and telemetry system, but prior to final acceptance of the work, the Control System Integrator must submit to Owner and Engineer complete documentation of the ladder logic for each PLC in the system. Control System Integrator is to submit two (2) printed copies and two (2) electronic copies of program files (of the PLC software) prior to final completion.

3.2 SYSTEMS ACCEPTANCE

- A. System acceptance shall be defined as that point in time when the complete system has passed the mutually defined field acceptance test and has performed as a functioning unit for 30 consecutive days without the loss of process control functions or process management functions. Loss of process control functions shall be defined as follows:
 1. Loss of a process loop controller. Loss of the alarm annunciator subsystem.
 2. Loss of process variable display and recording functions.
 3. Loss of communication with SCADA system without automatic restart.
 4. One (1) year warranty on the equipment begins upon successful completion of the field acceptance test.

3.3 INSTALLATION OF INSTRUMENTATION CONDUIT AND CABLES

- A. Furnishing and installation of all conduits needed for instrumentation and control signals or any other instrumentation or control conduit shall be the responsibility of the Electrical Sub-Contractor. Furnishing and installation of the instrumentation or control wiring shown on the Plans shall be the responsibility of the General Contractor. General Contractor shall coordinate sub-contractors, including but not limited to the Electrical Sub-Contractor and Control System Integrator, to provide a fully-functional control system. Control System Integrator shall supervise and authorize wiring connections in the process control and monitoring panels.
- B. Wire ferrules shall be used for connections.
- C. Use bottom entry for all conduit entry to instruments and junction boxes.

- D. Install electrical components per Division 26.
- E. Panel-Mounted Instruments:
 - 1. Mount and wire so removal or replacement may be accomplished without interruption of service to adjacent devices.
 - 2. Locate all devices mounted inside enclosures so terminals and adjustment devices are readily accessible without use of special tools and with terminal markings clearly visible.

3.4 FIELD QUALITY CONTROL

- A. Maintain accurate daily log of all startup activities, calibration functions, and final setpoint adjustments.
 - 1. Documentation requirements include the utilization of the forms located at the end of this section.
 - a. Loop Checkout Sheet
 - b. Instrument Certification Sheet
 - c. Final Control Element Certification Sheet
- B. Instrumentation Calibration:
 - 1. Verify that all instruments and control devices are calibrated to provide the performance required by the Contract Documents.
 - 2. Calibrate all field-mounted instruments, other than local pressure and temperature gauges, after the device is mounted in place to assure proper installed operation.
 - 3. Calibrate in accordance with the manufacturer's specifications.
 - 4. Bench calibrate pressure and temperature gauges. Field mount gauge within 1 day of calibration.
 - 5. Check the calibration of each transmitter and gauge across its specified range at 0, 25, 50, 75, and 100 percent. Check for both increasing and decreasing input signals to detect hysteresis.
 - 6. Replace any instrument which cannot be properly adjusted.
 - 7. Stroke control valves to verify control action, positioner settings, and solenoid functions.
 - 8. Mark range, date, setpoint and calibrator's initials on each instrument by means of blue or black ink on a waterproof tag affixed to the instrument.

9. Calibration equipment shall be certified by an independent agency with traceability to NIST. Certification shall be up-to-date. Use of equipment with expired certifications shall not be permitted.
 10. Calibration equipment shall be at least three times more accurate as the device being calibrated.
- C. Loop checkout requirements are as follows:
1. Check control signal generation, transmission, reception, and response for all control loops under simulated operating conditions by imposing a signal on the loop at the instrument connections. Use actual signals where available. Closely observe controllers, recorders, alarm and trip units, remote setpoints, radio systems, and other control components. Make corrections as required. Following any corrections, retest the loop as before.
 2. Stroke all control valves, cylinders, drives, and connecting linkages from the control room operator interface.
 3. Check all interlocks to the maximum extent possible.
 4. In addition to any other as-recorded documents, record all setpoint and calibration changes on all affected Contract Documents and turn over to the Owner.
- D. Provide verification of system assembly, power, ground, and I/O tests.
- E. Verify existence and measure adequacy of all grounds required for instrumentation and controls.

3.5 GRAPHICS DISPLAY OF HMI AND GUI

- A. The SCADA system requires development of graphical screens using a development software package. This specification details the guidelines for the development of state-of-the-art graphical screens. The graphics builder shall be interactive and menu-driven, requiring no programming.
- B. The software shall have the ability to directly import graphics and text in the following file formats: Autocad DXF, Windows BMP, Windows Meta File WMF, GIF, TIF, PCX, TXT, DIB, and RLE.
- C. The graphics builder shall be an ActiveX container allowing ActiveX objects to be inserted and edited in a visually interactive manner. It shall be possible to connect ActiveX properties to tags, allowing read/write between properties and tags without the need for scripts or code. ActiveX objects must have the same security as native graphics objects allowing ActiveX objects to be visible or hidden based on the privilege level of an operator.

- D. The graphics builder shall be capable of creating screens composed of both static and dynamic objects. To create these objects, the software shall provide sample screens and a set of standard shapes in a library. The developer shall be able to include these symbols by reference or create new symbols/objects.
- E. The graphics builder shall provide the following tools:
 - 1. Grid and guidelines (which can be displayed on screen) together with snap to grid and snap to guidelines to assist in aligning objects precisely.
 - 2. Horizontal and vertical alignment together with even spacing.
 - 3. Send to front/back. Bring forward one layer. Send backward one layer.
 - 4. Bitmap editing including pixel drawing, image resizing, and image cropping.
 - 5. Color swap from one color to another for a group of selected objects including colors within a bitmap. Color swap shall also include swapping a range of colors such as all reds to all greens so that shaded objects can be color changed without redrawing or re-rendering.
 - 6. Editing of nodes on polylines that provides the addition or removal of nodes plus movement of nodes.
- F. The graphics builder shall support an unlimited "undo" and "redo" feature.
- G. Graphic Screen Standards: It is the intent of these specifications to provide the Owner with state-of-the-art SCADA functionality. The following standards for SCADA graphical displays are intended to establish expectations for quality and performance functionality for all graphical screen development. The SCADA supplier is responsible for coordinating with the Engineer and the Operator to define screen requirements and develop graphical screens to these standards as a minimum.
 - 1. Graphic screens developed for this project are required to depict the actual process equipment configuration as accurately as possible.
 - 2. Graphic screens are required to incorporate 3D images accurately depicting pumps, tanks, piping, and process equipment representative of being controlled and/or monitored by the SCADA Software. The graphics for Out-Plant Systems graphics shall be simulated on a simple 2D background.
 - 3. All screen development will be based on P&ID of the process and/or the mechanical drawings of the processes.
 - 4. All overview and site-specific screens will incorporate a “navigational header bar” similar in function and appearance to Microsoft Internet Explorer. The intention of this specification is to provide a familiar, user-friendly navigation throughout the SCADA

graphical displays and shall be similar to, but not limited to, the sample screens as shown below:

5. Graphic Screens shall be developed with existing plant SCADA system in mind. Screens do not need to be identical to existing screens, but shall be is consistent in function and usability to the existing system(s).
6. Standard Alarm Screen functionality will be provided to ensure flexibility and quick access to live alarms, alarm history, and alarm grouping parameters. The following features and functionality will be included as a minimum:
 - a. An Alarm Screen header bar will head all alarm pages and reside below the Navigation Bar.
 - b. Buttons will be provided to dynamically switch between Alarm Summary and Alarm History.
 - c. A menu will be provided to allow user to select and open historical alarm archives. A time-date stamp file structure shall be used.
 - d. A pull-down menu bar will be provided to select operator configured alarm groups.
 - e. A user selectable field will allow both sorting of alarms by priority and the ability to define priority for all system alarms.
7. Standard Trending Screen functionality will be provided to ensure flexibility and easy access to real time and historical trend information for any variable TAG defined within the SCADA application. The following features and functionality will be provided as a minimum:
 - a. The Trending Screen will allow the user to define trend scenarios. A button will be provided to open a dialog window to select multiple variable TAGS and save them as a trend scenario for future use.
 - b. A pull-down menu will be provided to allow the user to open saved trend scenarios.
 - c. A button will be provided to allow the user to select real-time or historical trends.
 - d. A button will be provided for to save displayed trend info to a file in CSV data format for export to external software applications (such as Microsoft Excel).
 - e. A Print Trend button will be provided to allow user to print current trend. The print format will be a full page in landscape and include only the trend graph and axis scaling (print screen dumps are not acceptable).
8. Dragging the mouse over designated process areas in the above overview allows the operator to select predetermined processes or equipment and drill down to site-specific

detail screens.

9. Critical “overview” information such as tank levels, flows, and pressures will be indicated through data fields or animation effects such as level fills or color change.
 10. All monitored and or controlled process equipment will be animated or color-highlighted to indicate status changes. For example, a pump “running” condition will be signified by the pump color changing to bright green. A pump “required” condition will turn the pump graphic to turn bright yellow and flashing red will indicate a pump “fail” condition.
 11. Tank and vessel levels will be indicated with a tabular data field and by graphic “fill” simulating a rising or falling level within the tank or vessel.
 12. The ability to “drill down” to detail screens or graphics will be provided for designated process control equipment. Clicking on a device or process area will generate a detail graphic or pop-up window to access specific data or control functions. For example, clicking on Pump No. 1 would pull up a detail graphic for that individual equipment.
 13. Pop-up screens will be provided for device control and or status monitoring. For example, clicking on a pump graphic will open a Hand-Off-Auto control allow access to change control setpoints or view detail status or maintenance information.
- H. Graphic Display Submittals: The SCADA supplier shall coordinate a meeting with the Engineer and the Operator to define general display configuration, navigation, and functionality. The SCADA supplier shall submit sample graphics to the Engineer for final approval.

END OF SECTION 40 6900

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**SECTION 40 7000
– INSTRUMENTATION**

PART 1 GENERAL

1.1 DESCRIPTION

- A. This Work shall consist of furnishing and installing all material to provide a complete and workable process instrumentation system for the Sanford Underground Research Facility Improvements. This section includes specifications for the process instrumentation and associated materials and equipment. This section also defines responsibilities and requirements for coordination of the Work, shop drawing submittals, operator training, system checkout, spare parts, and warranty.

1.2 CONDITIONS AND SYSTEMS RESPONSIBILITY

- A. Instrumentation installation is the responsibility of the General Contractor. Final Terminations points within the RTU Panel will be shown by the Control System Integrator and handled by the electrical sub-contractor.
- B. The instrumentation equipment supplier shall be responsible for operator training, system checkout, and repair during the warranty period, and documentation, including submittal drawings and installation operation and maintenance manuals.

1.3 RELATED WORK SPECIFIED ELSEWHERE

- A. The following items of related work are specified and included in other sections of these Specifications:
 - 1. Division 1 For Submittal Requirements
 - 2. Division 40 Section “Integrator Coordination,” for coordination requirements between Control System Integrator, suppliers, and electricians to create a fully functioning control system.
 - 3. Division 40 Section “Process Integration,” for software and telemetry integration and controls requirements.
- B. The materials specifications for wire, appurtenances, and equipment apply to the materials required for the control system. The Control System Integrator shall coordinate control and monitoring system wiring requirements.

1.4 PRIOR APPROVAL

- A. The following items of materials and/or equipment must receive approval prior to bidding if it is intended to furnish products other than those specifically named in the Specifications.
 - 1. Pressure Transmitters

2. Pressure Gauges
 3. Float Level Switches
 4. Temperature Transmitters
 5. Dissolved Oxygen Sensors
 6. pH Analyzers
 7. Ammonia Analyzers
- B. The requirements for obtaining such approval are specified herein and in the Division 1.
- C. Contractors must submit to the Engineer within seven (7) calendar days before the scheduled bid opening date design information, including drawings they wish to have considered as an approved alternate. The design pre-submittal shall be complete and shall include as a minimum the following:
1. Drawings, specifications, and product literature with adequate detail to determine that the proposal will meet the requirements of the plans and specifications.
 2. A list of installations of similar type presently in service.
 3. A complete listing of changes that will be required in the contract plans and specifications to accommodate the alternate equipment.
- D. Alternate bidders shall state in writing that the equipment offered will provide comparable or superior features, performance quality, and materials of construction as the equipment specified. Prior approval of the alternate equipment shall not constitute final approval of specific equipment, but rather constitutes only approval of the respective equipment manufacturers to provide price quotations based on equipment meeting the specifications. Alternate equipment manufacturers shall modify their standard products as necessary to meet all provisions of the specifications without exception.
- E. The cost of any changes incidental to installation of the alternate equipment such as electrical wiring, relocation of piping, engineering supervision, as-built drawings, etc. shall be borne by the Contractor with no additional expense to the Owner.
- F. If after installation the alternate equipment does not perform in accordance with the specifications or other deficiencies are noted, the Owner will require the modification or replacement of such equipment to meet the specifications at no additional expense.

1.5 SHOP DRAWINGS AND BIDDING REQUIREMENTS

- A. Submit copies of shop drawings in accordance with Division 1 for all hardware items and software products listed under “Products”. Shop drawings shall include all catalog cuts, descriptive data, and drawings for the entire control system. If catalog cuts are furnished, the

specific model number, color, and all requirements shall be indicated on each copy of the shop drawings.

- B. Submit copies of the proposed instrumentation, including a listing of additional hardware required, software required, and implementation requirements.
- C. Submit instrumentation documentation as described in paragraphs 3.1 of this Specification.
- D. Submittals shall be prepared from original printed material or clear unblemished photocopies of original printed material. Facsimile information is not acceptable.
- E. Product technical data including:
 - 1. Acknowledgement that products submitted meet requirements of standards referenced
 - 2. Equipment catalog cut sheets
 - 3. Instrument data sheets:
 - a. ISA S20 or Owner approved equal
 - b. Separate data sheet for each instrument
 - 4. Materials of construction
 - 5. Minimum and maximum flow ranges
 - 6. Pressure loss curves
 - 7. Physical limits of components including temperature and pressure limits
 - 8. Size and weight
 - 9. Electrical power requirements and wiring diagrams
 - 10. NEMA rating of housing
 - 11. Submittals shall be marked with arrows to show exact features to be provided.
- F. Process connected instrument installation details containing the following minimum information:
 - 1. Bill of materials providing as a minimum the following information:
 - a. Tube material and size
 - b. Connection size
 - c. Fitting size, material, and rating

- d. Valve type and material
 - e. Instrument description
 - f. Pipe stand size and material
- 2. Tube slope requirements
- 3. Required elevations and dimensions
- G. Electrical schematic control diagrams. Diagrams shall include:
 - 1. Terminal identification
 - 2. Unique identification of all control devices and contacts
 - a. Utilize Owner's device identification numbers where applicable
 - 3. Wire identification
 - 4. Equipment identification
 - 5. Indication of remote and local devices and wiring
 - 6. Overcurrent protection indication
 - 7. Voltage
 - 8. All control logic
- H. Certifications:
 - 1. Documentation verifying that calibration equipment is certified with NIST traceability.
 - 2. Approvals from independent testing laboratories or approval agencies, such as UL, FM, or CSA. Certification documentation is required for all equipment for which the specifications require independent agency approval.
- I. Warranties: Provide copies of warranties and list of factory authorized service agents.

PART 2 PRODUCTS

2.1 PRODUCTS

- A. Pressure Transmitter: Furnish and install pressure transmitter with external indication.
 - 1. General Requirement: Transmitter shall produce a 4-20 mA output proportional to a liquid pressure. Provide transmitter completely solid state and of modular design to facilitate field repair. Provide a 2-inch diameter with digital display that is visible from eye level while standing without removing an end cover. Transmitters with top view

displays are not approved.

2. Specification details:

- a. Output Signal: 4-20 mA DC
- b. Type: Strain Gauge and Diaphragm
- c. Pressure Element
 - 1) Type: Strain Gauge
 - 2) Diaphragm & Body Material: 316 SS
 - 3) Connection Size and Rating : 1/2" NPT
- d. Transmitter
 - 1) Mounting: Floor Stand with Corporation Stop
 - 2) Provide local display
 - 3) Power Supply: 24 VDC

3. Approved Manufacturers: Pressure transmitters shall be Model IGP20 as manufactured by Foxboro, ABB 266DSH, Endress+Hauser, Rosemount, Siemens (SITRANS P320/420), or Owner approved equal.

4. Specific Application Requirements:

<u>Installation Identification</u>	<u>ID Code</u>	<u>Range</u>	<u>Size and Installation Notes</u>
Side Stream Holding Tank Level	PIT-101	0-10 FT (0-5 psi)	See Detail 5/Y-900
Pressure Filter Effluent Pressure (Existing)	PIT-201	Existing	Reinstall using existing assembly. Rewire as necessary.
Blower Effluent Header Pressure	PIT-401	0-20 psi	See Detail 3/Y-900

- B. Pressure Gauge: Liquid-filled pressure gauges with stainless steel ball valves for isolation shall be installed on the suction and discharge side of each pump and at locations as shown on the plans. Gauge tapping position is to be clear of equipment functions and movements and protected from maintenance and operation of equipment. Gauge face shall be so that gauge is readable from an accessible standing position.

1. General Materials Requirements: General requirements for pressure gauge are as follows:
 - a. Materials
 - 1) Bourdon tube, socket, and connecting tube: 316 Stainless Steel

- 2) Case: Phenolic
- 3) Diaphragm Seal Housing: 316 Stainless Steel
- 4) Filter Disc: 316 Stainless Steel
- 5) Housing: 316 Stainless Steel
- b. Accuracy: 1% of Full Range
- c. Accessories
 - 1) Provide diaphragm for fluid separation and provide appropriate pulsation dampening to extend gauge life.
 - 2) Provide stainless steel ball valves for isolation and other accessories as shown in Plans
- d. Enclosure shall be suitable for service at 250 Deg. F or maximum process temperature at which gauge is exposed.
- e. Unless otherwise required by codes, provide stem-mounted or flush-mounted, as required, with dial diameter as follows:
 - 1) Pipe sizes of 1-1/2 inch or less:
 - a) Dial Size: 3-1/2 inch
 - b) Gauge connection: 1/4 inch
 - 2) Pipe sizes larger than 1-1/2 inch
 - a) Dial Size: 4-1/2 inch
 - b) Gauge connection: 1/2 inch
2. Approved Manufacturers: Pressure gauge shall be manufactured by Ashcroft, Ametek, Siemens, NOSHOK (600/700 series), or Owner approved equal.
3. Specific Application Requirements:

<u>Installation Identification</u>	<u>ID Code</u>	<u>Range</u>	<u>Size and Installation Notes</u>
Side Stream Holding Tank Level	PI-101	0-10 FT (0-5 psi)	See Detail 5/Y-900
Pressure Filter Effluent Pressure (Existing)	PI-201	Existing	Reinstall using existing assembly.
Blower Effluent Header Pressure	PI-404	0-20 psi	See Detail 3/Y-900
Blower #1 Inlet Pressure	PI-401	0-10 psi	See Detail 4/Y-900
Blower #2 Inlet Pressure	PI-402	0-10 psi	See Detail 4/Y-900

<u>Installation Identification</u>	<u>ID Code</u>	<u>Range</u>	<u>Size and Installation Notes</u>
Blower #3 Inlet Pressure	PI-403	0-10 psi	See Detail 4/Y-900

- C. Float Level Switch: Furnish and install float level switches in each of the locations indicated on the plans.

1. General Requirements: General Contractor shall furnish and install float level switches in each of the locations indicated on the plans. Float switch shall be of rugged construction suitable for most corrosive liquids and suspended solids. A mechanical switch located in the plastic casing, freely suspended at the desired height from its own cable. When the liquid level reaches the regulator, the casing will tilt and the mechanical switch will close or break the circuit.
2. The float switch shall be constructed with a regulator casing that is made of a polypropylene and a cable sheathed with a special PVC compound. The plastic components shall be welded and screwed together. Adhesives shall never be used to secure plastic components. Provide cable hanger in location that shall allow easy removal of float switches for maintenance purposes.
3. Float switches shall be provided with approximately 50 feet of cable. Contractor to field verify length of cable. Cable shall be sealed using an epoxy adhesive.
4. Acceptable Manufacturers: Float level switches shall be ENM-10 Level regulator as manufactured by ITT Flygt or approved equal.
5. Specific Application Requirements:

<u>Installation Identification</u>	<u>ID Code</u>	<u>Size and Installation Notes</u>
North MBBR Basin High Level Alarm	FLS-301	Suitable for 0.95 – 1.10 g/cm ³ density
South MBBR Basin High Level Alarm	FLS-302	Suitable for 0.95 – 1.10 g/cm ³ density

- D. Temperature Transmitter (Room): Furnish and install loop powered temperature transmitters that generate a 4-20 mA signal proportional to the air temperature. Combined temperature and humidity sensors are acceptable.

1. General Requirements: Transmitter shall be an RTD transmitter and 100 ohm. Mount transmitter at eye level on wall in each of the following locations as shown in the project plans.
2. Acceptable Manufacturers:
 - a. TCSBasys Controls
 - b. ABB
 - c. Endress+Hauser
 - d. Or equal

- e. Combination temperature/humidity transmitters shall be Omega HX94C as manufactured by Omega or equal.

3. Specific Application Requirements:

<u>Installation Identification</u>	<u>ID Code</u>	<u>Range</u>	<u>Size and Installation Notes</u>
Blower Room Temperature	TT-401	0-150 Deg. F	Coordinate Installation Location with Engineer and Owner

E. DO, pH, Ammonia, and Temperature Sensor Controller

- General Requirements: The universal controller shall have a minimum of three analog 4-20 mA outputs. Contractor shall determine if additional outputs are needed. Controller shall communicate to listed sensors through Modbus. The DO and Ammonia shall be displayed as mg/L. Temperature shall be displayed as Fahrenheit or Celsius. Mount controller in accordance with manufacturer's instructions and recommendations.
- Controller shall be 24 VDC powered from RTU-2.
- Controllers shall have sensors as listed below and shown on the plans.
- Controller shall be mounted on the MBBR rail in a NEMA 4X polycarbonate enclosure. Enclosure shall have a clear front cover and be similar to Hammond PCJ16148CCLF or equal.
- Approved Manufacturers: Controller shall be HACH SC4500, YSI, or Owner approved equal.

F. Dissolved Oxygen Sensors: Furnish and install a continuous reading, on-line dissolved oxygen (DO) probe.

- General Requirements: The DO sensor shall measure dissolved oxygen in the range of 0.01 to 20.00 mg/L. Accuracy shall be ± 0.1 ppm for less than 5 ppm or ± 0.2 ppm for greater than 5 ppm. DO sensor shall have an integrated temperature sensor. Accuracy shall be $\pm 0.36^\circ$ F. The DO analyzer shall transmit a 4 to 20 mA signal proportional to the DO of the wastewater and be capable of also transmitting a 4 to 20 mA signal proportional to wastewater water temperature.
- Approved Manufacturers: DO probe shall be HACHLDO sc Model 2, YSI, or approved equal.
- Specific Application Requirements:

<u>Installation Notes</u>	<u>ID Code</u>	<u>Controller Code</u>	<u>Range</u>	<u>Installation Identification</u>
North MBBR Basin	AE-301	AIT-301	0-10 mg/l 0-120 DEG. F	See Detail 2/Y-900. Provide DO and wastewater temperature.

<u>Installation Notes</u>	<u>ID Code</u>	<u>Controller Code</u>	<u>Range</u>	<u>Installation Identification</u>
				Share controller with South MBBR Basin DO/Temp.
South MBBR Basin	AE-302	AIT-301	0-10 mg/l 0-120 DEG. F	See Detail 2/Y-900. Provide DO and wastewater temperature. Share controller with North MBBR Basin DO/Temp.

- G. pH Analyzers: Furnish and install on-line pH analyzers for monitoring the process pH at the application points listed. Each pH analyzer shall utilize a glass pH electrode equipped with a reference junction. The pH analyzer shall, via the controller, transmit a 4 to 20 mA signal proportional to the pH of the wastewater and be capable of also transmitting a 4 to 20 mA signal proportional to wastewater water temperature.

1. General requirements for each pH analyzer are as follows;
 - a. Output Signal: 4-20 mA DC (via controller)
 - b. Accuracy: +/- 0.02 pH
 - c. Sampling Frequency: Continuous
 - d. Zero and Span Adjustments: Calibrate to standard solutions
2. Approved Manufacturers: pH analyzer shall be Hach sc differential pH probe, YSI, or Owner approved equal.
3. Specific Application Requirements.

<u>Installation Notes</u>	<u>ID Code</u>	<u>Controller Code</u>	<u>Installation Identification</u>
MBBR Effluent	AE-303	AIT-302	See Detail 2/Y-900. Share controller with MBBR Effluent Ammonia probe.

- H. Ammonium Analyzers: Furnish and install on-line ammonia analyzers and transmitters for monitoring the process ammonia at the application points listed. Each ammonium analyzer shall potentiometric ion-selective measurement to measure the ammonium concentration in the process liquid. The ammonium analyzer shall transmit a 4 to 20 mA signal proportional to the ammonium of the wastewater and be capable of also transmitting a 4 to 20 mA signal proportional to wastewater water temperature.

1. General requirements for each pH analyzer and transmitter are as follows;
 - a. Output Signal: 4-20 mA DC (via controller)

- b. Accuracy: +/- 5%
 - c. Power Supply: 24 VDC
 - d. Sampling Frequency: Continuous
 - e. Calibration Method: Automatic Import of Factory Calibration
2. Approved Manufacturers: pH analyzer shall be HachA-ISC sc ISE Ammonium probe, YSI, or approved equal.
3. Specific Application Requirements.

Installation Notes	ID Code	Controller Code	Installation Identification
MBBR Effluent	AE-304	AIT-302	See Detail 2/Y-900. Share controller with MBBR Effluent pH probe.

PART 3 EXECUTION

3.1 GENERAL

- A. General: In addition to the shop drawings and descriptive literature required by the General Requirements, the Supplier shall provide complete system documentation necessary for installation, operation, and maintenance. The documentation shall be provided prior to shipment of hardware. The documentation shall include, but not necessarily be limited to, the following:
- 1. General description of equipment.
 - 2. Dimension drawings.
 - 3. Wiring diagrams for connection to process control system.
 - 4. Listing and description of routine maintenance requirements and equipment necessary to perform required maintenance. (Include in O&M Manual only).
 - 5. Installation and Startup: Process Instrumentation installation shall be inspected by a qualified representative of the manufacturer. Installation shall include, but not necessarily be limited to, setting equipment in place and connection of power and signal wiring. Instrumentation shall, unless otherwise specified, be powered from low voltage 24 VDC circuits out of the control panel. Connections shall be made to screw-type terminals. The Control System Integrator will provide terminal to terminal interconnection drawings for all terminations between control panels and field mounted instruments. The Electrical Sub-Contractor will install wiring between the process control panels and instruments and shall make wiring terminations. The Control System Integrator shall verify terminations in the process control and monitoring panels.

- B. Equipment shall be delivered to the site in an undamaged condition. Equipment shall be stored above ground and protected from the weather. Equipment shall be installed in strict accordance with manufacturer's recommendations and the Plans and Specifications. All materials, labor, and appurtenances shall be provided as necessary to provide functional Process Instrumentation.
- C. The Contractor and Manufacturer shall be responsible for coordinating with the Control System Integrator to supply all the necessary equipment.

3.2 PRODUCT HANDLING

- A. Comply with the pertinent provisions of the delivery schedule.
- B. Fabricated parts when delivered to the site shall be stored off the ground and protected from weather and damage. Control and electrical devices shall be stored indoors.
- C. Do not remove shipping blocks, plugs, caps, and desiccant dryers installed to protect the instrumentation during shipment until the instruments are installed and permanent connections are made.

3.3 INSTALLATION OF EQUIPMENT

- A. The equipment shall be erected and installed in strict conformance with the printed manuals provided by the equipment manufacturer.
- B. All anchor bolts and miscellaneous hardware shall be stainless steel. All bolted connections shall be provided with lock washer.
- C. The equipment shall be adjusted for proper alignment, both horizontal and vertical, in strict conformance with the printed manuals provided by the equipment manufacturer.

3.4 ACCEPTANCE

- A. Instruments shall be field tested after erection in the presence of the Engineer and equipment manufacturer to verify operation, uniformity, and compliance with the requirements specified by the manufacturer.
- B. All labor, materials, and test apparatus necessary to conduct testing shall be provided at no additional cost to the Owner.

3.5 INSTALLATION OF INSTRUMENTATION CONDUIT AND CABLES

- A. The furnishing and installation of any additional conduits needed for instrumentation and/or any other instrumentation or control conduit shall be the responsibility of the Electrical Sub-Contractor. The furnishing and installation of the instrumentation or control wiring shown on the Plans shall be the responsibility of the Electrical Sub-Contractor. Control System Integrator shall supervise wiring connections in the process control and monitoring panels.

3.6 INSTALLATION, OPERATION AND MAINTENANCE MANUALS

- A. Operation and Maintenance Manuals for each instrument shall be provided in accordance with Division 1

END OF SECTION 40 7000

**SECTION 43 2313
PUMPS**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. One sidestream pump, motor, and motor controller

1.2 RELATED REQUIREMENTS

- A. All equipment called for under this section shall be supplied by a reputable, qualified, and fully-experienced with the equipment specified.
- B. Section 40 2340 - Wastewater Process Piping
- C. Section 40 0552 - Process Valves
- D. Section 40 6113 – Integrator Coordination
- E. Section 40 6900 – Process Integration
- F. Section 40 7000 – Instrumentation and Control for Process Systems

1.3 SUBMITTALS

- A. See SDSTA Division 1 - Submittal Procedures.
- B. Product Data, Shop Drawings, and Design Data: Organize submittals by unit process so that equipment and interconnections of a process can be reviewed at the same time.
 - 1. Owner reserves the right to reject incomplete submittals without review.
- C. Operation and Maintenance Manuals: Two (2) copies of the Operation and Maintenance Manuals shall be provided for the pump in accordance with Division 1 of these Specifications.

1.4 PRIOR APPROVAL

- A. All materials and/or equipment must receive approval prior to bidding if it is intended to furnish products other than those contained within these Specifications and supplied by designated, approved equipment suppliers. Materials and equipment changes to the Contract Plans and Specifications which will required prior approval are as follows:
 - 1. Sidestream Pump
- B. The requirements for obtaining such approval are specified in the Instruction to Bidders and the General Requirements.
- C. Where equipment prequalification submittal is required for specific equipment, submit following data to the Owner within ten (10) calendar days before the scheduled bid opening

date, design information including drawings for the equipment seeking to be an approved alternate. The design pre-submittal shall be complete and include as a minimum the following:

1. Manufacturer, model number, and other characteristics identifying equipment proposed.
2. Product data submittal including drawings, specifications, product literature with adequate detail that what is proposed will meet the requirements of the plans and specifications.

PART 2 PRODUCTS

2.1 GENERAL

- A. The Contractor shall furnish and install as shown in the plans and described in these specification one (1) horizontal close-coupled, end suction centrifugal pump, Goulds Model 3656LH, Paco, Aurora, or approved equal. Pump unit shall be of one manufacturer and provided complete including electric motor drive and controller.
- B. The pump shall produce 100 gpm at a total dynamic head of 25 ft with a minimum total shut-off head of 2 ft. Minimum efficiency at design conditions shall not be less than 58.2%. The pump shall be close-coupled to a 1.5 hp, 3600 rpm, 220 volt, 1 phase, 60 hz, TEFC, horizontal motor with a service factor of 1.15, 40 degrees C ambient. Motor shall be non-overloading across the entire pump curve. Entire unit shall be mounted on a cast iron drip-rim base using cap screws to ensure full benefit of the pump back pull-out feature. Pumps shall not be secured with floor studs. Pump shall be secured to concrete pad under the Cone bottom tank in the Influent Building.
- C. Pump casing shall be spiral volute type, back pull-out design with NPT threaded suction and discharge connections and shall be constructed of Cast Iron, ASTM A48 CL20. The pump discharge nozzle shall be tangentially oriented. A pump casing drain shall be provided with a steel or brass pipe plug.
- D. A replaceable suction wear ring of Bronze ASTM B584 C87500 shall be provided and held securely by means of an interference fit in the casing suction.
- E. The pump impeller shall be of enclosed design, constructed of Bronze ASTM B584 C87500 material and key driven. A stainless steel cap screw and washer shall provide positive attachment of the impeller to the motor shaft.
- F. The seal housing shall be constructed of Cast Iron ASTM A48 CL20 material and shall hold the stationary seat of the mechanical shaft seal. The seal housing shall be held in place in a machined fit on the pump casing to maintain component alignment and "O-ring" sealed to insure against leakage.
- G. The pump shaft seal shall be a John Crane Type 21 mechanical seal or equal constructed of the following materials: Stationary Face: Ceramic, Rotating Face: Carbon, Elastomers: Buna-N, Metal Components 18-8 SS.

- H. The pump drive motor shall be non-overloading of NEMA standard design with JM shaft extension and C-Face mounting suitable for close-coupled pump mounting. Motor rating shall be 1.5 hp, 1 phase, 230 V, 8A, IP 55, 3500 rpm.
- I. Pump shall be controlled by an integral and pre-wired mounted pump controller operating with Hand-Off-Auto switch, with Automatic control provided by a 24V DC signal from RTU-2 for starting and stopping of the pump. Pump controller shall be able to provide a running confirmation and H-O-A status to RTU-2.

PART 3 EXECUTION

3.1 DELIVERY, STORAGE AND INSTALLATION

- 1. Pumps shall be delivered to the site in undamaged condition. Pumps shall be stored above ground and protected from the weather. Pumps shall be installed in strict accordance with manufacturer's recommendations and these Specifications. Pumps installation shall be supervised by a factory-trained representative on the site. Vibration testing and harmonic frequency analysis shall be performed by the authorized factory representative for all centrifugal pumps.
- 2. Install pumps to provide access for periodic maintenance, including removing motors impellers, couplings, and accessories.
- 3. Pumps and piping shall be supported separately so piping is not supported by pumps.

3.2 CERTIFIED PUMP CURVES

- 1. The pump manufacturer shall factory test each pump with its respective drive and motor for compliance with maximum and preset capacities as specified in this section. Six (6) certified copies of these test results shall be submitted to the Engineer for review and approval prior to shipment.

3.3 CONNECTIONS

- 1. Install all connections as stated in the Contract Drawings.

3.4 FIELD SERVICES

- 1. Each pump manufacturer shall provide the services of a factory trained service technician for a minimum of one (1) eight (8) hour day for installation and checkout of each pump or pump system and to instruct plant operating personnel in the proper operation and maintenance procedure for the installation. Manufacturer's sales representatives that have not had complete factory service training will not be an acceptable substitute. Six (6) copies of the operation and maintenance manuals shall be provided for each pump or pump system specified herein. Startup services shall include checking the natural frequencies and vibrations amplitudes and frequencies of centrifugal pumps. Complete reports including the results of frequency and vibration testing shall be submitted to the

Engineer for approval. Vibration amplitude in excess of three (3) mils will not be acceptable for any centrifugal pump.

3.5 GUARANTEE

1. All equipment shall be guaranteed against defects in materials, workmanship, and design for a period of two (2) years from the date of startup to the effect that any part or equipment that should prove to be defective during the warranty period shall be repaired or replaced at no cost to the Owner. The Contractor is hereby notified that the responsibility for the complete and satisfactory operation or function of all equipment and materials is definitely a part of the Contract, regardless of the manufacturer's guarantee of any item furnished. The Contractor is responsible for placing all equipment in operation, furnishing all lubrication, packing, and other accessories necessary for initial operation, and seeing that proper operating and maintenance instructions are prepared.

3.6 DELIVERY, STORAGE, AND INSTALLATION

1. Pump shall be delivered to the site in undamaged condition. Pump shall be stored above ground and protected from the weather. Pump shall be installed in strict accordance with manufacturer's recommendations and these Specifications. Pump installation shall be supervised by a factory-trained representative on the site.

END OF SECTION 43 2313

SECTION 46 0043
UNIT PROCESS – MOVING BED BIOFILM REACTOR SYSTEM

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. One (1) moving bed bio-reactor (MBBR) treatment system
- B. MBBR Media
- C. Aeration Grid and Diffusers
- D. Instrumentation Requirements
- E. Media Retention Screens
- F. Positive Displacement Blowers with Integral Variable Frequency Drives

1.2 RELATED REQUIREMENTS

- A. All equipment called for under this section shall be supplied by a reputable, qualified, and fully-experienced with the equipment specified.
- B. MBBR system Supplier shall be responsible for coordinating with control system integrator to provide a complete functional system in accordance with these specifications.
- C. Section 40 2340 – Wastewater Process Piping
- D. Section 40 0559 – Hydraulic Gates
- E. Section 40 0552 – Process Valves
- F. Section 40 6113 – Integrator Coordination
- G. Section 40 6900 – Process Integration
- H. Section 40 7000 - Instrumentation
- I. Section 43-2313 - Pumps

1.3 SUBMITTALS

- A. See SDSTA Division 1 - Submittal Procedures.
- B. Product Data, Shop Drawings, and Design Data: Organize submittals by unit process so that equipment and interconnections of a process can be reviewed at the same time.
 - 1. Owner reserves the right to reject incomplete submittals without review.
- C. Submittals shall include at a minimum the following:

1. Design Summary including design conditions specified herein.
 2. Equipment Provided by MBBR Supplier
 3. Media Fill Fraction in Each Basin (% of volume of the MBBR basins)
 4. Media Type and Volume
 5. Maximum Air Requirement
 6. Minimum Air Requirement to keep Media in suspension and basins adequately mixed
 7. Aeration System Design, including aeration grid layout, material, and design as well as Blower information as required in the Positive Displacement Blower section of this section.
 8. Drain screen size and layout
 9. Retention sieve size and layout
 10. Plan for Start-Up and Commissioning Trips by manufacturer representative
 11. Performance Guarantee Information
- D. Operation and Maintenance Data in accordance with SDSTA Division 1.

1.4 PRIOR APPROVAL

- A. All materials and/or equipment must receive approval prior to bidding if it is intended to furnish products other than those contained within these Specifications and supplied by designated, approved equipment suppliers. Materials and equipment changes to the Contract Plans and Specifications which will required prior approval are as follows:
1. MBBR System including media, media retention sieves and screens, aeration system including manifold and diffusers
 2. Positive Displacement Blowers
- B. The requirements for obtaining such approval are specified in the Instruction to Bidders and the General Requirements.
- C. Where equipment prequalification submittal is required for specific equipment, submit following data to the Owner within ten (10) calendar days before the scheduled bid opening date, design information including drawings for the process seeking to be an approved alternate. The design pre-submittal shall be complete and include as a minimum the following:
1. Manufacturer, model number, and other characteristics identifying equipment proposed.

2. Product data submittal including drawings, specifications, product literature with adequate detail that what is proposed will meet the requirements of the plans and specifications.
 3. List of at least two existing installations of identical model number equipment, with location, owner contact information, date of installation, and project design conditions equivalent to those specified for this project.
 4. Certification by bidder that proposed equipment will function as specified.
 5. Evidence of financial responsibility adequate to complete the project and assure viability of equipment warranty.
 6. A complete listing of changes that will be required in the contract plans and specifications to accommodate the alternate equipment.
- D. Alternate bidders shall guarantee in writing, signed by an officer of the company, that the equipment offered will provide comparable or superior features, performance quality, and materials of construction as the equipment specified. Prior approval of the alternate equipment shall not constitute final approval of specific equipment, but rather constitutes only approval of the respective equipment manufacturers to provide price quotations based on equipment meeting the specifications. Alternate equipment manufacturers shall modify their standard products as necessary to meet all provisions of the specifications without exception.
- E. The cost of all changes incidental to installation of the alternate equipment such as electrical, mechanical, piping modifications, engineering supervision, as-build drawings, etc. shall be borne by the Contractor with no additional expense to the Owner.
- F. If after installation the alternate equipment does not perform in accordance with the specifications or other deficiencies are noted, the Owner will require the modification or replacement of such equipment to meet the specifications at no additional expense.

1.5 QUALITY ASSURANCE

- A. Qualifications: The MBBR manufacturer/supplier and appurtenant equipment manufacturers shall modify the standard equipment as necessary to meet the minimum values specified for dimensions, design, and the intent of this Specification.
1. Manufacturers Experience
 - a. Manufacturer shall provide documents demonstrating adequate qualifications with required design calculations
 - b. The MBBR manufacturer and appurtenant equipment manufacturers shall have at least 10 operational installations in the U.S. at similar or higher flows, or

- c. The MBBR manufacturer shall have 10 years' experience with MBBR equipment in similar installations.
- 2. Fabrication Personnel
 - a. Trained and experienced in the fabrication of materials and equipment
 - b. Knowledgeable of the design and the approved Shop Drawings
- B. Requirements of the following organizations shall be considered minimum
 - 1. OSHA - Occupational Safety and Health Act
 - 2. ANSI - American National Standards Institute
 - 3. ASTM - American Society for Testing and Materials
 - 4. AISI - American Iron and Steel Institute
 - 5. AISC - American Institute of Steel Construction
 - 6. AWC - American Welding Society
 - 7. GLUMRB - Great Lakes Upper Mississippi River Board (10-State Standards)
 - 8. Township, County, State Codes

1.6 DELIVERY, STORAGE, AND HANDLING

- A. The contractor shall unload, deliver, store, handle, and temporarily support equipment prior to installation in strict accordance with the manufacturer's recommendations and instructions. Contractor shall protect all exposed surfaces and keep records of the storage parameters, including dates that storage procedures were performed. The Contractor shall be responsible for work, equipment, and materials until inspected, tested, and accepted by the Owner and Engineer.
- B. Protect the equipment from contamination by dust, dirt, vibration, and moisture. Protect from corrosion, deformation and other damage during delivery, storage and handling.
- C. Contractor shall inspect equipment upon delivery and note any damage from shipping. Contractor shall report any damage to manufacturer and Engineer.

1.7 SYSTEM DESIGN AND PERFORMANCE REQUIREMENTS

- A. Summary: There shall be supplied one (1) Moving Bed Biofilm Reactor (MBBR) system, furnished and installed complete with the media, aeration system, media retention screens, positive displacement blowers with integral variable frequency drives (VFDs), and other appurtenances and accessories specified, indicated on the Plans, or otherwise required.

B. Equipment Design and Performance:

1. Sieve (screen) Assemblies shall be used to retain the carrier elements at emergency capacity design flow, 1900 gpm, within each reactor tank where mixing and/or aeration systems are designed to keep the sieve assemblies clear of debris. Design sieve assemblies to minimize clogging potential and be compatible with the wall pipe assemblies shown on the Drawings.
2. The Aeration System shall be nominally full floor coverage system, designed to adequately mix the tank contents, entrain the carrier elements throughout the liquid volume, provide enough air for oxygen transfer requirements and fulfill the performance specifications per Manufacturer recommendations.
3. Unless otherwise reviewed and approved by Engineer, the Aeration System shall include aeration grid assemblies and air distribution pipe "drop legs" adequate for mixing via aeration in each of the reactor tanks.
4. The aeration manifold shall be designed to provide uniform distribution of air to each lateral and allow for a turn down of at least 50% of the design airflow without loss of equal distribution of air to each lateral.
5. Air diffusers shall provide medium or coarse bubble air efficiency as necessary to fulfill performance requirements and transfer the actual oxygen requirement.
6. Sieves/screens shall be designed using plastic or HDPE material and oriented such that the screen is continuously being cleaned by impact with the carriers or other proven method. Sieves/screens shall minimize hydraulic head loss to less than 4 inches per reactor per tank.
7. All retention sieves and screens shall be constructed of PVC or HDPE material and hardware shall be duplex stainless steel. No media retention sieves or screens constructed of stainless steel will be accepted. Only duplex stainless steel hardware or prior approved equivalent will be accepted.
8. For specific performance guarantee for the MBBR system, see Part 2 - Products of this Specification Section. For testing requirements related to the performance guarantee of the MBBR System, see Part 3 – Execution of this Specification Section.

PART 2 PRODUCTS

2.1 GENERAL

- A. The Moving Bed Biofilm Reactor process allows carrier elements to move about freely within a reactor using the suppliers standard aeration system in aerobic reactors. Sieve assemblies shall be used to retain the carrier elements within each reactor.

2.2 MBBR DESIGN REQUIREMENTS

1.	Average Influent BOD	< 30 mg/L
2.	Average Influent TDS	2,253 mg/L
3.	Average Influent Ammonia Maximum Influent Ammonia Maximum Effluent Ammonia Maximum Effluent Ammonia	2.3 mg/L 4.3 mg/L 0.47 mg/L 30-day average 0.90 mg/L Daily Maximum
4.	Design Flow	1,900 gpm
5.	Total Number of MBBR Basins	2
	Basin operation with average influent Ammonia	2 Basins, Parallel Operation
6.	Basin operation with maximum influent Ammonia	2 Basins, Series Operation
9.	MBBR Basin Working Volume (per Basin)	55,600 gal
10.	MBBR Tank Dimensions (per Basin)	As shown in the Contract Plans
11.	Minimum Freeboard	2.4 ft (series) – 3.1 ft (parallel)
13.	Basin Minimum Sidewater Depth	15.9 ft (parallel) – 16.6 ft (series)
14.	Max Headloss Through Screens @ 1900 gpm	4 inches

2.3 ACCEPTABLE MANUFACTURERS

- A. The MBBR system shall be provided:
 - 1. Headworks International, Houston, TX
 - 2. World Water Works, Inc., Oklahoma City, OK.
 - 3. Owner/Engineer Approved Equal
- B. Process: Moving Bed Biofilm Reactor and Appurtenant Equipment as specified herein.
- C. Configuration: Two (2) basin parallel operation under average loading conditions, Two (2) basin series operation under peak loading conditions

2.4 BIOFILM CARRIER MEDIA

- A. Material of Construction: Virgin HDPE
- B. Minimum Media Fill Rate: 40%
- C. Maximum Media Fill Rate: 50%
- D. The neutrally buoyant HDPE biofilm carrier media within each bioreactor shall provide a protected surface for the growth of a diverse biofilm community. The media shall be resistant to ultraviolet radiation and a wide range of aqueous solutions, acids, alkalis, oxidizing agents, oils,

fats, and alcohols.

2.5 ROTARY LOBE POSITIVE DISPLACEMENT BLOWERS

- A. Blowers shall be supplied by the MBBR manufacturer and shall be able to provide the required air for the manufacturers respective MBBR system. Blowers shall be provided with Integral Variable Frequency Drives (VFD). Furnish all labor, materials, equipment, and incidentals required and install complete, ready for operation and field test three (3) new rotary positive displacement blowers and appurtenances as shown in the plans and specified herein.
 - 1. Manufacturers:
 - a. Rotary lobe positive displacement blowers with integral VFD
 - 1) Aerzen
 - 2) Kaeser
- B. Submittals
 - 1. Submit in accordance with Division 1, copies of all materials required to establish compliance with this Section. Submittals shall include at least the following information:
 - 2. Certified general arrangement drawings showing materials, details of construction, dimensions, and connections.
 - 3. Complete Blower Performance Data including:
 - a. RPM
 - b. Capacity – scfm and icfm
 - c. Discharge pressure
 - d. dB(A) noise pressure level
 - e. Maximum gear tip speed and rotor tip speed (fpm)
 - f. HP required at rated capacity and pressure
 - g. Rated maximum pressure rise of blowers
 - h. List of recommended spare parts broken down into on hand parts and long term for 2 years operation and 3 to 5 years operation.
 - i. Descriptive Brochures
 - j. Performance Curves
 - k. Motor Data

4. Complete blower package operating and maintenance instructions professionally published, hard copy and electronic copy, shall be furnished for all equipment included under these specifications in accordance with Division 1.

C. Blower Performance Criteria

1. Quantity of Machines: 3 units
2. Design Inlet Temperature: 100 °F
3. Site Elevation: 5118 feet above sea level
4. Design Relative Humidity (%): 80%
5. Design Flow: as required by MBBR Manufacturer
6. Minimum Air flow: as required by MBBR Manufacturer to keep media suspended
7. Minimum Turndown: 50% of speed
8. Design Discharge Pressure: 8.4 psig (MBBR manufacturer to verify)
9. Maximum Blower Speed: 80% of maximum
10. Brake Horsepower (Max): as required for air flow rate given by MBBR manufacturer
11. Motor Size (max): 40 hp max; as required for air flow rate given by MBBR manufacturer
 - a. Package BHP to include pressure loss through a clean inlet filter / silencer, pressure loss of the exhaust silencer and check valve.
12. Free Field Noise Guarantee 73 dB(A) at 1 meter (at design point)

D. Spare Parts

1. Furnish the following spare parts for each blower package specified:
 - a. Complete set of matched V-belts
 - b. One filter element per filter
 - c. Volume of oil change for first service interval
2. Spare parts shall be properly bound and labeled for easy identification without opening the packaging.

E. Blower Casing:

1. The blower casing shall be of one-piece construction, with separate sideplates that are bolted and pinned to the housing.

2. Materials shall be close-grained cast iron ASTM A48 suitably ribbed to prevent distortion under the specified operating conditions.
3. Minimum blower casing pressure rating shall be 36 psig.
4. Inlet and outlet shall be grooved connections.
5. The casing shall incorporate a proven means of pulsation cancellation which achieves 90% or better reduction in vibration. Systems without a means of pulsation cancellation shall not be accepted.
6. The vibration level as measured at the blower casing, in the X/Y planes of the bearings, shall not exceed $\frac{1}{2}$ "/sec RMS when operating at the specified maximum operating pressure and speed in the actual blower package.

F. Rotors:

1. Each rotor shall be of the "stiff" design with first lateral critical speed at least 120% of the maximum allowable operating speed.
2. The rotors shall be of the straight, three-lobe type, and shall operate without rubbing or liquid seals or lubrication.
3. Rotor/shaft shall be one single piece. Cast, hollow rotors shall be capped, dust tight. Open rotors are not acceptable.

G. Bearings:

1. Each rotor/shaft shall be supported by anti-friction bearings and fixed to control the axial location of the rotor/shaft in the unit.
2. Regardless of theoretical bearing life calculations, the bearings shall be sized for a minimum expected life of 5 years between overhauls. Calculated bearing life shall be submitted, based on specified operating conditions.

H. Timing Gears:

1. The rotors shall be timed by a pair of single helical AGMA 12 quality gears with hardened and ground teeth; minimum AGMA service factor of 1.70. Spur cut gears are unacceptable.
2. Gears shall be mounted on the shafts with a tapered interference fit and secured by a locknut. Pinned gears are unacceptable.

I. Seals:

1. Seal shall be designed to prevent lubricant from leaking into the air stream as well as to prevent oil from leaking out of the machine.

2. Four rotary piston ring shaft seals, an oil slinger and an O-ring seal shall be provided at the point where the shaft passes through the sideplates.
3. Further provision shall be made to vent the rotor side of the oil seal to atmosphere to eliminate any possible carry-over of lubricant into the air stream.

J. Lubrication:

1. The timing gears and the bearings shall be splash lubricated. Grease lubrication shall be not acceptable.

K. Oil Sight Glass:

1. A recessed oil sight glass must be provided on each oil sump.
2. Protruding sight glasses shall not be acceptable

L. Painting:

1. Painting shall be per supplier's standard meeting the following criteria:
2. Except for machined sealing and machined mounting surfaces, the package shall be painted dark blue.
3. Aluminum, stainless steel, and brass shall not be painted.
4. The supplied motor shall not be over sprayed and will be supplied with the motor manufacturer's standard protection and paint color.
5. Painted Cast Iron and Carbon Steel shall be Alkyd Resin Primer and Final coat with a total dry film thickness of 70µm. Surface preparation SSPC10 or better.
6. Sound enclosure shall be powder-coated polyester base total dry film thickness 80µm.
7. Galvanized components shall only be painted with appropriate surface preparation

M. Blower Accessories

1. Inlet Filter / Silencer:
 - a. Each package shall be supplied with one combination inlet filter silencer.
 - b. The inlet filter silencer shall be mounted directly to the inlet flange of the blower.
 - c. The filter media efficiency must meet the requirements of ASHRAE 52.2 MERV7 50-70% @3-10 microns corresponding to EN779 G4.
 - d. The silencer portion shall be located upstream of the inlet filter.

- e. Filter and silencer performance losses shall be included in the blower performance calculation.
 - f. The filter element shall be designed to trap dirt on the inside so that upon changing, dirt does not fall into the machinery. Filters where dirt accumulates on the external surface of the filter will not be permitted.
2. Inlet Pipe Filter: The dry type felt inlet filter complete with weather hood shall be 97% efficient in removing one (1) micron particles and larger. The pressure drop of inlet filter shall not exceed 2 inches of water column at 1550 SCFM. A differential pressure gauge shall be provided to monitor the inlet pipe filter pressure drop, Dwyer model 2020 magnahelic. The inlet filter shall be mounted by the contractor. The filter element must be changeable without the use of tools. Inlet filter shall be as manufactured by EM Products or equal.
3. Base Frame / Discharge Silencer:
- a. Each package shall be supplied with one combination base frame / discharge silencer.
 - b. The silencer shall be a chamber type design for maximum sound attenuation and shall not use fibrous or absorption materials of any kind. Internal absorption material has been shown to degrade and internally foul diffusers and will not be permitted.
 - c. The silencer shall be fabricated of a single shell of pressure vessel quality steel with continuous welds.
 - d. The silencer shall be subject to a pressure test for tightness and strength at a minimum of 1.65 times the maximum blower operating pressure.
 - e. The silencer shall have a machined inlet connection where the discharge flange of the blower stage bolts directly to, with no intermediary pieces. Threaded connection between the compressor stage and the discharge silencer is subject to leakage and misalignment and will not be permitted.
 - f. Discharge silencer performance losses shall be included by the blower vendor in the blower performance calculation. This is another reason why the blower accessories must be supplied by the manufacturer of the blower stage.
 - g. The base frame shall be constructed from welded carbon steel or cast iron that shall be designed to maintain alignment of the blower internal components and the drive during operation.
 - h. The base frame shall be designed to resist distortion while being installed on vibration isolating mounts.

- i. The blower manufacturer shall supply a stainless-steel grounding lug fully welded to the base.
- 4. Flexible Connectors:
 - a. Blower manufacturer shall provide flexible connectors for each package. Each package shall be connected to the plant piping via flexible connector located at the connection of both the discharge and inlet of each blower.
 - b. Flexible connectors shall prevent the transmission of noise and vibrations from the blower package into the piping.
 - c. Flexible discharge connectors shall be Proco Style 240, Type EE, EPDM, with a grooved discharge connection, rated for 300 °F at 20 psig.
- 5. Electric Motor:
 - a. Each package shall be supplied with a WEG manufactured TEFC motor that shall operate on 460 Volts, 3 Phase, 60 Hertz current, 3600 RPM.
 - 1) Torque NEMA B
 - 2) Temperature Rise Class B
 - 3) Dust tight enclosures (Severe Duty)
 - 4) Class F inverter rated insulation with Class H applied varnish
 - 5) 3:1 constant torque
 - 6) All cast iron construction, including frame, end bells, conduit box and fan cover
 - 7) NPT threaded and gasketed F3 top mounted conduit box
 - 8) Copper windings
 - 9) Regreasable bearings, positive pressure lubrication system with automatic drawn plugs – pressure compensated (Frame sizes 254T and larger).
 - b. All frame sizes shall be NEMA standard, suitable for overhung belt drive and with the conduit box location on top of the motor. IEC frame motors shall not be allowed.
 - c. The motor shall be mounted on a pivoting base to provide automatic tensioning of the belts.
 - d. The motor nominal rating after any corrections for ambient conditions shall be 10% above the maximum operating bHp.

- e. The motor shall have a 1.15 service factor.
 - f. Motor windings shall be supplied with a normally closed thermostat, one per phase, wired in series to form a fail-safe motor protection circuit for the external fault circuit of the motor controller.
 - g. Motors shall be equipped with an Aegis ring and insulated NDE bearing to mitigate the effects of stray motor currents.
 - h. Blower manufacturer shall be responsible for coordinating the starting torque requirement of the blower and the motor.
6. V-Belt Drive:
- a. Each package shall be supplied with a V-belt drive that shall be of the high-capacity type, oil and heat resistant. Drive shall be designed for a minimum service factor of 1.4 times operating power (bHp), or 1.1 times the motor nameplate Hp, whichever is larger to allow a minimum of 1.4-service factor based on the maximum blower bHp.
 - b. Belt tensioning shall be automatic without the use of any devices or interaction on the part of the operator. Neither slide rails nor load-adjusting springs shall be used.
 - c. Sheaves shall be dynamically balanced regardless of the operating speed.
7. Belt Guard:
- a. The belt drive shall be guarded in compliance with OSHA regulations.
 - b. Portions of the guard shall be easily removable allowing for belt inspection and replacement.
 - c. Guard material shall be perforated carbon steel.
8. Vibration Isolators:
- a. Each package shall be supplied with vibration isolating feet with a minimum efficiency of 80%.
 - b. Blower manufacture shall be responsible for attenuating noise and vibration in the blower package such that no special installation base shall be required, nor shall any additional measures be required to reduce vibrations from the blower package being transmitted to the base or the piping.
9. Pressure Safety Valve:
- a. Each package shall be supplied with a single pressure safety valve on the discharge side of the blower mounted downstream of the discharge silencer and upstream of

the check valve.

- b. The safety valve shall be set to protect the blower from exceeding its maximum pressure rating and shall be sized to pass 100% of the design flow.
- c. The safety valve shall be field adjustable, spring loaded, and have a certificate of conformity to PED.
- d. The pressure relief valve shall be housed by the sound enclosure and shall relieve into a segmented section of the sound enclosure. Weighted relief valves inside in the enclosure are not permitted.
- e. The valve shall be manufactured by Aerzen or Kaeser.

10. Check Valve:

- a. Each package shall be supplied with one check valve that shall be installed on the discharge line.
- b. The check valve shall be of the full-bore low pressure-drop, flapper type design with a steel body, and steel flap embedded in EPDM with full-contact seal.
- c. The valve shall be removable without disturbing the piping. Pressure losses produced by the check valve shall be included in the blower performance calculation. Check valves requiring installation in the discharge piping shall not be considered unless installation cost of the external valve is included in supplier's proposal.
- d. The valve shall be manufactured by Aerzen or Kaeser.

11. Instrumentation:

- a. Each package shall be supplied with the following instrumentation:
 - 1) Inlet Vacuum Gauge (4" Gauges)
 - a) Blower manufacturer standard gauge with 4" dial and scale from 0 to -40 inches of water column.
 - b) Gauge to function as a filter maintenance indicator.
 - 2) Inlet Vacuum Switch
 - a) Ashcroft Model B4-64-B-XFS-XBP or equal
 - b) Type 400 pressure Switch in NEMA 4X enclosure
 - c) DUAL general purpose 15A, 110-480V switches (2) SPDT snap-acting, NOT independently adjustable

- d) Buna-N Actuator Seal
- e) Factory set (-20-inches H2O, decreasing)
- f) Mounting bracket
- g) Operating range of -30 to +30-inches H2O.
- 3) Discharge Pressure Gauge (4" Gauges)
 - a) With 4" dial and scale from 0 to 20 psig.
 - b) The pressure gauge shall have a stainless-steel case.
 - c) Gauge shall be dry (no fill) with no pulsation snubber required
- 4) Discharge Pressure Switch
 - a) Ashcroft Model B4-24-V-XRN-XJK-15 PSI or equal
 - b) Type 400 pressure Switch in NEMA 4X enclosure
 - c) Single general purpose 15A, 110-480V switches (2) SPDT snap-acting, NOT independently adjustable
 - d) Viton Actuator Seal
 - e) Internal range scale and operating range
- 5) Discharge Temperature Gauge / Switch (4" Gauges)
 - a) With 4" dial and scale from 32°F to 397°F
 - b) NEMA 4 enclosure, 5A @ 250volt, SA 28 SPDT microswitch
 - c) UL & CSA approved.
- 6) E-Stop Switch
 - a) Siemens model 52PX2V2 or equal
 - b) Mounted on the face of the blower enclosure
 - c) NEMA 4X rating
 - d) Two (2) normally
- 7) Terminal Strip
 - a) The switches and motor thermostat shall be prewired to a labeled terminal junction

12. Each blower shall receive its initial oil filling at the factory. Oil to be fully synthetic Delta Lube.
13. Acoustical Sound Enclosure:
 - a. Each package shall be supplied with a sound enclosure covering the entire blower package.
 - b. The enclosure shall provide suitable protection for outdoor installation under the specified site conditions (wind load and snow load).
 - c. The enclosure shall be designed so as to be able to install them side-by-side with all maintenance done from the front or back of the package.
 - d. Details shall be as follows:
 - 1) Panels shall be made of galvanized steel sheet, powder coated in a light reflecting, blue color per RAL 5001. The skid shall be of the same color.
 - 2) The enclosure and the blower package shall both be mounted on a skid / oil-drip pan designed for meeting environment protection standards and for easy transportation and installation.
 - 3) A grounding strap shall be installed between the blower base and the package skid to bypass any vibration isolating mounts.
 - 4) Quick release panels, each less than 50 lb (as mandated by OSHA) must provide easy and quick access for routine maintenance of the blower and the package components.
 - 5) Enclosure Cooling Fan:
 - a) A high efficiency blower shaft driven ventilation fan shall provide ventilation and cooling integral to the sound enclosure.
 - b) Cooling fan shall be sized for sufficient heat removal from the sound enclosure
 - 6) Electrical components, instrumentation and instrument connections shall not be mounted or interface with moving panels of the sound enclosure.
 - 7) Both blower oil sumps shall be piped to a common fill and drain, located at the front of the package for easy maintenance. An oil level indicator shall be mounted on the outside of the enclosure, which gives an accurate oil level indication while the blower is in operation. All oil lines to be hydraulic hose with fittings. No plastic tubing with compression fittings is allowed.

14. Variable Frequency Drive:

- a. Each blower package shall include a factory mounted, 6-pulse, constant torque, variable frequency drive.
- b. Drive shall operate on 460 VAC, 3 phase, 60 hertz power and shall be integrated with the local blower permissive switches.
- c. The drive shall include the following features and accessories:
 - 1) NEMA 12 enclosure for indoor installation
 - 2) Rotary fused disconnect
 - 3) Method to minimize power line harmonics while providing a near unity power factor.
 - 4) Input surge protection to withstand surges of 2.3 times line voltage for 1.5 msec.
 - 5) Modbus communication over CAT5 cable
 - 6) Minimum 100kA SCCR safety rating
- d. The VFD shall have the following local indicators with local reset:
 - 1) E-Stop
 - 2) Inlet Pressure High
 - 3) Discharge Pressure High
 - 4) Motor Over Temp
 - 5) Blower Over Temp

N. FIELD TESTING

- 1. After installation of all equipment has been completed and as soon as conditions permit, the manufacturer shall provide one (1) trip for a total of two (2) 8-hour days to verify the installation and conduct an acceptance test under actual operating conditions.
 - a. The Manufacturer shall perform a physical check of the blower installation, perform safety checks, power up the equipment and perform functional testing.
 - b. The functional test shall consist of 4 hours of operation of each blower with vibration, temperature, and pressure readings as well as motor amp readings taken and recorded at 60-minute intervals.

- c. The Manufacturer shall provide operations and maintenance training to the plant personnel. The training shall consist of 1 hour of classroom training using the Operation and Maintenance Manual for reference and 2 hours of hands-on training at the blower package.
2. If required, Contractor shall make any changes, at his own expense, to the installation that may be necessary to assure satisfactory operation. Contractor shall be held liable for changes needed in the installation.
3. Manufacturer shall provide a written field test / start up report after completion of testing.

2.6 AERATION GRID

- A. The entire aeration system shall be a full floor coverage device, designed to adequately mix the tank contents, entrain the carrier elements throughout the liquid volume, provide enough air for oxygen transfer requirements and fulfill the performance specifications per Manufacturer recommendations.
- B. Each aeration grid shall be comprised of CPVC or FRP piping and supports. The aeration system shall include aeration grid assemblies and air distribution pipe "drop legs" adequate for mixing via aeration in each of the two reactor tanks. Termination point shall be grooved fittings at the top of the tanks.
- C. The aeration manifold shall be designed to provide uniform distribution of air to each lateral and allow for a turn down of at least 50% of the design airflow without loss of equal distribution of air to each lateral.
- D. Diffuser Piping System: All pipe, fittings, and associated hardware shall be supplied by the manufacturer of the dome diffusers and shall be designed to be installed in the field without solvent welding. All solvent welds must be factory assembled and tested prior to shipment. Materials and appurtenances shall meet the following requirements:
 1. Pipe: All pipe shall be made from CPVC. Minimum nominal wall thickness for the UPVC pipe shall be 0.138 inches. Minimum pressure class rating shall be 125 psi.
 2. Base Plates: Each dome diffuser shall incorporate a matching base plate integrally bonded to the piping system.
 3. Gaskets: Gaskets suitable for withstanding the action of sewage shall be provided to affect sealing between the ceramic dome and the base plate. Gaskets shall be made of natural or modified rubber and of the proper durometer to affect the necessary sealing.
 4. Expansion Joints and Fittings: All piping couplings, joints, tees, and crosses must incorporate a mechanical expansion joint. The purpose of the expansion joint is to eliminate stress buildup in the piping network. No solvent welding of pipe laterals will be allowed. All pipe fittings will be easily removable to facilitate replacement of pipes should damage occur from foreign objects during construction or operation. Systems

requiring multiple pipe disassembly to remove damaged sections shall provide one fully removable repair coupling for every 20 lengths of pipe to facilitate on-site repair.

5. Mounting Provisions: Support systems shall be designed to allow movement of piping to avoid stress buildup. Support, mounting, and tie down provisions shall be adjustable to compensate for variation in tank floor height, but not to exceed 1" total variation. The tie down system shall be of such a nature that it can be easily installed on a plain flat concrete floor. Each tie down fixture shall have a demonstrated margin of safety of 10 against calculated buoyant forces and shall be tested in accordance with mounting tests specified herein. Maximum spacing of support and tie down provisions shall be eight feet.
 6. Aeration Dropleg Pipe: Each aeration grid shall be supplied with a Schedule 40 galvanized steel dropleg pipe to tie into air piping as shown on the plans, with grooved connection fitting at the top of the tank.
- E. Air Header Piping System: All pipe, fittings, diffusers and associated hardware may be supplied by the manufacturer of the aeration system. The Contractor shall submit detailed fabrication and installation drawings for the air header layout, supports, and hold downs for review by the Engineer prior to manufacture.
- F. Manufacturer's Tests: All pipe, fittings, and associated hardware may be supplied by the manufacturer of the aeration system. The Contractor shall submit detailed fabrication and installation drawings for the air header layout, supports, and hold downs for review by the Engineer prior to manufacture.
1. Permeability Testing: Ceramic dome diffusers shall have a design mean permeability rating of 15 scfm when used without flow control device. Diffusers shall be sampled and tested under a plan designed to give 95% confidence that the true mean permeability rating is within the range of 13-17 scfm for each shipment of diffusers furnished. The test plan shall be submitted with the product submittal.
 2. Uniformity Testing: All diffusers accepted for permeability shall be randomly sampled to verify uniformity. Uniformity is defined as substantially even distribution of air bubbles when the diffuser is submerged and operating at 1.0 cfm. A minimum of one diffuser from each 500 shall be tested.
 3. Strength Testing: All diffusers accepted from uniformity testing shall be randomly tested to verify adequate strength. Adequate strength shall be defined as the ability to withstand one full turn (after hand tight) of the securing bolt when the dome is properly mounted on the PVC base plate. A minimum of one diffuser from each 500 shall be tested.
 4. Mounting Tests: The support and tie-down provisions of the diffuser piping shall be tested to assure that it provides a margin of safety of 10 against calculated buoyant forces. The support and tie-down system for the header piping shall be tested to assure that it provides a margin of safety of 2 against calculated buoyant forces. Testing shall be done

by use of a static load applied to a fulcrum to produce a vertical extracting force equal to 10 times or 2 times the calculated maximum buoyant force to which the connection or support will be subjected.

5. Inspection: All pipes shall be inspected for proper joints, supports and tie downs, end plugs, and drain relief valves.
 6. Level Test: Tanks shall be flooded with clear water to the top of the dome diffusers. The level of the dome shall then be checked and adjusted so that all domes are at the same elevation within +/- 1/8".
 7. Uniformity and Leakage Test: The tanks shall be flooded with clear water to a depth of one (1) foot above the domes. The air compressor shall be turned on and air supplied evenly to all headers. The surface of the water will then be visually inspected to see that air flow is uniformly distributed across the tanks.
- G. Liquid Purge System: Provide a liquid purge system to drain the entire submerged aeration piping system for each aeration grid including airlift purge educator line and control valve.
- H. Source Quality Control: The diffuser supplier must be an Authorized Distributor or Representative of the blower being supplied. Authorized OEM is not acceptable.
- I. Warranty: Warrant all parts to be free from defects in materials and workmanship for a period of one year after installation or 18 months after delivery whichever occurs first. Furnish replacement parts to the Owner for any items found to be defective within the one-year warranty period.
- J. Anchors and Fasteners: Duplex stainless steel
- K. Other Non-Submerged and Partially Submerged Components - PVC
- L. Other Submerged Components - PVC

2.7 SIEVE ASSEMBLIES

- A. A total of two (2) sieve assemblies shall be provided in the reactor for a) tank drain and b) effluent of wastewater. Individual sieves shall be constructed of PVC. Drain screen and effluent screen dimensions and openings shall match the drawings. The purpose of the screens is to retain the HDPE filter media in the reactors.
- B. Cylindrically shaped sieve/screen devices shall be provided for each reactor tank. For cylindrical sieve/screen design, the required screen area shall be provided in five (5) equally sized screen units that are fabricated with a flanged end, gasketed, ready to be bolted to a flanged wall pipe and at the concrete reactor tank wall.

2.8 SUPPORTS

- A. The system supplier shall provide all necessary supports for the aeration manifold and sieve assemblies. All submerged supports and connection hardware shall be constructed of PVC or FRP and use duplex stainless steel anchors and fasteners.

PART 3 EXECUTION

3.1 INSTALLATION / STARTUP SERVICES

- A. Install equipment in conformance with:
 - 1. The Shop Drawings reviewed and approved by Engineer
 - 2. The Manufacturer's recommendations

3.2 FABRICATION

- A. All welding shall be done in accordance with the recommendations of the American Welding Society. All welding shall be done by a professional (e.g., TIG or MIG) suitable for the materials to be welded. Welds shall be free of porosity, cracks, holes, and flux. All weld spatter and burrs shall be removed. All welds shall be uniform in appearance. Sharp projections of cut or shear edges shall be ground to a radius as required.
- B. Any piping lengths or fittings or ancillary equipment requiring field assembly by Contractor shall be provided with flanged ends or standard connection ends approved by Engineer

3.3 MANUFACTURER'S SERVICES

- A. General
 - 1. Provide the services of an engineering representative of the Manufacturer to assist the Contractor of Mixed Bed Biofilm Reactor equipment during construction and to verify installation. At a minimum, includes:
 - a. Providing the Contractor sufficient copies of all the necessary reviewed Shop Drawings
 - b. Coordinating all deliveries with the Contractor
 - c. Providing the necessary on-site supervision during installation
 - d. Assist in start-up
 - e. Demonstrate operation and maintenance to the Owner's personnel
 - f. Review operation and maintenance manual with Owner's personnel
 - g. Submit manufacturer's engineer's written approval of installation

2. Provide the services of an engineering representative of the Manufacturer to start-up and train Owner personnel in the proper operation and maintenance of the MBBR system furnished under this section.

B. Start- up Assistance

1. Includes:
 - a. Providing a field technician to verify the installation
 - b. Submit written report of installation verification and acceptance to Engineer.
 - c. Submit written notice to contractor and Engineer of all deficiencies, changes, or additions
2. Does not include:
 - a. Installation assistance and supervision time
 - b. Training time
3. Duration:
 - a. Minimum: Five 8-hour working days for equipment and process start-up.
 - b. Or more as necessary to complete start-up and commissioning of the MBBR system in accordance with performance guarantee specified herein.
4. Schedule
 - a. Coordinate with the Contractor, Engineer, Owner, and any Subcontractors to complete the start-up procedure.
 - b. Submit to the Contractor and Engineer written schedule at least 14-days prior to system to be started, listing:
 - 1) Tasks to be accomplished.
 - 2) Dates and times.
 - 3) Subcontractors and Manufacturer representatives that will be present

C. Training:

1. Includes:
 - a. Operation and maintenance training on all equipment specified under this Section
 - b. Equipment calibration training on all equipment specified under this Section.

- c. Troubleshooting methodology
- 2. Equipment Training:
 - a. Provide all the necessary equipment to instruct Owner designated personnel.
 - b. Include O&M manuals and process training manuals, demonstrations, practice problems, video, and other Manufacturer literature necessary for a thorough training.
- 3. Duration:
 - a. Minimum: one 8-hour working day
 - b. Or more as necessary to complete training
- 4. Schedule:
 - a. Coordinate with the Contractor, Engineer, Owner and any Subcontractors to complete the training.
 - b. Submit written itinerary for each training subject for the Engineer to review

3.4 PROCESS PERFORMANCE VERIFICATION

- A. The Process Performance Period shall commence after the MBBR Process has adequate time to acclimate to the wastewater being provided
- B. The Process Performance Period will last for no less than 30 consecutive days. The MBBR System manufacturer shall employ the services of a third party certified laboratory to perform laboratory analysis described on the sample locations and at the frequency shown below:
 - 1. Sample Locations: Influent and Effluent
 - 2. Sample Frequency: Three (3) times per week
 - 3. Analyses per sample, per location:
 - a. Ammonia
 - b. All other investigative analysis in the event of performance failure.
- C. Acceptance of the process performance testing shall be determined based on the following requirements. If any one of these requirements is not met, the process performance test fails.
 - 1. The running average of the effluent concentration must be less than the required effluent concentration at all times.
 - 2. No test can fail to meet the required effluent ammonia concentration.

3. If a test fails to meet any of the requirements, the performance test will be restarted and be of the full duration.
4. If the process performance warranty cannot be satisfied within 6 months following the start of the Process Performance Period, despite the best efforts of the MBBR System supplier, the MBBR manufacturer shall make all necessary modifications to the MBBR process to achieve the specified performance at no cost to the Owner (at the MBBR manufacturer's expense).

END OF SECTION 46 0043