



Sanford

Underground Research Facility

South Dakota Science and Technology Authority

Dewatering Control System Recapitalization

Technical Specifications

TABLE OF CONTENTS

SDSTA DIVISION 01

- 01 11 00 – Summary of Work
- 01 30 00 – Administrative Requirements
- 01 32 00 – Construction Progress Schedules
- 01 33 00 – Submittal Procedures
- 01 35 23 – Safety and Environmental Requirements
- 01 45 00 – Quality Control for Construction
- 01 50 00 – Temporary Construction Facilities and Controls
- 01 78 00 – Closeout Submittals
- 01 93 08 – Operation and Maintenance Data

DIVISION 26 – ELECTRICAL

- 26 0500 – Common work Results for Electrical
- 26 0519 – Low-Voltage Electrical Power Conductor and Cables
- 26 0526 – Grounding Bonding for Electrical Systems
- 26 0529 – Hangers and Supports for Electrical Systems
- 26 0533 – Raceways and Boxes for Electrical Systems
- 26 0553 – Identification for Electrical Systems

DIVISION 40 – PROCESS INTEGRATION

- 40 6113 – Integrator Coordination
- 40 6900 – Process Integration

END OF INDEX

SDSTA DIVISION 01 SPECIFICATION

Dewatering Control System Recapitalization

TABLE OF CONTENTS

SECTION 01 11 00 SUMMARY OF WORK	2
SECTION 01 30 00 ADMINISTRATIVE REQUIREMENTS	3
SECTION 01 32 00 CONSTRUCTION PROGRESS SCHEDULES.....	5
SECTION 01 33 00 SUBMITTAL PROCEDURES	7
SECTION 01 35 23 SAFETY AND ENVIRONMENTAL REQUIREMENTS	11
SECTION 01 45 00 QUALITY CONTROL FOR CONSTRUCTION.....	17
SECTION 01 50 00 TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS.....	21
SECTION 01 78 00 CLOSEOUT SUBMITTALS.....	23
SECTION 01 93 00 OPERATION AND MAINTENANCE DATA	25

Section 01 11 00 Summary of Work

1 GENERAL

1.1 WORK COVERED BY CONTRACT DOCUMENTS

1.1.1 Project Description

The work includes rehabilitating the obsolete dewatering control system. Rehabilitation will be accomplished by installing new equipment, including new pump station controllers, new process supervision controllers, and new training & development controllers and incidental related work.

1.1.2 Location

The work is located at the Sanford Underground Research Facility, approximately as indicated. Work areas on the surface will be located at the Rounds Operational Center, the Administration Building, the Yates Hoist Building, the Wastewater Treatment Plant, the Ross Top (a.k.a. Vent Bag Building), and the Ross Guard Shack. Work areas in the underground will be located in the pump rooms on the 1250L, 2450L, 3650L, and 5000L. Access to these underground locations will require the Contactor to utilize the cage conveyance in the Ross Shaft to move persons and materials.

1.2 OCCUPANCY OF PREMISES

Building and/or location of work will be occupied during performance of work under this contract.

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.

1.3 EXISTING WORK

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.

--- End of Section ---

Section 01 30 00 Administrative Requirements

1 GENERAL

1.1 PROGRESS AND COMPLETION PICTURES

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 photographs with the monthly invoice. Photographs provided are for unrestricted use by the SDSTA.

1.2 SUPERVISION

1.2.1 MINIMUM REQUIREMENTS

Have at least one qualified superintendent, or competent alternate, capable of reading, writing, and conversing fluently in the English language, on the job-site at all times during the performance of contract work.

1.2.2 SUPERINTENDENT QUALIFICATIONS

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.

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.

1.2.2.1 Duties

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 weekly progress 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.

1.2.3 NON-COMPLIANCE ACTIONS

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 ensure timely completion. Furthermore, the Contracting Officer may issue an order stopping all or 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

After award of the contract but prior to commencement of any work at the site, the Contractor must 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 ---

Section 01 32 00 Construction Progress Schedules

1 GENERAL

1.1 SUBMITTALS

Construction Schedule

Monthly Schedule Updates

1.2 ACCEPTANCE

Prior to the start of work, prepare and submit to the Project Manager for acceptance a construction schedule in the form of a Network Analysis Schedule (NAS) or Bar Chart Schedule.

The acceptance of a Baseline Construction Schedule is a condition precedent to:

- The Contractor starting work on the demolition or construction stage(s) of the contract.
- Processing Contractor's invoice(s) for construction activities.
- Review of any schedule updates.

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

1.3.1 Network Analysis Schedule (NAS)

Use the critical path method (CPM) to schedule and control project activities. Prepare and maintain project schedules using Microsoft Project or an approved alternative. Build the schedule as follows:

- a. The Project Schedule must show all on-site construction, major inspections, and closeout activities. SDSTA and Contractor on-site work activities must be driven by calendars that reflect Saturdays, Sundays and all Federal Holidays as non-work days.
- b. With the exception of the Contract Award and End Contract milestone activities, no activities shall be open-ended. No activity must have open start or open finish logic.

1.3.2 Bar Chart Schedule

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.

1.3.3 Schedule Submittals and Procedures

Submit the Network Analysis Schedules (NAS), Bar Chart Schedules, and updates in hard copy and on electronic media that is acceptable to the Project Manager.

1.4 SCHEDULE MONTHLY UPDATES

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

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:

- Excusable Delay: Force-Majeure (e.g. unusual weather) - Contractor may receive time extension, but time will not be compensable.
- Inexcusable Delay: Contractor Responsibility - Contractor will not receive time extension.
- Compensable Delay: SDSTA Responsibility - Contractor may receive compensable time extension.

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

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. Meeting minutes will be taken by the superintendent or other designated rep 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 and in an electronic format acceptable to 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 ---

Section 01 33 00 Submittal Procedures

1 GENERAL

1.1 DEFINITIONS

1.1.1 Submittal Descriptions (SD)

Submittal requirements in addition to those noted below may be specified in the technical specification sections and drawings.

Preconstruction Submittals

Submittals required prior to start of construction:

- List of Proposed Subcontractors
- Construction Progress Schedule
- Submittal Register
- Schedule of Prices
- Health and Safety Plan
- Quality Control (QC) Plan
- Environmental Protection Plan

Shop Drawings

Drawings, diagrams, and schedules specifically prepared to illustrate some portion of the work.

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.

Drawings prepared by or for the Contractor to show how multiple systems and interdisciplinary work will be coordinated.

Product Data

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.

Samples of warranty language when the contract requires extended product warranties.

Samples

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.

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.

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.

Test Reports

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.

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.

Report which includes finding of a test made at the job site or on a sample taken from the job site, on a portion of work during or after installation.

Certificates

Statements created using 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. Statements must be dated after award of project contract and clearly name the project.

Operation and Maintenance Data

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.

This data is intended to be incorporated in an operations and maintenance manual or control system.

Closeout Submittals

Documentation to record compliance with technical or administrative requirements or to establish an administrative mechanism.

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

1.2.1 Use of Submittal Register

Submit a register of submittals, arranged in chronological order by dates required by construction schedule. For this project, the Contractor is required to establish a project specific account through Submittal Exchange or SDSTA approved method for the processing of all submittals. 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.

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.

Submit revised submittal schedule to reflect changes in current status and timing for submittals.

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.
- h. Scheduled dates for installation.
- i. Activity or event number.

1.3 VARIATIONS

Variations from contract requirements require SDSTA approval and will be considered where advantageous to SDSTA.

1.3.1 Considering Variations

Discussion with Project Manager prior to submission will help ensure functional and quality requirements are met and minimize rejections and re-submittals.

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.

1.3.2 Proposing Variations

When proposing variation, deliver a 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 the documentation required for variation, include the submittals required for the item. Clearly mark the proposed variation in all documentation.

1.3.3 Warranting that Variations are Compatible

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.

1.3.4 Review Schedule Extension

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

Schedule and submit interrelated submittals concurrently, such as component items forming a system. 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.

- 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.
- Resubmit register and annotate monthly with actual submission and approval dates. When all items on the register have been fully approved, no further resubmittal is required.
- 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.

1.4.1 Review Notations

Submittals will be returned to the Contractor with the following notations:

- Submittals marked "accepted" authorize the Contractor to proceed with the work covered.
- Submittals marked "accepted as noted" or "accepted as noted, resubmittal not required," authorize the Contractor to proceed with the work covered, provided Contractor takes no exception to the corrections.
- 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.

- Submittals marked "not reviewed" will indicate that the 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 has not been reviewed. Resubmit submittals that have been returned for lack of review by Contractor or for being incomplete, with appropriate action, coordination, or change.

1.5 REJECTED SUBMITTALS

If the Contractor considers any correction or notation on the returned submittals to constitute a change to the contract drawings or specifications, notice must 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.

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

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 Section QUALITY CONTROL FOR CONSTRUCTION requirements of this contract is responsible for dimensions, the design of adequate connections and details, and the satisfactory construction of all work.

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

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 will ensure 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.

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.

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 will replace such materials or equipment to meet contract requirements.

Approval of the Contractor's samples does not relieve the Contractor of his responsibilities under the contract.

--- End of Section ---

Section 01 35 23 Safety and Environmental Requirements

1 GENERAL

1.1 CONTRACTOR'S RESPONSIBILITY FOR PROJECT SAFETY AND ENVIRONMENTAL PROTECTION

- 1.1.1 The Contractor recognizes the importance of performing the work in a safe and responsible manner to prevent damage, injury, or loss to individuals, the environment, and the work itself, including materials and equipment incorporated into the work or stored on-site or off-site. Contractor assumes responsibility for implementing and monitoring all Environment, Safety and Health (ESH) precautions and programs related to the performance of the work.
- 1.1.2 The Contractor and subcontractors shall comply with all legal and SDSTA-specific reporting requirements relating to ESH set forth in the contract documents. The Contractor will verbally notify of any injury, loss, damage, or accident arising from the work to Project Manager and to the SDSTA ESH Safety Representative (ESH Safety Rep), to the extent mandated by legal requirements, to all government or quasi-government authorities having jurisdiction over safety-related matters involving the project or the work. All persons injured while working at SURF will be immediately evaluated, and treated as necessary, by a medical professional before returning to work. Contractor and its subcontractors will immediately report to the Project Manager all spills of a regulated substance of one gallon or greater, and all other significant impacts to the environment (soil, water, air) in performance of the work. Contractor will also immediately notify the Project Manager of any failure to comply with state and federal environmental laws, rules, and regulations.
- 1.1.3 The Contractor's responsibility for ESH under this specification is not intended in any way to relieve subcontractors and sub-subcontractors of their own contractual and legal obligations and responsibilities.
- 1.1.4 The Contractor is responsible for screening all subcontractors with respect to safety and to adopt a safety selection process consistent with requirements defined herein. In addition, Contractor is responsible for flowing down all ESH requirements of the Contract to its subcontractors, including monitoring and enforcing compliance.

1.2 ESH REQUIREMENTS AND COORDINATION

- 1.2.1 Safety and protection of the environment are of the utmost concern on this contract. Safety in this context refers to the health and safety of people and the protection of the environment. Nothing contained herein relieves the Contractor from complying with all applicable standards and regulations found in 29 CFR Part 1926 (OSHA construction standard), 40 CFR (Federal environmental regulations, and Part 74 of the Administrative Rules of South Dakota (State environmental regulations), where applicable. Site specific safety requirements are defined in the SURF ESH Manual located at: <https://www.sanfordlab.org/esh>. Mine Safety and Health Administration (MSHA) compliance may be acceptable, where applicable.
- 1.2.2 The Contractor will address the safety requirements defined herein and in the SDSTA ESH Manual. Contractor costs associated with the implementation of the requirements will be borne by the Contractor. Safety deficiencies discovered after the award will be remedied at no cost to SDSTA and may at the Contracting Officer's discretion be deducted from the contract amount.

- 1.2.3 The Contractor shall have a designated Safety Representative (SR), approved by SDSTA, present on the Project at all times when work is physically being performed. The SR may have other minor duties, but the position's primary role is to oversee safety of the worksite and work being performed by the Contractor, as well as that of its subcontractors. The superintendent or qualified designee may act as the SR. If shift work will be utilized, the Contractor must have a SR for each shift. In the case of shift work, the Contractor will designate one SR as the lead for the project. The training requirements for the second SR are the same as the lead and are as follows:
- The SR shall have underground safety experience and training (e.g., MSHA part 48) when applicable.
 - The SR shall be certified in CPR, AED, and First Aid.
 - The SR is responsible for administering the Contractor's ESH program.
 - The SR will escort the ESH Safety Rep on a monthly ESH site visit.
 - The SR will provide training to all employees working on their behalf in regard to oil pollution prevention, solid and hazardous waste management, and storm water management, if applicable.
 - The Contractor will supply a weekly ESH report to the ESH Safety Rep, detailing any ESH related items.
- 1.2.4 The Contractor shall have at least one individual certified in CPR, AED, and First Aid onsite at all times.
- 1.2.5 The Contractor is responsible for identifying the need for Qualified and/or Competent Persons for specific tasks as defined in 29 CFR 1926.
- 1.2.6 The Contractor must have a documented Site-Specific Environment, Safety and Health Program/Plan in place and accepted by SDSTA before work will be authorized to start. This program must be consistent with the requirements in the SDSTA ESH Manual. The program will be based on the hazards inherent to the Means and Methods adopted by the Contractor and its associated work environment. The scope of work will dictate the required program elements for this contract. Program elements may include those listed on the ESH Manual of the SURF website at <https://www.sanfordlab.org/esh>.
- If the Contractor chooses to adopt one or more specific elements of the SDSTA ESH program, it must adopt that element in its entirety.
- 1.2.7 The Contractor is expected to follow a work planning and controls process that is aligned with the SDSTA. (See SURF website ESH Manual at <https://www.sanfordlab.org/esh>.) The work planning and controls process must be conducted and documented prior to the start of work in the form of a Job Hazards Analysis (JHA). A JHA, developed by the SR, approved by the Project Manager and ESH Safety Rep. The JHA will be reviewed with the individual(s) expected to perform the work prior to work starting on a specified task. The SR is expected to review all JHAs. Copies of JHA(s) must be present at the location where work is being performed and accessible to the individuals performing the work and to SDSTA representatives.
- 1.2.8 The Contractor will conduct a daily crew work planning meeting (tailgate/toolbox talk), including, when necessary, subcontractor employees, prior to the beginning of each shift. This talk will include the plan of work for the day, a review of hazards and potential regulatory issues, inspection/removal of loose puncture hazards as part of a general daily cleanup requirement of the work area, and the review of applicable JHAs. These documented talks will be submitted to the Project Manager or uploaded to a designated electronic database at the end of each day, or by the end of the work week.

1.2.9 The Contractor is responsible for assuring that all Contractor employee safety training is completed in compliance with SDSTA guidelines, standards, and associated regulations. The following training is required for all Contractor personnel before they start work:

- Sanford Underground Research Facility (SURF) Surface and/or Underground Orientation Training, if onsite for less than 40 hours in a 12-month period
- Cultural Awareness video
- Any specific equipment training (e.g.: crane operator)
- Site specific training for environmental compliance (e.g.: spill prevention, Hazmat, storm water, etc.)

For contractor personnel working on-site more than 40 hours in a 12-month period, the following training is required:

- General Safety Basic Training (Surface and/or Underground)

1.2.10 The Contractor must have an individual trained and qualified as a SURF Guide for each area that the Contractor will be working. The Guide must be onsite with the workers at all times. Refer to ESH-(1000-S)-73189 Facility Access Standard or the SURF Training Department for Contractor Guide training.

1.2.11 The Contractor shall provide all common Personal Protective Equipment (PPE) required for the work (hard hats, safety toe boots, safety glasses with side shields, hi-visibility clothing and required fall protection equipment including suspension trauma straps, and full body harness (ANSI A10.14 approved). All contractor personnel shall follow the ESH-(7000-S)-71493 PPE Standard and supporting documents.

- Unique PPE required for aerial lift equipment:
 - Anyone working from an aerial lift must wear a personal fall restraint system or SRL following manufacturer's recommendations.
 - Fall protection must be attached to the manufacturer's designated anchor point.
- Unique PPE required for any underground work will be provided by SDSTA for the duration of the project and at a minimum includes:
 - W65 Self Rescuers (must be maintained according to MSHA requirements) (always required when working underground)
 - Gas Tester(s) (M40M or equivalent)
 - Cap lamps

1.2.12 Smoking, use of tobacco products, including vapor, alcohol, controlled substances, or weapons are not allowed within the boundaries of SURF. All property owned and operated by the SDSTA is designated as tobacco and vapor-free. This applies to all areas of the surface and the underground. The Contractor shall manage and maintain a drug and alcohol policy that aligns with that of SDSTA written policy and procedures. The ESH department review of this document may be required.

1.2.13 If SDSTA perceives the Contractor has created or is exposed to an imminent danger, unacceptable risk, or a non-compliance situation, SDSTA will stop work until safe conditions are re-established. Such work stoppages will be at the expense of the Contractor and will not add time to the completion date of the contract. All personnel have the right and responsibility to authorize a stop work onsite whenever encountering an unsafe condition or act. Refer to the ESH-(2000-S)-202124 Stop Work Standard.

- 1.2.14 In the event of an incident, Contractor will notify the Project Manager and/or ESH Safety Rep immediately and never later than the end of shift on the day of incident. Contractor shall complete the ESH-(3000-F)-173324 First Report of Incident and Investigation form and submit to the Project Manager or ESH Safety Rep. Contractor shall conduct an incident investigation in accordance with the SDSTA Standard. The investigation will include preparing a written report summarizing the results of the investigation, corrective actions taken to prevent a reoccurrence, and any lessons learned. SDSTA may at its discretion participate in and facilitate the incident investigation. Time and expense incurred by Contractor performing an incident investigation will be at the Contractor's expense.
- 1.2.15 The Contractor may, with SDSTA written permission, operate SURF-owned equipment. The Incidental Operator must first meet SDSTA requirements for the operation of said equipment. The Contractor shall regularly inspect, test, and calibrate as necessary all equipment, machinery, tools, or other items furnished by SDSTA that are employed in Contractor's work. Contractor shall take reasonable precautions to avoid damage to facility structures and utilities. If apparent defects are found in SDSTA-provided materials or equipment, defective equipment shall be taken out of service and Contractor shall promptly notify the Project Manager of such defect(s) in writing. Contractor provided equipment shall be inspected and maintained prior to arriving on-site and before each use. Failure of Contractor-provided equipment shall not be entitled to any compensation for downtime or delays or schedule extensions.
- 1.2.16 When working in the headframes, the Contractor will maintain six-foot distance away from an open shaft hole when the cage gate is open or have 100% tied-off (Fall Arrest) protection.
- 1.2.17 The Contractor acknowledges that periodic evacuation drills and exercises are required by SDSTA to validate the adequacy and effectiveness of the ESH-(6000-S)-185207 Emergency Management Standard. Contractor also recognizes that such drills and exercises enhance its employees' understanding of Emergency Management Standard. Contractor agrees to participate in quarterly evacuation drills, which may or may not be scheduled in advance, during the term of this contract. It is understood that Contractor will not be entitled to any additional compensation for participating in these evacuation drills or exercises.
- 1.2.18 The Contractor agrees to assess whether Contractor's employees have the physical, mental, and emotional capacity to perform assigned tasks competently and in a manner that does not unreasonably threaten safety, health, or property, including participation in emergency procedures applicable to Contractor's work location. The ESH-(2000-S)-15209 Fatigue Management Standard regulates the impacts of fatigue for safety, health, and productivity onsite. Refer to the SURF website ESH Manual at <https://www.sanfordlab.org/esh> for further information.
- 1.2.19 The Contractor shall follow use of ladders and shall meet the requirements of OSHA 1926.1053 (Subpart X) and OSHA 1910.23 (Subpart D). Prior to using a ladder, the following shall be considered:
- Alternative methods, such as platform/podium ladder, scaffolding, scissor lift, or aerial lift.
 - Fall protection is required when working from a standard ladder at a height greater than four feet.
 - Fall protection is required when working from the platform of a three-sided podium ladder at a height greater than six feet.

- Additional fall protection is not required when working from a four-sided podium ladder.

Refer to the SURF website ESH Manual at <https://www.sanfordlab.org/esh> for further information on the ESH-(7000-S)-73415 Fall Protection and Prevention Standard.

- 1.2.20 The Contractor shall manage all waste, both solid and hazardous, as well as all obsolete, expired, or unused materials procured by the Contractor, including the cost of disposal. The Contractor shall manage and dispose of all wastes generated in compliance with all applicable state and federal laws and regulations. The Contractor shall minimize, to the extent practical, the generation and accumulation of waste during the lifespan of the project. Waste shall not be allowed to accumulate to the point of becoming a threat to the environment (air, land, water) and must not be stored on the ground for longer than a single work shift. Where large amounts of waste are anticipated, a roll off bin should be used. When a roll off bin is not used, wastes must be removed from the work site on a regular basis.

All clean-up and disposal costs associated with Contractor spills or equipment leaks of environmentally regulated substances in the performance of their work are the responsibility of the Contractor. Spills and leaks must be cleaned up immediately, and leaks must be repaired to prevent further environmental contamination.

If the Contractor will be disturbing one or more acres, it is the responsibility of the Contractor to obtain a South Dakota Stormwater Construction Permit and to comply with that permit, including the installation and maintenance of stormwater pollution controls. Stormwater flowing off the work site must be clean, with no visible sheen or solids. Any existing stormwater pollution controls that are altered during Contractor activities must be returned to full operating condition as soon as possible.

Work that results in the storage of petroleum products (55 gallons or greater in a single container) or the installation of oil-filled operational equipment with a volume of 55 gallons or greater must be reported to the Environmental Department, and secondary containment must be installed.

Visible air emissions occurring from roads, stockpiles, conveyors, etc. used during Contractor work must be controlled by the Contractor.

- 1.2.21 All chemicals to be used at SURF must be pre-approved by SDSTA and Safety Data Sheets (SDS) must be maintained by the Contractor and be readily available to workers on site.
- 1.2.22 Flammables (defined in 30 CFR Part §57.4460 Storage of flammable liquids underground) are not allowed underground. Flammables used on the surface are to be stored in engineered flammable cabinets or in containers with a minimum one-hour fire resistance.
- 1.2.23 Combustibles in the underground work areas shall be managed as per 30 CFR Part 57.4104 - 57.4531, as applicable.
- 1.2.24 Tier 4 engines are required at SURF for underground use. Lower Tier 3 equipment may be allowed underground but only with SDSTA permission. All underground diesel equipment must be approved by SDSTA prior to usage.
- 1.2.25 SDSTA reserves the right to restrict or deny access of any Contractor employee to the work location.

- 1.2.26 The Contractor shall report the hours worked on site by Contractor's employees on a monthly basis to the Project Manager named in the contract. Hours shall be emailed to the Project Manager no later than the 3rd day of the month for hours worked the previous month.

Refer to the SURF website, ESH Manual at <https://www.sanfordlab.org/esh>, for further information on all standards.

--- End of Section ---

Section 01 45 00 Quality Control for Construction

1 GENERAL

1.1 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

- Preconstruction Submittals
- QC Plan;

Submit a QC plan within 15 calendar days of Contract award.

1.2 INFORMATION REQUIREMENTS

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, Rework Items List, and Testing Plan and Log.

Deliver the following to the Project Manager and the designated SDSTA QA Rep:

- DAILY Report: By 10:00 AM the next working day after each day that work is performed;
- Field Test Reports: One copy, within one week after the test is performed;
- QC Certifications: As required by the paragraph entitled "QC Certifications."

1.3 QC PROGRAM REQUIREMENTS

Establish and maintain a QC program as described in this section. The QC program consists of a QC Manager, a QC plan, a Project Preconstruction Conference, Weekly Status Meeting, submittal review, testing, and QC certifications and documentation necessary to provide materials, equipment, workmanship, fabrication, construction, and operations that 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.

1.3.1 Preliminary Work Authorized Prior to Acceptance

The only work that is authorized to proceed prior to the acceptance of the QC plan is the mobilization of storage and office trailers, the installation of temporary utilities, and surveying.

1.3.2 Acceptance

Acceptance of the QC plan is required prior to the start of construction. 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.

1.3.3 Notification of Changes

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

1.4.1 QC Manager

1.4.1.1 Duties

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 Preconstruction Conference, 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.

1.4.1.2 Qualifications

An individual with a minimum of 5 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.

1.4.2 Alternate QC Manager Duties and Qualifications

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

1.5.1 Requirements

Provide 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.

- I. QC ORGANIZATION: A chart showing the QC organizational structure and its relationship to the production side of the organization.
- II. NAMES AND QUALIFICATIONS: In resume format, for each person in the QC organization.
- III. DUTIES, RESPONSIBILITY AND AUTHORITY OF QC PERSONNEL: Of each person in the QC organization.
- IV. 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.
- V. 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.
- VI. TESTING LABORATORY INFORMATION: Testing laboratory information required by the paragraphs "Accredited Laboratories" or "Testing Laboratory Requirements", as applicable.
- VII. 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.
- VIII. PROCEDURES TO COMPLETE REWORK ITEMS: Procedures to identify, record, track and complete rework items.
- IX. DOCUMENTATION PROCEDURES: Use SDSTA formats or agreed upon formats with SDSTA QA Manager and Contractor.
- X. PROCEDURES FOR COMPLETION INSPECTION: See the paragraph entitled "COMPLETION INSPECTIONS".

1.6 PROJECT PRECONSTRUCTION CONFERENCE

During the Preconstruction 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.

1.7 TESTING

Except as stated otherwise in the specification sections, perform sampling and testing required under this contract.

1.7.1 Test Results

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

1.8.1 Invoice Certification

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.

1.8.2 Completion Certification

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

1.9.1 Final Inspection

Near the completion of all work, a Final Inspection is scheduled with the QC Manager and SDSTA project team. During this inspection, the QC Manager develops a punch list of items which do not conform to the approved drawings and specifications. Include in the punch list any remaining items on the "Rework Items List" which were not corrected prior to the Final Inspection. The punch list includes the estimated date by which the deficiencies will be corrected. A copy of the punch list shall be provided to the Project Manager. Any items noted on the punch list shall be corrected in a timely manner and shall be accomplished before the Contract Completion Date. 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 SDSTA that the project is ready for the SDSTA Final Acceptance Inspection. A pre-final walkthrough with the PM is recommended to ensure the Contractor is adequately prepared for the Final Inspection.

1.9.2 Final Acceptance

When all items on the punch list have been completed, a Final Acceptance inspection is performed. The QC Manager, superintendent or other Contractor management personnel, and SDSTA project team will attend this inspection to verify that the facility is complete and ready to be occupied.

1.10 DOCUMENTATION

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.

1.10.1 As-Built Drawings

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.

1.11 NOTIFICATION ON NON-COMPLIANCE

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 ---

Section 01 50 00 Temporary Construction Facilities and Controls

1 GENERAL

1.1 REFERENCES

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.

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C511 Standard for Reduced-Pressure Principle Backflow Prevention Assembly (latest edition)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 241 Standard for Safeguarding Construction, Alteration, and Demolition Operations (latest edition)

NFPA 70 National Electrical Code (latest edition)

1.2 SUBMITTALS

Submit the following in accordance with Section SUBMITTAL PROCEDURES:

- Construction Site Plan

1.3 CONSTRUCTION SITE PLAN

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.

2.1 TEMPORARY WIRING

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.

3.1 EMPLOYEE PARKING

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

3.2.1 Temporary Utilities

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

3.2.2 Sanitation

SDSTA has portable toilets on the 1250L, 2450L, 3650L, and 5000L in cutouts near the Ross Shaft. The contractor will be allowed to use these portable toilets for the duration of the project. The toilets are

pumped weekly. The contractor will be required to bring the toilets to the shaft station so they can be transported to the surface for pumping and replacing the toilet once pumped. The 5000L, 3650L, 2450L, and 1250L are not high-foot-traffic areas, so the primary waste generated will be from the Contractor.

SDSTA has permanent restrooms at the Rounds Operational Center, the Administration Building, the Yates Hoist Building, the Wastewater Treatment Plant, and the Ross Top (a.k.a. Vent Bag Building).

3.2.3 Fire Protection

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 CONTRACTOR'S TEMPORARY FACILITIES

3.3.1 Appearance of Temporary Facilities

a. 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.

3.3.2 Security Provisions

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

3.4 CLEANUP

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.

--- End of Section ---

Section 01 78 00 Closeout Submittals

1 GENERAL

1.1 DEFINITIONS

1.1.1 As-Built Drawings

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.

1.1.2 Record Drawings

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

1.2 SUBMITTALS

Submit the following in accordance with Section SUBMITTAL PROCEDURES:

- Product Data
- Spare Parts Data
- Manufacturer's Instructions
- Posted Instructions
- As-Built Drawings
- Final Approved Shop Drawings

2 PRODUCTS

2.1 AS-BUILT DRAWINGS

2.1.1 Markup Guidelines

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 markups must be neat, legible, and accurate.

2.1.2 As-Built Drawings Content

Show the following information on the as-built drawings:

- 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.
- The location and dimensions of any changes within the building structure.
- Layout and schematic drawings of electrical circuits and piping.
- Correct grade, elevations, cross section, or alignment of roads, earthwork, structures, or utilities if any changes were made from contract plans.

- Changes in design details 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.
- The topography, invert elevations, and grades of drainage installed or affected as part of the project construction.
- Where contract drawings or specifications present options, show only the option selected for construction on the working as-built markup drawings.
- Systems designed or enhanced by the Contractor, such as HVAC controls, fire alarm, fire sprinkler, and irrigation systems.
- Actual location of anchors, construction and control joints, etc.
- Unusual or uncharted obstructions that are encountered in the contract work area during construction.

2.2 CLEANUP

Leave premises "broom clean." Remove waste, surplus materials, rubbish, and construction facilities from the site.

--- End of Section ---

Section 01 93 00 Operation and Maintenance Data

1 GENERAL

1.1 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

- Operation and Maintenance Data
- Training Plan

1.2 OPERATION AND MAINTENANCE DATA

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.

1.2.1 Package Quality

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.

1.2.2 Commissioning Authority Review and Approval

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

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.

1.3.1 O&M MANUAL LABEL REQUIREMENTS

Provide the following information on the label:

- a. Building or Level 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 detailed descriptions of the data package items required.

1.4.1 Operating Instructions

Provide specific instructions, procedures, and illustrations for the following phases of operation for the installed model and features of each system:

1.4.1.1 Safety Precautions and Hazards

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.

1.4.1.2 Operator Prestart

Provide procedures required to install, set up, and prepare each system for use.

1.4.1.3 Startup, Shutdown and Post-Shutdown Procedures

Provide narrative description for Startup, Shutdown and Post-shutdown operating procedures including the control sequence for each procedure.

1.4.1.4 Normal Operations

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

1.4.1.5 Emergency Operations

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.

1.4.1.6 Operator Service Requirements

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

1.4.1.7 Environmental Conditions

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.

1.4.2 Preventive Maintenance

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.

1.4.2.1 Preventive Maintenance Plan, Schedule, and Procedures

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, diagrams, and diagnostic techniques necessary to operate and troubleshoot the system after acceptance.

1.4.3 Appendices

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:

1.4.3.1 Parts Identification

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

1.4.3.2 Warranty Information

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.

1.4.3.3 Personnel Training Requirements

Provide information available from the manufacturers that is needed for use in training designated personnel to properly operate and maintain the equipment and systems.

1.4.3.4 Testing Equipment and Special Tool Information

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.

2 PRODUCTS

Not Used

3 EXECUTION

3.1 TRAINING

Provide comprehensive training for the new systems and equipment. The training must be targeted for the Wastewater Treatment Plant Operators and I&C Technicians. Training must include field lectures based on the system operating requirements.

3.1.1 Training Plan

Submit a written training plan to the Project Manager for approval. The training plan must be approved by the Quality Control Manager prior to forwarding to the SDSTA. Also, coordinate the training schedule with the Project Manager and QC. Include within the plan the following elements:

3.1.2 Training Content

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:

- a. 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.
- b. I&C Technician training for operation, maintenance, programming, and troubleshooting shall be provided. At least two (4) 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" Rockwell Automation classroom instruction on the system furnished under this Contract.
- c. Start-up, normal operation, shutdown, unoccupied operation, seasonal changeover, manual operation, controls set-up and programming, troubleshooting, and alarms.
- d. Relevant health and safety issues.
- e. Discussion of how the feature or system is environmentally responsive. Advise adjustments and optimizing methods for energy conservation.
- f. Design intent.
- g. Use of O&M Manual Files.
- h. Review of control drawings and schematics.
- i. Interactions with other systems.
- j. Special maintenance and replacement sources.
- k. Tenant interaction issues.

--- End of Section ---

Revision History

Rev	Date	Section	Paragraph	Summary of Change	Authorized by
01	MM/DD/ YYYY	NA	NA	Initial Release	CCR Number

**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. Quality Assurance.
 - 3. 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 and Owner"
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 or process area during progress of construction to facilitate the electrical installations.
- E. Coordinate installation locations of all equipment with other trades to verify proper fit and function.

- F. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- G. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed.
- H. 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.
- I. Where electrical identification devices are applied to field-finished surfaces, coordinate installation of identification devices with completion of finished surface.

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 State Electrical Laws and Statutes, and the National Electrical Code (NEC).

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 or process area's 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 a Nationally Recognized Testing Laboratory where testing is provided and shall bear their mark.

PART 2 - PRODUCTS

2.1 NOT USED

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 for additional installation requirements.
- J. 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.
- K. 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 the marked NRTL Listing for through penetration fire stop systems.
- L. See all Specification Drawings and contract documents for approximate equipment locations and confirm locations on site. Coordinate equipment connections with SDSTA, review shop drawings, and verify connection requirements (voltage, amperage, phase, location, etc).

3.2 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. Contractor shall visit the site of construction before submitting bid and become familiar with existing conditions.
- C. 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.
- D. 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.
- E. Contractor shall assume in their 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 Owner for decision; however, Contractor shall be responsible for any damage caused by themselves to equipment in removal or handling.
- F. Fixtures and other equipment removed and to be re-used shall be cleaned before reinstallation. New lamps shall be provided for all fixtures.
- G. Any existing switches or receptacles that are relocated shall be replaced with new device.
- H. 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.
- I. The Owner will be occupying the existing facility during construction. 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.

3.3 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 Owner prior to drilling through any structural beam. No such cutting or drilling process shall endanger the structural integrity of the building, drift, or cavern.
- 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.

3.4 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 0500

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 1000 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.

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.
 6. Owner approved equal.
- B. Copper Conductors: Comply with NEMA WC 70.
- C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN-2 and XHHW-2. Conductors used in the underground spaces shall be constructed with Low-Smoke Zero Halogen (LS0H, or LSHF) jackets.

2.1 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.
 6. Owner approved equal.
- 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, TFFN, ITC, TC in raceway or supported by cable tray.
- F. Class 2 Control Circuits: PLTC, ITC, TC in raceway or supported by cable tray.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. 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.
- B. 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.
- C. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
- D. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."
- E. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."
- F. Compensate for voltage drop. 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.
- G. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.
- H. 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 the National Electrical Code (NEC).
- 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. 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

**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 rock bolts used to support cable tray.

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.
 - h. Owner approved equal.
 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 NRTL-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.
 - 5) Owner approved equal.
 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.
 - 6) Owner approved equal.
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. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- B. 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.
 - 10. Owner approved equal.
- 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.

2.1 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.
- 14. Owner approved equal.
- 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.

2.2 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.
 - 4. Owner approved equal.
- 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.

2.3 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.
 15. Owner approved equal.
- 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.

2.4 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.
 - e. Owner approved equal.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Apply raceway products as specified below, unless otherwise indicated:
1. Exposed Conduit: Rigid steel conduit (RMC).
 2. Concealed Conduit, Aboveground: RMC.
 3. Buried 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: NEMA 250, Type 3R or 4.
 6. Boxes: Cast aluminum. Malleable iron is prohibited.
- 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 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.

- 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. Mounting Heights: Install equipment and devices at heights indicated on Electrical Symbols & Abbreviations sheet, unless noted otherwise.
- F. Backboxes shall not be installed back-to-back. Provide 6-inch separation minimum unless otherwise noted.
- G. Do not install backboxes in fully grouted cells of masonry walls.
- H. 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.
- I. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.
- J. Conduit and Cabling: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.
- K. 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.
- L. 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.
- M. 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.
- N. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

O. 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.

P. 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.

Q. 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.

R. 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.

S. 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.

T. Hazardous Locations: Comply with the NEC.

U. Masonry Box Support: Provide supports to secure box even with top of concrete blocks.

3.3 INSTALLATION OF BURIED 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 BURIED 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 BURIED-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"
4. Label Contractor installed electrical equipment per NEC 110.16(A).
5. Label Contractor installed service equipment per NEC 110.16(B).
6. Label the Available Interrupting Current (AIC) on each Contractor installed 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. Buried-Line Warning Tape: During backfilling of trenches install continuous buried-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 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 26 – Electrical
 - 3. Division 40 - Process Integration, Instrumentation and Control for Process Systems

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 PLCs, HMIs, SCADA, and processes.
 - a. Pre-Submittal Documentation – The Control System Integrator shall be responsible for understanding the site prior to submittal of instrumentation and line diagram documents. Integrator shall verify measurements, locations, lay lengths, diameters, and connection style of instruments, and other relevant information prior to finalizing the design, ordering materials, 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. In addition, the Control System Integrator shall be responsible for the following:
 - 1) The final design, construction, programming, and testing of the new control panel products and SCADA system.
 - 2) Purchasing of all materials for the new control cabinets.
 - 3) Overseeing and verifying the communications cabling and all communication terminations required for operation of the new control system equipment.
 - 4) Overseeing and verifying the field connections and functionality of all sensors and devices connected to the new control system.

- 5) Development and deployment of a modern SCADA System incorporating the dewatering process.
 - 6) Define and refine the control loop requirements with the Owner.
 - 7) Configuration of data historians and alarm setpoints.
 - 8) Develop and test control logic for the new control system.
 - 9) Develop HMI and SCADA interface screens and reports.
 - 10) Commissioning, field verification, and functionality of the new control system.
 - 11) Generating the O&M manuals regarding all equipment supplied for the new control system and providing complete system documentation.
 - 12) Providing construction administration services in the form of project management and technical oversight during project execution.
 - 13) Provide operations and maintenance training to SDSTA staff needed to operate, troubleshoot, maintain, and expand the new dewatering control system.
2. Electrical Sub-Contractor – The Electrical Sub-Contractor shall be the Control System Integrator (or their Sub-Contractor) and shall provide the installation and wiring of the new control system.
 - a. The 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 are the equipment suppliers that are providing control panels, equipment, and/or signals that must interface with other parts of the dewatering control system. 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 SCADA 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 – Existing instrumentation will be re-used for this project. Instrumentation in need of replacement will be provided by the SDSTA. The Control System Integrator will be responsible for ensuring proper calibration and scaling of both the existing and replacement instrumentation.
- B. The Control System Integrator, Electrical Sub-Contractor, Process Equipment Suppliers, and Instrumentation Suppliers shall attend a conference call with the Owner prior to the start of construction to go through the above responsibilities and submittal process for the project.

1.3 SUBMITTALS

- A. Operation and Maintenance Manuals:
 1. See Section 01 0008 Operation and Maintenance Data for requirements for:
 - a. 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 dewatering control system for the Sanford Underground Research Facility. 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 4-20 mA or discrete 24 Vdc. Control System Integrator shall verify signals of new equipment and 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 control cabinets for process improvements.
 2. Integration of process improvements into a new local control SCADA system.
 3. Coordinating with the Electrical Sub-Contractor, Instrumentation Supplier, and Equipment Suppliers.
 4. Coordination with the Owner.
 5. Disconnection and discarding of replaced equipment.
 6. Testing of control systems.
 7. Provide all necessary Operator and I&C Technician 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 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 the work so that it will be installed at the proper time and without delaying the completion of the entire project. The plan for the sequence of tasks shall be reviewed with the Owner prior to starting design work to minimize impact on project schedule.
 2. It is the responsibility of the Control System Integrator and Electrical Sub-Contractor to install all controls equipment in strict accordance with manufacturer's recommendations.

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.
- 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. 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 dewatering, 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.

1.6 SHOP DRAWINGS REQUIREMENTS

- A. Submit copies of shop drawings in accordance with Division 1 for all supplied hardware items and control products. Shop drawings shall include all catalog cuts, descriptive data, and drawings for the entire dewatering 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 replacement and 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 new SCADA system into the existing facility.
- 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. Materials of construction
 - 4. Environmental limits of components including temperature and humidity
 - 5. Size and weight
 - 6. Electrical power requirements and wiring diagrams
 - 7. NEMA rating of housing
 - 8. Submittals shall be marked with arrows to show exact features to be provided.
- F. Loop diagrams per ISA S5.4.
 - 1. 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. 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 dewatering 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 inches x 17 inches
- H. 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
- I. Control cabinet drawings
- J. Backpanel layout drawings
- K. Graphic layouts
- L. Graphic component construction
- M. Nameplate layout drawing
- N. 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 shall be employed exclusively throughout submittals.
- O. 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.
- P. Testing reports:
 1. Source quality control reports
- Q. Warranties: Provide copies of warranties and list of factory authorized service agents.

PART 2 PRODUCTS

2.1 GENERAL

- A. Coordinate with Electrical Sub-Contractor, Instrumentation Supplier, and Equipment Supplier 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 field wiring.
 - b. Analog signal wiring shall be minimum 18-gauge twisted, shielded pair for field wiring.
 - c. Ground Wires for field control wiring (analog and discrete) shall be a minimum of 16-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 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 Control System Integrator 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 instruments and equipment. 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 be the responsibility of the project awarded Control System Integrator to visit the site for investigation of existing system prior to developing the rehabilitative dewatering control system design. 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. Limited functionality of the dewatering 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. It is anticipated that there will be no automatic control of a dewatering pump room while its control cabinet is being upgraded. Manual operation via a Hand-Off-Auto switch on the dewatering pump motor soft starter cabinet by SDSTA staff may be possible.
 - c. The Control System Integrator shall develop and integrate an adequate number of graphic screens on the HMI and SCADA software to both accurately and legibly 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 Specification drawings.
 - e. Verify that switches, buttons, and lights on the dewatering pump motor soft starter cabinets have been wired to provide a means of manual pump control in the event of a PLC failure.
 - f. All existing and new alarm conditions related to the dewatering system shall report to the new SCADA system and Process Monitoring HMIs. Local alarms in the dewatering pump rooms shall report to the local Pump Station Controller.
 - g. Coordinate with Owner for any equipment to be salvaged.

2.4 PROCESS CONTROL FUNCTIONS

- A. I/O Points: The specification drawings indicate the number of inputs and outputs to and from the dewatering control system instrumentation. The number of wires and terminations will vary with configuration of the control system. The control system shall monitor and control the Analog/Discrete inputs and outputs shown on the specification drawings.
- B. Operational Description – General Control Functions:
 - 1. General: It is intended that the Process Monitoring HMIs, Pump Station Controllers, and new SCADA provide a system for monitoring the dewatering process and equipment in underground pump rooms. The work in this contract will include installing and connecting the panels and equipment furnished under this contract, connecting signals from instruments and equipment, and configuring the new SCADA. 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, Soft Start, 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 the Pump Station Controllers, Process Monitoring HMIs, and new SCADA system shall provide the means for monitoring the dewatering control system equipment and the overall dewatering process.
- 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 and new SCADA system. Displays of accumulated run time for each item of equipment shall be available through the operator interface displays.
- 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.
- e. Remote Access: The Control System Integrator shall provide the Owner with remote (off-site) access to all controls. The interface screens shall be the same as the new SCADA. The Control System Integrator shall work with the Owner to determine security and connection requirements for remote access.
- f. Privilege Levels: The new SCADA and HMI interfaces shall utilize logins to grant different levels of access to the dewatering control system. The Control System Integrator shall work with the Owner to finalize these levels, but generally, there are three types of access: read-only, operator, and technician.
 - 1) Read-only access permits users to view the data and make no modifications or changes. Users with read-only access typically have limited access to the system and are not authorized to make any modifications or adjustments.

- 2) Operators have a higher level of access to the control system, and they typically have the authorization to monitor and control the system. They can start and stop the process, monitor performance, and analyze data from the system. Operators may not have the same level of authority as technicians, but that are still authorized to carry out day-to-day operations.
 - 3) Technicians have the highest level of access to the control system and can modify, maintain, and troubleshoot the system. Technicians are authorized to make substantial changes to the system, repair damage, and resolve issues. They possess the technical knowledge required to manage, configure, and maintain the 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 dewatering process. 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 dewatering process in order to create a local SCADA system that feels seamlessly to the plant operators. The Control System Integrator shall work closely with the Owner and operators when developing the new dewatering control system in order to reflect the desired operation. The following is a narrative of the normal operation of the dewatering process. The functional descriptions included in this specification are not intended to be a complete functional description of the entire dewatering process. Equipment, instrumentation, and panel tags listed in the Plans and Specifications for this project are not intended to be used for final tags. The Controls System Integrator shall be responsible for developing tags for the instrumentation, equipment, and panels of the new dewatering control system. Revised tags shall be provided to the Owner in the Construction Plans of Record Documents.
 - a. Background:
 - 2) The underground dewatering system at the SURF is comprised of a 600-hp submersible pump and a series of 700-hp pump stations that push infiltrating groundwater up to the surface via pipes within the Ross Shaft. The submersible pump is suspended at the #6 Winze in what is known as the “Deep Pool” or “Deep Well” 6,000 feet below the facility’s surface. This submersible pump discharges to an underground sump on the 5000-Level at an average flow rate of between 800 and 1,500 GPM. A pump station on the 5000-Level then takes water from the sump and pushes it towards the surface until it reaches another sump on the next pump station level, which resides at the 3650-Level. Next, the 3650-Level pump station pushes water from its sump to the next pump station’s sump on the 2450-Level. The 2450-Level pump station, in turn, pushes water from its sump up to the next pump station’s sump on the 1250-Level. Lastly, the 1250-

Level pump station pushes water from its sump up to the surface, which is discharged into a surface reservoir called “Mill Reservoir.”

Overall, the pump stations remove infiltrating water at an average rate of 700 GPM. The facility’s wastewater treatment plant (WWTP) draws water from Mill Reservoir and processes it until it is environmentally safe to discharge into Gold Run Creek. Since restarting in 2008, the underground dewatering system has pumped 6.1 billion gallons of infiltrated water at an average rate of 597 million gallons per year.

b. New Equipment Installation Locations:

- 1) The new Pump Station Controller cabinets will be mounted in the following locations:
 - 1250-Level Pump Room
 - 2450-Level Pump Room
 - 3650-Level Pump Room
 - 5000-Level Pump Room
- 2) The new Process Monitoring HMI cabinets will be mounted in the following locations:
 - Wastewater Treatment Plant (WWTP), Control Room
 - Rounds Operational Center, Maintenance Shop
 - Yates Hoist Building, Hoist Operator Platform
 - Ross Top
 - Ross Guard Shack
- 3) The new SCADA computer will be set up in the following location:
 - Admin Building

2.5 MONITORING AND CONTROL SYSTEM HARDWARE AND MATERIALS

- A. Control panels shall contain the power supplies necessary to power the field transmitters requiring 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.
- B. 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.
- C. 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 the 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.
- D. Equipment connections shall be made with wire ferrules and 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.

- E. The complete installation shall be done such that all relays, control devices, and panel instruments are completely accessible without major dismantling of panel equipment.
- F. 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.
- G. Condensation protection and panel ventilation: Provide an effective means to keep condensation and corrosion to a minimum within the enclosed control panels without overheating components.
- H. 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), indication lights, keypad, and switches as required to facilitate the control sequences specified herein. PLCs, I/O, and backplane equipment shall be installed. See specification drawings for preliminary panel layouts.
 - 1. Enclosures shall be corrosion resistant NEMA Type 4 painted carbon. The panels shall be fabricated with front access doors. 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.
 - 2. NRTL Listing Requirement
 - 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/markings 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 mark specified above. Upon request from the Owner, the panel manufacturer shall supply documentation to the Owner proving they are an NRTL- certified manufacturing facility for the type of equipment required. Only control panel 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 an NRTL-listed enclosure manufactured by Hoffman Engineering Company, EQUIPTO Enclosures, Rittal North America, Saginaw Control & Engineering (SCE), Wiegmann Enclosures, Hammond Enclosures, or an Owner approved equal.
 - 5. Interior brackets, hinged equipment racks, and mounting pans shall be provided for mounting panel equipment.

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.
 - a. Lettering on nameplates shall be a minimum of 3/8" in height for capital letters. Engraving schedules shall be approved by the Owner 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.
- I. 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.
 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 Phoenix Contact or Owner approved equal.
 4. All internal panel wiring shall be in complete conformance with UL Standard 508A. All field 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.
- J. 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 or fuses to the panel. All instrumentation systems, annunciator panels, lighting circuits, or similar major devices requiring 120 VAC power shall have an individual circuit breaker or fuse. 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. Analog control signal circuits shall be independently fused so that a circuit problem with one does not interrupt operation of others.
- K. Power Supplies: Switched-mode power supplies shall be used to supply power to all equipment requiring a constant DC voltage supply, which does not have self-contained voltage regulation equipment. 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. 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 PULS, Phoenix Contact, 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 Pump Station Controller cabinet and Process Monitoring HMI cabinet. Provide on-line UPS that will continue to operate flawlessly in the event of a mains power failure. UPS shall provide 8 hours of operation without utility power. UPS shall be manufactured by PULS, Phoenix Contact, Eaton, Powerwave, APC, or Owner approved equal.
- L. 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 Phoenix Contact, General Electric, Allen Bradley, Square D, IDEC RH series, Potter Brumfield, Automation Direct, or an Owner approved equal.
- M. 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 Phoenix Contact, Allen Bradley, General Electric, Square D, AGASTAT Series 7000, IDEC RTY series, Automation Direct, or an Owner approved equal.

- N. Switches and Pushbutton Controls: Sequence selector switches shall be multiple deck, rotary-type detent switches. 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
 - b. Square D
 - c. IDEC
 - d. Eaton
 - d. Owner approved equal
- O. Fuse Holders: Fuse holders for AC and DC instrument systems shall be terminal block plug type, snap-lock type, 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 container located inside the panel enclosure near the fuse holder mounting brackets.
- P. Pump Station Controllers: The local dewatering 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. Reference specification drawing number D-PSC for preliminary characteristics of the new Pump Station Controllers. The programmable control system may be used for driving:
1. Control loops
 2. Sequential controls
 3. Statuses and alarms
 4. Digital displays of analog signals
 5. Non-resetting flow or runtime totalizers
 6. Manual control for the dewatering pump 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 local process.

7. Programmable Logic Controllers (PLCs): The PLCs furnished shall be designed for ladder logic control sequence programming. 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 20-25% 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.
 8. Human Machine Interface (HMI): Provide 10-inch NEMA 4 front panel mounted touch screen with color display. The HMI shall be Allen Bradley PanelView Plus or Owner approved equal.
 9. 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.
 10. 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 and shall use descriptive text.
 11. System input/output (I/O) capacity for the control addition shall be provided for the inputs and outputs listed in the plans plus 20-25% spare slots. 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.
 12. Interposing relays shall be utilized to isolate the PLCs' discrete output signals from field devices. This isolation is intended to protect the controllers from potential damage caused by electrical noise, feedback, voltage mismatch, and overload.
 13. Receptacles: A duplex receptacle shall be mounted inside the panels. Duplex receptacles shall be of the 5 ampere minimum, 125 VAC, 2 pole, 3 wire, grounding type complete with box. The receptacle shall have integral GFCI protection.
 14. Interior Illumination: Interior illumination shall be installed inside the control cabinets with a switch that will turn the light on and off. Control cabinet interior lighting fixtures shall be complete with ballast, wiring, and LED lamps.
- Q. Process Monitoring HMI Cabinets: The facility-level dewatering process control and monitoring functions shall be provided by HMI cabinets that exchange data with the new SCADA and Pump Station Controllers. The HMI Cabinets shall be used for the process monitoring and control at the locations shown on Plan Sheets. Reference specification drawing number D-PMH for preliminary characteristics of the new Process Monitoring HMIs. The process monitoring cabinets may be used for:
1. Annunciating and acknowledging alarms raised by the new SCADA and Pump Station

Controllers.

2. Allowing operators to schedule run times of the underground dewatering pumps.
3. Viewing real-time and historical trends related to the dewatering process.
4. Viewing an overview graphic of the dewatering process with key status and sump levels shown.
5. Viewing similar information and performing the same control adjustments that could be done at each pump room's local HMI.
6. Human Machine Interface (HMI): Provide 10-inch NEMA 4 front panel mounted touch screen. The HMI shall be Allen Bradley PanelView Plus or Owner approved equal.

R. Training & Development Controllers:

1. One identical Pump Station Controller cabinet shall be constructed for the Owner to utilize as both a training and development platform for troubleshooting, modifying, maintaining, and expanding the pump station controllers in the future.
2. One identical Process Monitoring HMI cabinet shall be constructed for the Owner to utilize as both a training and development platform for troubleshooting, modifying, maintaining, and expanding the pump station controllers in the future.

S. SCADA Computer: The Owner shall provide the SCADA computer needed for hosting the new SCADA system. As part of the finalizing the new dewatering control system design, the Control System Integrator shall work with the Owner to determine hardware and operating system specs required to support the new SCADA system. During the installation phase of the Contract, the Control System Integrator will be responsible for configuring the new SCADA software on the SCADA computer, deploying the new SCADA system, and commissioning the new SCADA system.

T. Software: The Control System Integrator Owner shall provide and utilize their own software for developing the new dewatering control system and the new SCADA system. The Owner shall provide the software needed at the Owner's facility to install, host, maintain, troubleshoot, and expand the new dewatering control system and new SCADA system. The Control System Integrator shall work with the Owner to determine the software and license types required at the facility to effectively operate, support, and expand the new control and SCADA systems. The following is a preliminary list of software needed at the Owner's facility for the new control system.

1. Rockwell Automation Studio 5000 Logix Designer Professional or Owner approved equal. This software product enables users to design, program, and maintain control systems for industrial automation applications. It provides a unified platform for configuring, programming, and monitoring the performance of the entire family of Allen-Bradley Logix 5000 controllers. This software offers advanced features, such as real-time data exchange with external devices, motion control, and sequential function chart programming. It's designed for industrial professionals, who use it to create and optimize industrial processes for maximum efficiency, productivity, and safety.

2. Rockwell Automation FactoryTalk View Machine Edition or Owner approved equal. This software product allows users to create and manage graphical interfaces for machine-level interactions in industrial automation applications. It is optimized for use on various types of industrial PCs and PanelView HMI terminals, providing an easy-to-use platform for designing and testing HMI applications. This software enables users to create intuitive and visually appealing interfaces that can help increase productivity and efficiency. It also features tools for testing and debugging, which is a critical aspect of ensuring the reliable operation of industrial systems.
 3. Rockwell Automation FactoryTalk View Site Edition or Owner approved equal. This software product allows users to create and manage graphical interfaces for SCADA applications. It features tools for designing and testing SCADA applications, and allows for remote monitoring and control of industrial systems. This software enables users to create intuitive and visually appealing interfaces that can help increase productivity and efficiency at an enterprise level. Additionally, it provides a set of shared software components and services through FactoryTalk Services Platform (FTSP) to ensure reliable and secure communication across the system.
 4. Rockwell Automation FactoryTalk Historian Site Edition or Owner approved equal. This software product provides data collection, storage, and analysis capabilities for large-scale industrial applications. It enables users to capture time-series data from different sources including paper records, smart devices, and control systems. The system is designed to support distributed architectures, allowing users to centralize data storage, manage archives, and monitor performance. Additionally, it includes advanced features such as trending, comparative analysis, and alerts, enabling users to gain insights and optimize performance of their industrial processes.
- U. Networking Equipment: The Owner shall provide the networking equipment and communication cables used in the new dewatering control system. The Control System Integrator shall work with the Owner to determine the communication hardware & software configuration settings for the new SCADA, Pump Station Controllers, and Process Monitoring HMI Cabinets.

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 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. 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.
5. Listing and description of routine maintenance, requirements, and equipment necessary to perform required maintenance. (Include in O&M Manual only).
6. Specifications and descriptions of panel mounted hardware including lights, switches, annunciators, controllers, displays, and power supplies, etc.
7. List of recommended spare parts.
8. 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 Control System Integrator. Testing shall be open to observation by the Owner and Control System Integrator 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.
9. 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 existing distribution panels. 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.
10. 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.
11. The control panels shall be installed at the locations shown on the design 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.

12. The Control System Integrator shall provide system start-up by a team of 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.
13. 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.
14. I&C Technician training for operation, maintenance, programming, and troubleshooting shall be provided. At least two (4) 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" Rockwell Automation classroom instruction on the system furnished under this Contract.
15. The Control System Integrator shall provide:
 - a. Programmable Logic Controller and 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.
16. After successful completion of the new dewatering control and SCADA system, but prior to final acceptance of the work, the Control System Integrator must submit to Owner the 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.
- B. Power outages in the electrical distribution system that last longer than 8 hours will not be counted as a loss against process control during acceptance test.

3.3 INSTALLATION OF INSTRUMENTATION CONDUIT, CABLE TRAY, AND CABLES

- A. Furnishing and installation of all conduits and cable tray 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 control wiring shown on the Plans shall be the responsibility of the Control System Integrator. The Control System Integrator shall coordinate sub-contractors, including but not limited to the Electrical Sub-Contractor to provide a fully functional control system. The 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 entries to instruments, control cabinets, and junction boxes in the dewatering pump rooms. Use side entry for entries into enclosures that are mounted at floor level.
- 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 Calibration and Scaling 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 to assure proper installed operation.
 3. Calibrate in accordance with the manufacturer's specifications.
 4. 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.
 5. Any instrument which cannot be properly adjusted and fails check-out will be replaced by the Owner.
 6. Stroke control valves to verify control action, positioner settings, and solenoid functions.
 7. 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.
 8. 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.
 9. 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 Control System Integrator and the Owner 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 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 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.
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 as 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. Sump and reservoir 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 Control System Integrator shall coordinate a meeting with the Owner to define general display configuration, navigation, and functionality. The Control System Integrator shall submit sample graphics to the Owner for final approval.

END OF SECTION 40 6900