CONTRACT DOCUMENTS

AND

SPECIFICATIONS

FOR

PROJECT NO. TMUA-W 21-04
WOODS PUMP STATION IMPROVEMENTS

ATTENDANCE AT PRE-BID CONFERENCE IS MANDATORY

PREPARED BY:
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OKLAHOMA CA NO. 1975
EXPIRES 6/30/26
GH PROJECT NO.: 0141G
MARCH 2025

WATER AND SEWER DEPARTMENT

Account Numbers: 2331W00005.WATERCAP.7417400.6021

Water and Sewer Department
175 S. 2nd Street, Suite 1300
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VOLUME II - TECHNICAL SPECIFICATIONS

(NO TEXT FOR THIS PAGE)

CONTRACT DOCUMENTS

AND

SPECIFICATIONS

FOR

PROJECT NO. TMUA-W 21-04
WOODS PUMP STATION IMPROVEMENTS

Prepared for:

TULSA METROPOLITAN UTILITY AUTHORITY
CITY OF TULSA, OKLAHOMA

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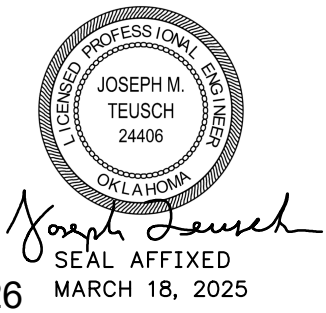

Oklahoma CA No. 1975, Expires 06/30/2026
GH Project No. 0141G
March 2025

GREELEY AND HANSEN

VOLUME II - TECHNICAL SPECIFICATIONS

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SECTION 00 00 10

TULSA MUNICIPAL UTILITIES AUTHORITY

WOODS PUMP STATION IMPROVEMENTS

VOLUME II – TECHNICAL SPECIFICATIONS

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SUMMARY OF WORK

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Description of Work

B. Constraints

C. Work By Others

D. CONTRACTOR's Use of Site

E. Security

F. Safety

G. Work Sequence

H. Owner Occupancy

1.2 DESCRIPTION OF WORK

A. General: The Work comprises furnishing all labor, materials, equipment, supplies, and services for the Woods Pump Station Improvements Project. The work includes, but is not limited to, pump refurbishments, new electric motors and AFDs, HVAC equipment, roof modifications, new electrical feeders, electrical and SCADA improvements, and all associated Work complete in place as shown and specified in the Contract Documents titled “Woods Pump Station Improvements” Project.

B. The Work includes, but is not limited to, the following:

1. Removal of existing natural gas engines and associated cooling system, intake/exhaust piping and roof penetration repair.

2. Refurbishment and re-installation of existing pumps.

3. Installation of new 400 hp 480V electric motors and adjustable frequency drives and control equipment.

4. Installation of new HVAC equipment.

5. Installation of new process control equipment.

6. Development and implementation of new PLC panels programming for the Woods Pump Station.

7. Replacement of electrical feed equipment including new feeders for new outdoor transformer.

8. Replacement of existing standby generator and automatic transfer switch.

9. All startup, commissioning, testing, record documentation, and training associated with improvements.

C. The Work includes:

1. Furnishing all labor, materials, superintendence, plant, power, light, heat, fuel, water, tools, appliances, equipment, supplies, services and other means of construction necessary or proper for performing and completing the Work.

2. Sole responsibility for adequacy of CONTRACTOR'S plant and equipment.

3. Maintaining the Work area and site in a clean and acceptable manner.

4. Maintaining existing facilities in service at all times except where specifically provided for otherwise herein.

5. Protection of finished and unfinished Work.

6. Repair and restoration of Work damaged during construction.

7. Furnishing as necessary proper equipment and machinery, of a sufficient capacity, to facilitate the Work and to handle all emergencies normally encountered in Work of this character.

8. Furnishing, installing, and protecting all necessary guides, track rails, bearing plates, anchor and attachment bolts, and all other appurtenances needed for the installation of the devices included in the equipment specified. Make anchor bolts of appropriate size, strength and material for the purpose intended where not specifically shown or specified. Furnish substantial templates and shop drawings for installation.

D. Implied and Normally Required Work: It is the intent of these Specifications to provide the OWNER with complete operable systems, subsystems and other items of Work. Any part or item of Work which is reasonably implied or normally required to make each installation satisfactorily and completely operable is deemed to be included in the Work and the Contract Amount. All miscellaneous appurtenances and other items of Work incidental to meeting the intent of these Specifications are included in the Work and the Contract Amount even though these appurtenances may not be specifically called for in these Specifications.

E. Quality of Work: Regard the apparent silence of the Contract Documents as to any detail, or the apparent omission from them of a detailed description concerning any Work to be done and materials to be furnished as meaning that only the best general practice is to prevail and that only materials and workmanship of the best quality are to be used. Interpretation of these specifications will be made upon this basis.

1.3 CONSTRAINTS

A. The Contract Documents are intended to allow the CONTRACTOR flexibility in construction of the Work, however, the following constraints apply:

1. Prepare and submit a proposed sequence of construction for completing the Work in accordance with Section 01 32 16. Arrange the schedule to complete work in phases and permit operation by the OWNER of completed phases and parts thereof.

2. One functioning pump shall be available for service at all times during construction.

3. No work which interferes with critical operations of facilities shall be performed between April 1 and October 31 of each year during construction.

4. Owner will allow use of bridge crane provided no lifted loads exceed 50% of the rated capacity of the crane. prior to commencing the work, submit to the engineer for information, anticipated lifts and loading as well as perform an initial inspection indicating any defects or damage to the overhead crane and all associated components. contractor will be held responsive for any damage resulting from use of the crane. if any load exceeds 50% of the rated capacity of the crane, the contractor will provide a load test and inspection of the crane performed by an OSHA certified crane and hoist inspection company prior to commencing the work and must pass a load test and inspection upon completion of the work. Load test and inspection shall be at the contractor's expense.

5. Generators provided and operated at all times during the construction period by the CONTRACTOR shall be the “Whisper Quiet” type and rated to have a maximum noise level of 55 dBA during their operation.

6. Provide and make as a part of Work any temporary structures, connections, piping, electrical and other services necessary to maintain service during the construction period. Remove all temporary facilities after successful completion of the Work.

7. Work on this Contract must be coordinated with the operation of the site. Notify the OWNER, with written notice, of the CONTRACTOR's planned procedures for each specific alteration or shutdown of existing facilities 30 calendar days before the alteration or shutdown begins. Do not commence with the alteration or shutdown until specific permission has been granted by the OWNER in each case. The OWNER will coordinate the CONTRACTOR's planned procedure with the operation of the site. The making of connections to existing facilities or other operations that interfere with the operation of the existing equipment must be completed as quickly as possible and with as little delay as possible. Prior to commencing with the work all required components, tools, and equipment are to be on-site. Work multiple or extended shifts to complete the work within the specified amount of time. The costs for any additional labor, equipment, and material to complete the required modifications within the specified amount of time are to be included in their associated Contract Item and no separate payment will be made therefore.

8. Any operational functions of the existing site that are required to be done to facilitate the work of the CONTRACTOR will be performed by OWNER only as identified in approved planning.

9. If it is necessary for the proper operation or maintenance of the site, the CONTRACTOR must reschedule work to not conflict with necessary operation or maintenance of the site.

10. The OWNER will be the sole judge of when the CONTRACTOR's operations are causing interference with conveyance and wastewater treatment processes, and the OWNER's orders and instructions must be carried out without delay.

11. CONTRACTOR shall perform work in such a manner to prevent damage to portions of the system and structures which are to remain in place. Repair or replace, without cost to the City, any portions of system and structures which are outside of the limits of removal, as shown on the Contract Documents, and which are damaged by the CONTRACTOR.

1.4 WORK BY OTHERS

A. Work on other projects, may take place concurrently with this CONTRACT and these are excluded from this CONTRACT. Coordinate work schedules to accommodate simultaneous projects.

1.5 SITE CONDITIONS

A. Actual Conditions: Make any geotechnical investigations deemed necessary to determine actual site conditions.

B. Underground Utilities: Locate and identify all existing underground utilities prior to the commencement of Work.

C. Quality and Quantity: Make any other investigations and determinations necessary to determine the quality and quantities of earth and rock and the methods to be used to excavate these materials.

1.6 CONTRACTOR'S USE OF SITE

A. Limit use of site and premises for Work and storage to allow for the following:

1. OWNER occupancy and access to operate existing facilities.

2. Coordination of site use with ENGINEER.

3. Responsibility for protection and safekeeping of products under this CONTRACT.

4. Providing additional off site storage at no additional cost to OWNER as needed.

1.7 SECURITY

A. The project site where equipment installation Work is to be performed under this Contract is an unsecured site. The CONTRACTOR shall be responsible for security as described below at the site where he is performing Work under this Contract.

B. Site Access: The CONTRACTOR shall implement the following measures to apply to all Work performed under this Contract.

1. For each employee the CONTRACTOR employs for work at the project site, CONTRACTOR shall provide the following information to the ENGINEER: Name, address, Social Security Number, office and cell phone numbers, length of employment with CONTRACTOR. The same information shall be provided for CONTRACTOR’s subcontractors.

2. CONTRACTOR shall maintain a log book listing as a minimum the names of all persons admitted to the secured site by the CONTRACTOR, the purpose of the site visit, the dates and times of arrival at the site, entry to the secured site, and departure from the site.

3. CONTRACTOR and OWNER acknowledge that CONTRACTOR shall not solely be responsible for all secured access to the site, that City personnel will have access and will be performing their regular duties pertaining to the operation and maintenance of the site facilities, and that security at the site shall require the cooperation of all persons authorized to access the site for the performance of their work. To the extent that CONTRACTOR is responsible for and has control of secured access, CONTRACTOR shall restrict site access to only persons essential to the performance or inspection for the work being performed under the Contract.

4. CONTRACTOR shall provide ENGINEER twenty-four (24) hours advance notification of any delivery of equipment or materials to the site, and shall make arrangements with ENGINEER to provide for inspection of such delivery.

C. Any observation by the CONTRACTOR of activity at or associated with the project site that CONTRACTOR observes and considers to be unusual or suspicious in nature, or that CONTRACTOR believes poses a threat to the integrity or welfare of the project site or associated facilities, shall be duly noted at the time of the observation in the log book identified in item B.2 above. Any such observation shall be immediately reported to the ENGINEER.

D. No statement pertaining to security in these Specifications shall constitute a contract between CONTRACTOR and OWNER for the performance of security services.

1.8 SAFETY

A. CONTRACTOR shall be responsible for performing all Work under this contract in a safe manner and in compliance with all applicable local, state, and federal safety and health regulations.

B. CONTRACTOR shall submit a site-specific safety plan and emergency response plan prior to start of Work. CONTRACTOR's attention is directed to safety regulations applicable to the Work under this contract.

C. Fire Prevention and Protection: The CONTRACTOR shall take all necessary measures to prevent fire, and shall provide satisfactory fire fighting means at the location of Work.

1.9 WORK SEQUENCE

A. Construct Work in stages to accommodate OWNER's use of premises during construction period and in accordance with the limitations on the sequence of construction specified. Coordinate construction schedules and operations with ENGINEER.

B. Coordinate Work of all subcontractors.

1.10 OWNER OCCUPANCY

A. OWNER will occupy premises during entire period of construction in order to maintain normal operations. Cooperate with OWNER's representative in all construction operations to minimize conflict, and to facilitate OWNER usage.

B. Conduct operations so as to inconvenience the general public in the least.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

A. Starting Work: Start Work within 10 days following the date stipulated in the written order from the Authority to proceed with the work and execute with such progress as may be required to prevent delay to other contractors or to the general completion of the project. Execute Work at such items and in or on such parts of the project, and with such forces, material and equipment, as to complete the Work in the time established by the Contract. At all times, schedule and direct the Work so that it provides an orderly progression to completion within the specified time for completion. However, do not start on-site construction activities other than Engineer’s Field Office, Contractor’s Field Office and Sheds, and exposed temporary utilities, until 60 days have elapsed from the date stipulated in the written order.

END OF SECTION

Contractor Evaluation Form

Contractor:			
Section 1: Process Description			
Process:	Facility:		
Project Description/Number:			
Section 2: Evaluation *(if answer is no, provide comments in space provided)*	Acceptable? (Circle Answer)		
Contractor consistently adhered to facility safety policies and procedures.	Yes	No	N/A
Contractor obtained all necessary permits prior to initiating work.	Yes	No	N/A
Contractor completed all monitoring as required by permits (i.e. hot work/confined space).	Yes	No	N/A
Contractor followed access control procedures.	Yes	No	N/A
Contractor used required personal protective equipment at all times.	Yes	No	N/A
Contractor provided adequate staffing to complete job safely.	Yes	No	N/A
Contractor used proper tools for all tasks as required.	Yes	No	N/A
Contractor informed plant superintendent/project engineer of any project changes.	Yes	No	N/A
Contractor maintained a clean job site (i.e. demonstrated good housekeeping).	Yes	No	N/A
Section 3: Comments			

Section 4: Contractor Rating	*Circle Answer*		Date
Overall contractor safety rating	Satisfactory	Unsatisfactory	
Prepared by: Plant Superintendent	_____ signature		

Management of Change Form

Facility:		Process Involved:
Proposed Change Date:		
Prepared By:	Title:	Date:

Type of Change - *(circle one)*

Chemical Process Technology Facility Equipment Procedural

Description of Proposed Change and Potential Hazards	*Summarize the technical basis for the proposed change and any potential health and safety impacts resulting from the proposed change. Indicate whether the proposed change sinificantly affects safety or the results of any previous hazard analyses. If the change is temporary, indicate proposed change start and end dates.*

Authorization to Proceed with Change

Title	Signature	Date
Environmental Operations Manager		

RMP Program Documentation: *(To be completed **prior to startup** following change)*	*Circle Answer*		*Completion Date (if yes)*
Have affected personnel (I.e., operations, maintenance, and contract) been informed of and trained in this change?	Yes	No	
Are operating procedures or maintenance procedures required to be updated as a result of this change?	Yes	No	
If yes, have affected personnel been trained in the updated SOPs?	Yes	No	
Is the Process Hazard Analysis, Offsite Consequence Analysis, or RMP applicability affected by this change?	Yes	No	
If yes, has a hazard assessment update been performed (if needed) and has the revised RMP been submitted?	Yes	No	
Is process safety information required to be updated as a result of this change?	Yes	No	
If yes, has a Prestartup Safety Review been performed?	Yes	No	

Authorization For Startup*

Title	Signature	Date
Environmental Operations Manager		

*Authorization based upon data provided, in part, by the Contractor. This approval does not relieve the Contractor of responsibility for conformity to the requirements of the plans and specifications and all applicable local, state, and federal regulations.

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SECTION 01 26 00

CHANGE ORDER, WORK CHANGE DIRECTIVE AND FIELD ORDER PROCEDURES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Definitions

B. Change Orders

C. Work Change Directives

D. Field Orders

1.2 DEFINITIONS

A. Change Order: Refer to the Change Order definition in Article 1 of the General Conditions.

B. Work Change Directive: Refer to the Work Change Directive definition in Article 1 of the General Conditions.

C. Overhead: Overhead is defined as the cost of administration, field office and home office costs, general superintendence, office engineering and estimating costs, other required insurance, materials used in temporary structures (not including form work), additional premiums on the performance bond of the CONTRACTOR, the use of small tools, scheduling costs, and all other costs incidental to the performance of the change or the cost of doing business.

D. Field Orders: Refer to the Field Order definition in the Supplementary Conditions.

1.3 CHANGE ORDERS

A. Initiation of Proposals:

1. From time to time, the OWNER or the ENGINEER may issue a request for a Change Order proposal. The request will contain a description of the intended change with supplementary or revised Drawings and Specifications as applicable, and the projected time for accomplishing the change.

2. The CONTRACTOR may propose a change in the Work by submittal of a Change Order request to the ENGINEER describing the proposed change with a statement of the reason for the change and the effect on the Contract times and price, along with supporting documentation.

B. Execution of a request for a Change Order Proposal:

1. When a proposal is requested for changed Work, submit proposal within 14 days following receipt of the request from OWNER or ENGINEER. State the increase or decrease, if any, in Contract Completion times and Contract Price.

2. Explain proposal in sufficient detail to permit review by OWNER.

3. For omitted Work, the decrease in the Contract Price will be determined by the ENGINEER and will include appropriate amounts for profit and overhead.

4. The OWNER and ENGINEER will review the proposal and may request additional information and documentation. Provide these items upon request.

5. If the OWNER decides to proceed with the change, the OWNER will issue a Change Order for signature first by the CONTRACTOR and then by the OWNER.

6. The CONTRACTOR will promptly complete the approved change in the Work on receipt of the executed Change Order.

a. Failure to sign the Change Order does not relieve the CONTRACTOR from performing the Work if the Change Order is signed by the OWNER.

C. Execution of a change order request:

1. The OWNER and ENGINEER will review the request and may request additional information and documentation. Provide these items upon request.

2. For omitted Work, the decrease in the Contract Price will be determined by the ENGINEER and will include appropriate amounts for profit and overhead.

3. If the OWNER decides to proceed with the change, the OWNER will issue a Change Order for signature first by the CONTRACTOR and then by the OWNER.

4. The CONTRACTOR will promptly complete the approved change in the Work on receipt of the executed Change Order.

   a. Failure to sign the Change Order does not relieve the CONTRACTOR from performing the Work if the Change Order is signed by the OWNER.

D. Compute the cost of both additive and deductive changes in the Work in accordance with General Conditions GC-26.

1.4 WORK CHANGE DIRECTIVES

A. Initiation by OWNER: OWNER may issue a Work Change Directive with a Notice to Proceed without a prior request for a Change Order Proposal or the CONTRACTOR's signature.

B. Payment Determination: The OWNER will designate the method of determining the amount of compensation or credit.

C. Timing: Proceed with the change in the Work immediately upon receipt of the Work Change Directive.

D. Addition to Contract: The Work Change Directive Orders will be incorporated into the Contract Documents via a Change Order at a later date.

1.5 FIELD ORDERS

A. The ENGINEER may issue a written order at any time during the course of construction.

B. Field Orders serve as documentation of minor changes in the Work not involving a change in the Contract Price or Times.

C. Proceed with the change described in the Field Order immediately upon receipt of the field order.

D. If CONTRACTOR is of the opinion that the Field Order affects either the Contract Price or Times, provide written notice to ENGINEER within 48 hours of receiving the Field Order.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

END OF SECTION

SECTION 01 29 00

PAYMENTS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Schedule of Values

B. Application for Payment

1.2 SCHEDULE OF VALUES

A. Approval of Schedule: Submit for approval a Schedule of Values, in duplicate, for all of the Work. Submit schedule of Values within 15 calendar days after work has commenced. Prepare the schedule of values as a detailed breakdown of lump sum and unit prices bid for each item of the Contract. The total of all items, so broken down, shall equal the total amount of the Contract. Submit such other information relating to bid prices as requested by the ENGINEER, and revise the Schedule of Values to a form acceptable to the ENGINEER. Following acceptance of the Schedule of Values, it may be used for checking CONTRACTOR'S applications for partial payments, but shall not be binding on the OWNER or ENGINEER for any purpose whatsoever. Be advised that no partial payment will be processed unless the Schedule of Values is submitted in accordance with the above requirements.

B. Format: Utilize a format similar to the Table of Contents of the Project Specifications. Identify each line item with number and title of the major specification section. Identify site mobilization, bonds and insurance. Include within each line item, a direct proportional amount of CONTRACTOR'S overhead and profit.

C. Revisions: With each Application for Payment revise schedule to list approved Change Orders.

1.3 APPLICATION FOR PAYMENT

A. Required Copies: Submit three copies of each application. Present required information in typewritten form or on electronic media printout. Present actual invoices for materials for direct payment by OWNER. Include a current summary of payment to date.

B. Execute certification by signature of authorized officer.

C. Use data from approved Schedule of Values.

D. Stored Materials: When payment for materials stored is permitted, submit a separate schedule for Materials Stored showing line item, description, previous value received, value incorporated into the Work and present value.

E. Submit the Extension of Time Request Form with each partial payment application in accordance with General Condition GC-14.

F. Change Orders: List each authorized Change Order including Change Order number and dollar amount as for an original item of work.

G. Final Payment: Prepare Application for Final Payment as required in General Condition GC-29(2).

H. Submit an updated construction schedule with each Application for Payment. Revise schedule to show Work completed to date and remaining Work. Schedule remaining Work to achieve completion of all contract Work by the contract completion date.

I. Submit application for payment to ENGINEER on, or before, the first day of each month.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

END OF SECTION

SECTION 01 29 50

CONTRACT ITEMS

PART 1 GENERAL

1.1 CONTRACT ITEM 1 – MOBILIZATION AND DEMOBILIZATION

A. Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary to mobilize and subsequently demobilize the construction preparatory operations. The Work includes bonds, insurance, movement in and out of personnel and equipment, project signs, and establishment of the Contractor's offices. A maximum of 3 percent of the total bid for Contract Item 1 is allowed for Mobilization and Demobilization in the bid proposal.

B. Payment: Payment for Mobilization and Demobilization will be distributed in the following manner:

1. Sixty percent (60%) of the price bid for mobilization and demobilization may be included in the pay estimate which reflects five percent (5%) completion of the Work.

2. An additional fifteen percent (15%) of the price bid for mobilization and demobilization may be included in the pay estimate which reflects fifty percent (50%) completion of the Work.

3. The final twenty five percent (25%) of the price bid for mobilization and demobilization may be included in the final pay estimate.

1.2 CONTRACT ITEM 2 – CONSTRUCTION ALLOWANCE

A. Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary to perform the additional miscellaneous work as directed by the Owner. This work is not shown on the drawings or specified, but which is subsequently identified by the Engineer as being necessary to complete the project. When work is required under this Item, the Contractor will be sent a request for proposal by the Engineer. If the proposal is accepted by the Owner, the Contractor will be notified to proceed with the required work. All work will be performed by the Contractor's own forces to the greatest extent possible. An allowance of one hundred thousand dollars ($100,000) is included in this item. This allowance will be used to compensate the Contractor for work performed under this item. No Work will be performed under this allowance without the written consent of the Owner.

B. Payment: Payment for Work Allowance will be made from the Contract lump sum price. At the completion of the Contract, all remaining funds will be deducted from the total contract price.

1.3 CONTRACT ITEM 3 – SWPPP/SOIL PROTECTION AND SITE RESTORATION

A. Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services for the Stormwater Pollution Prevention Plan (SWPPP) and Soil Protection and Site Restoration Work as shown, specified, and directed in the Contract Documents. Work includes implementation of SWPPP and Soil erosion protection at the site and all Work, including grading, seeding, watering, and fertilizing, for the restoration of the Site to pre-construction conditions.

Payment: Payment for SWPPP/Soil Protection and Site Restoration will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

1.4 CONTRACT ITEM 4 – EXISTING PUMP MOTOR/GEAR REDUCER DEMOLITION

A. Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services for the demolition of the existing pump motors and gear reducers together with all associated and appurtenant Work as shown, specified and directed in the Contract Documents.

Work includes the removal from service, demolition of, and hauling away and disposal of the existing pump motors and gear reducers.

B. Payment: Payment for this Contract Item will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

1.5 CONTRACT ITEM 5 – AIR INTAKE / EXHAUST PIPING DEMOLITION AND ROOF REPAIR

A. Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary for the completion of the Work. This includes: demolition and disposal of the intake and exhaust piping associated with the existing pump motors and roof rehabilitation together with all associated and appurtenant Work as shown or specified in the Contract Documents, except for Work specifically included under other Contract Items.

B. Payment: Payment for this Contract Item will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

1.6 CONTRACT ITEM 6 – CAPACITY AND SCADA CONTROL PANEL DEMOLITION

A. Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary for the completion of the Work. This includes: demolition and disposal of the SCADA Control Panel together with all associated and appurtenant Work as shown or specified in the Contract Documents, except for Work specifically included under other Contract Items.

B. Payment: Payment for this Contract Item will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

1.7 CONTRACT ITEM 7 – ELECTRICAL DEMOLITION

A. Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary for the completion of the Work. This includes: demolition and disposal of electrical equipment together with all associated and appurtenant Work as shown or specified in the Contract Documents, except for Work specifically included under other Contract Items.

B. Payment: Payment for this Contract Item will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

1.8 CONTRACT ITEM 8 – HVAC EQUIPMENT

A. Description: Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary for the completion of the Work. This includes: installation, testing, startup, and training of the new HVAC equipment together with all associated and appurtenant Work as shown or specified in the Contract Documents, except for Work specifically included under other Contract Items.

B. Payment: Payment for this Contract Item will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

1.9 CONTRACT ITEM 9 – ELECTICAL FEEDERS

A. Description: Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary for the completion of the Work. This includes: installation and testing of the electrical feeders, conduit, and conduit hangers together with all associated and appurtenant Work as shown or specified in the Contract Documents, except for Work specifically included under other Contract Items.

Payment: Payment for this Contract Item will be made at the per unit Contract price.

1.10 CONTRACT ITEM 10 – CONCRETE DUCTBANK

A. Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary to install new concrete ductbanks including work to unclassified excavation, backfill and compaction of select fill, installing new ductbanks and removal and disposal of excess excavated material as shown and specified in the Contract Documents, except for Work specifically included under other Contract Items.

B. Payment: Payment for this Contract Item will be made at the per unit Contract Price.

1.11 CONTRACT ITEM 11 – ELECTRIC MOTORS

A. Description: Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary for the completion of the Work. This includes: installation, testing, startup, and training of the new electrical motors together with all associated and appurtenant Work as shown or specified in the Contract Documents, except for Work specifically included under other Contract Items.

B. Payment: Payment for this Contract Item will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

1.12 CONTRACT ITEM 12 – ELECTRICAL EQUIPMENT STARTUP AND TESTING

A. Description: Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary for the completion of the Work. This includes: startup and training of the new electrical equipment together with all associated and appurtenant Work as shown or specified in the Contract Documents, except for Work specifically included under other Contract Items.

B. Payment: Payment for this Contract Item will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

1.13 CONTRACT ITEM 13 – EXTERIOR TRANSFORMER

A. Description: Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary for the completion of the Work. This includes: installation, testing, startup, and training of the Exterior Transformer equipment together with all associated and appurtenant Work as shown or specified in the Contract Documents, except for Work specifically included under other Contract Items.

B. Payment: Payment for this Contract Item will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

1.14 CONTRACT ITEM 14 – 480V SWITCHBOARD

A. Description: Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary for the completion of the Work. This includes: installation, testing, startup, and training of the new 480 volt switchboard equipment together with all associated and appurtenant Work as shown or specified in the Contract Documents, except for Work specifically included under other Contract Items.

B. Payment: Payment for this Contract Item will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

1.15 CONTRACT ITEM 15 – MAIN DISTRIBUTION PANELBOARD

A. Description: Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary for the completion of the Work. This includes: installation, testing, startup, and training of the new primary distribution panelboard equipment together with all associated and appurtenant Work as shown or specified in the Contract Documents, except for Work specifically included under other Contract Items.

B. Payment: Payment for this Contract Item will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

1.16 CONTRACT ITEM 16 – EMERGENCY DISTRIBUTION PANELBOARD

A. Description: Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary for the completion of the Work. This includes: installation, testing, startup, and training of the new emergency distribution panelboard equipment together with all associated and appurtenant Work as shown or specified in the Contract Documents, except for Work specifically included under other Contract Items.

B. Payment: Payment for this Contract Item will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

1.17 CONTRACT ITEM 17 – 400HP 480V AFDS

A. Description: Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary for the completion of the Work. This includes: installation, testing, startup, and training of the new 400 horsepower, 480 volt adjustable frequency drive equipment together with all associated and appurtenant Work as shown or specified in the Contract Documents, except for Work specifically included under other Contract Items.

B. Payment: Payment for this Contract Item will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

1.18 CONTRACT ITEM 18 – AUTOMATIC TRANSFER SWITCH; 240V, 150A

A. Description: Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary for the completion of the Work. This includes: installation, testing, startup, and training of the new automatic transfer switch equipment together with all associated and appurtenant Work as shown or specified in the Contract Documents, except for Work specifically included under other Contract Items.

B. Payment: Payment for this Contract Item will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

1.19 CONTRACT ITEM 19 – OIT PROGRAMMING (APPROXIMATELY 5 SCREENS)

A. Description: Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary for the completion of the Work. This includes: development, implementation, testing, and training of new operator interface terminal (OIT) programming together with all associated and appurtenant Work as shown or specified in the Contract Documents, except for Work specifically included under other Contract Items.

B. Payment: Payment for this Contract Item will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

1.20 CONTRACT ITEM 20 – SCADA HMI PROGRAMMING (APPROXIMATELY 5 SCREENS)

A. Description: Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary for the completion of the Work. This includes: development, implementation, testing, and training of new SCADA HMI programming together with all associated and appurtenant Work as

shown or specified in the Contract Documents, except for Work specifically included under other Contract Items.

B. Payment: Payment for this Contract Item will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

1.21 CONTRACT ITEM 21 – PLC CONTROL PANEL (APPROXIMATELY 350 I/0 POINTS)

A. Description: Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary for the completion of the Work. This includes: development, construction, implementation, testing, and training of new PLC Control Panel together with all associated and appurtenant Work as shown or specified in the Contract Documents, except for Work specifically included under other Contract Items.

B. Payment: Payment for this Contract Item will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

1.22 CONTRACT ITEM 22 – TESTING, COMMISSIONING, AND DRAWINGS

A. Description: Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary for the completion of the Work. This includes: all testing, commissioning, and record drawings required for the process integration together with all associated and appurtenant Work as shown or specified in the Contract Documents, except for Work specifically included under other Contract Items.

B. Payment: Payment for this Contract Item will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

1.23 CONTRACT ITEM 23 – CONSTRUCTION ALLOWANCE
(BID ALTERNATE)

A. Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary to perform the additional miscellaneous work as directed by the Owner. This work is not shown on the drawings or specified, but which is subsequently identified by the Engineer as being necessary to complete the project. When work is required under this Item, the Contractor will be sent a request for proposal by the Engineer. If the proposal is accepted by the Owner, the Contractor will be notified to proceed with the required work. All work will be performed by the Contractor's own forces to the greatest extent possible. An allowance of one hundred thousand dollars ($100,000) is included in this item. This allowance will be used to compensate the Contractor for work performed under this

item. No Work will be performed under this allowance without the consent of the Owner.

B. Payment: Payment for Work Allowance will be made from the Contract lump sum price. At the completion of the Contract, all remaining funds will be deducted from the total contract price.

1.24 CONTRACT ITEM 24 – 400 HP 480V SPARE VFD
(BID ALTERNATE)

A. Description: Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary for the completion of the Work. This includes: purchasing and delivery to the Owner a new spare 400 horsepower, 480-volt variable frequency drive as shown or specified in the Contract Documents, except for Work specifically included under other Contract Items.

B. Payment: Payment for this Contract Item will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

1.25 CONTRACT ITEM 25 – 35 KW GENERATOR
(BID ALTERNATE)

A. Description: Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary for the completion of the Work. This includes: installation, testing, startup, and training of the new 35kW Generator equipment together with all associated and appurtenant Work as shown or specified in the Contract Documents, except for Work specifically included under other Contract Items.

B. Payment: Payment for this Contract Item will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

1.26 CONTRACT ITEM 26 – PUMP REFURBISHMENT
(BID ALTERNATE)

A. Description: Description: The Work under this Contract Item includes furnishing all labor, materials, equipment and services necessary for the completion of the Work. This includes: installation, testing, startup, and training of the existing pump refurbishment together with all associated and appurtenant Work as shown or specified in the Contract Documents, except for Work specifically included under other Contract Items.

B. Payment: Payment for this Contract Item will be made at the per each Contract price. Monthly progress payments will be made based upon Contractor's percent complete for this Contract Item as approved by the Engineer.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 01 31 00

COORDINATION AND MEETINGS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Coordination

B. Preconstruction Conference

C. Progress Meetings

1.2 COORDINATION

A. General: Coordinate scheduling, submittals, and Contract work to assure efficient and orderly sequence of installation of interdependent construction elements.

B. Accessory Placement: Place conduits, saddles, boxes, cabinets, sleeves, inserts, foundation bolts, anchors and other like work in floors, roofs or walls of buildings and structures in conformity with the construction program.

1.3 PRECONSTRUCTION CONFERENCE

A. General: Prior to commencement of the Work, in accordance with paragraph 2.06 of the General Conditions, the OWNER will conduct a preconstruction conference to be held at a predetermined time and place.

B. Delineation of Responsibilities: The purpose of the preconstruction conference is to designate responsible personnel, to establish a working relationship among the parties and to identify the responsibilities of the OWNER, ENGINEER and the CONTRACTOR. Matters requiring coordination will be discussed and procedures for handling such matters, established. The agenda will include:

1. Submittal procedures
2. Partial Payment procedures
3. Maintenance of Records
4. Schedules, sequences and maintenance of facility operations
5. Safety and First Aid responsibilities
6. Change Orders
7. Use of site
8. Housekeeping
9. Equipment delivery

C. Attendees: The preconstruction conference is to be attended by the representatives of the CONTRACTOR, the OWNER and the ENGINEER who will be associated with the project. Representatives of regulatory agencies, subcontractors, and principal suppliers may also attend when appropriate.

D. Chair and Minutes: The preconstruction conference will be chaired by the CONTRACTOR who will also arrange for the keeping and distribution of meeting notes to all attendees.

1.4 PROGRESS MEETINGS

A. Meeting Frequency and Format: Schedule progress meetings on at least a monthly basis or more frequently as warranted by the complexity of the Project, to review the Work, discuss changes in schedules, maintain coordination and resolve potential problems. Invite OWNER, ENGINEER and all subcontractors. Suppliers may be invited as appropriate. Meeting notes will be prepared by CONTRACTOR who will distribute the notes to attendees within 10 calendar days after each meeting. Meeting notes will summarize meeting highlights.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

END OF SECTION

SECTION 01 32 16

PROGRESS SCHEDULE

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Scheduling Responsibilities

B. Submittals

C. Network Requirement

D. Cost Loading

E. Progress of the Work

F. Schedule Updates

1.2 SCHEDULING RESPONSIBILITIES

A. Format: Use the Critical Path Method to schedule and monitor job progress. Provide all information concerning sequencing logic and duration of all activities as well as the initial CPM logic network diagram and tabulated report data. Provide a licensed copy of the project scheduling software (version in use by Contractor) for Engineer's use for duration of the Project.

B. Initial Submittal: Within 30 days after the Notice to Proceed, submit the initial logic network diagram to the ENGINEER for review. Within 60 days submit final network diagram. All submittals are to consist of 6 color copies and a computer file(s).

C. Updates: On a monthly basis, furnish to the ENGINEER updated information on logic, percent complete, actual start and finish date and direction changes. Distribute copies at Progress Meetings.

D. Adherence: Schedule and direct forces in a manner that will allow for completion of the Work within the Contract time specified.

E. Accuracy: Provide initial schedule and subsequent update information to reflect the best efforts of the CONTRACTOR and all subcontractors as to how they envision the Work to be accomplished. Similarly, all progress information must be an accurate representation of the CONTRACTOR's and subcontractor's actual

performance. Complete Work under this Contract in accordance with the established CPM schedule.

F. Cost of Revisions: At no additional cost to the OWNER, revise schedule when in the judgement of the ENGINEER, it does not accurately reflect the actual prosecution of the Work.

1.3 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 1.

B. CPM Schedule:

1. Within 30 days after the date stated in the Notice to Proceed, submit to the ENGINEER prints of a proposed CPM network diagram and tabular reports for the first 90 days of the Work. Draw initial logic diagram as described herein and submit on sheets 24 inches by 36 inches. Include both procurement and construction activities. Schedule a review meeting with the ENGINEER and the OWNER (or OWNER's Consultants) within 2 weeks of its submission. Revise and resubmit the 90-day schedule until it is acceptable to the ENGINEER.

2. Within 60 Days after the Notice to Proceed, submit to the ENGINEER 3 sets of the proposed CPM logic diagram and tabular reports for the entire Contract duration. Include both procurement and construction activities. Sort these tabular reports by total float and activity number. Provide a predecessor/successor report, resource loading report, and project calendar. Draw logic diagram as described.

3. Schedule review meeting with the ENGINEER and the OWNER within 2 weeks of its submission. If a review of the submitted CPM Schedule indicates a work plan which will not complete the Work within the time requirements stated in the Contract, reallocate resources, revise the CPM Schedule and resubmit it until it is acceptable. Failure by the CONTRACTOR to submit an acceptable schedule may, at the OWNER's sole discretion, be cause for the withholding of any partial payment otherwise due under the Contract.

4. Review of the Schedule by the ENGINEER will not constitute ENGINEER's representation that the Work can be completed as shown on the Schedule.

C. Submittals Schedule: In addition to the above scheduling requirements, submit a complete and detailed listing of anticipated submittals during the course of the Contract. Coordinate these submittals with those of subcontractors and suppliers. Identify each submittal by Contract drawing number and Specification section number. Show the anticipated submission due date for each submittal along with

the date on which its return is required. For planning purposes, average turn-around time for shop drawings will be 14 Calendar Days after receipt. Longer durations for review may be required and will not be considered a basis for a claim for additional time or compensation.

1. Submit Submittal schedule within 10 Days from the Notice to Proceed. Revise as required and incorporate the dates and review durations into the CPM Schedule.

1.4 NETWORK REQUIREMENTS

A. Diagram: Show in the network diagram the order and interdependence of activities and the sequence in which the Work is to be accomplished. The purpose of the network analysis diagram is to show how the start of a given activity is dependent on the completion of preceding activities and its completion restricts the start of succeeding activities. Follow a time scaled precedence format. Time scale the detailed network diagram showing a continuous flow from left to right. The schedule will describe and indicate the critical path. Activities with total float less than 10 Days as defined as near critical.

B. Develop the schedule activities into two major groups; procurement activities; and construction activities:

1. Include the following procurement activities as a minimum:

a. Permits
b. Easements
c. Submittal items
d. Approval of submittal items
e. Fabrication and delivery of submittal items.

Tie each of the above procurement items logically to the correct construction activity in the overall CPM construction schedule. Include allowances for the resubmittal and re-review of complex shop drawings.

2. Under construction activities section utilize physical work activities to describe how the job will be constructed.

C. Activity Durations: Break the work into activities with durations of 1 to 20 Days each, except for nonconstruction activities, such as procurement of materials and delivery of equipment, and other activities which may require longer durations. To the extent feasible, group activities related to a specific physical area of the project on the network for ease of understanding and simplification. The ENGINEER and OWNER will review the selection and number of activities.

1. For each activity on the network indicate the following:

   a. A single duration, no longer than 20 Days (i.e., the single best estimate of the expected elapsed time considering the scope of work involved in the activity) expressed in Days. Include normal holidays and weather delay. Show critical path for the schedule.

   b. Assign an activity I.D. number to each activity. The I.D. number will be numeric with a maximum of 5 digits.

   c. Include a brief description of the activity. If this description is not definitive, a separate listing of each activity and a descriptive narrative may be required.

   d. Cost load each activity, except for procurement activities, to indicate the total estimated costs of the activity. No activity shall exceed $25,000 except for equipment items. Assign material costs to delivery activities.

   e. Load each activity with the estimated work hours to be expended on each activity.

D. Incomplete Schedule: Failure to include on the network any element of work required for the performance of this Contract does not excuse the CONTRACTOR from completing all Work required within the applicable completion time, notwithstanding the network review by the ENGINEER or the OWNER and OWNER's Authorized Representative.

1.5 COST LOADING

A. Schedule of Values: Allocate a dollar value to each activity on the construction schedule as specified. Include in dollar value the cost of labor, equipment, and material, and a pro rata contribution to overhead and profit. The sum of the activities cost shall be equal to the total contract price. In submitting cost data the CONTRACTOR certifies that it is not unbalanced and that the value assigned to each activity represents the CONTRACTOR's estimate of the actual costs of performing that activity.

B. Documentation: If, in the opinion of the ENGINEER, the cost data does not meet the requirements for a balanced Contract Price breakdown, present documentation to the ENGINEER substantiating any cost allocation. If an activity on the construction schedule has been assigned a disproportionate allocation of direct costs, overhead and profit the cost allocations will be considered unbalanced.

1.6 PROGRESS OF THE WORK

A. Delays to Critical Path: Whenever it becomes apparent from the current monthly CPM Schedule update that delays to the critical path have resulted and these delays are through no fault of the OWNER, and hence, that the Contract completion date will not be met, or when so directed by the OWNER, take one or more of the following actions to improve the Completion Date at no additional cost to the OWNER.

1. Increase construction labor in such quantities and crafts as will substantially eliminate the backlog of Work.

2. Increase the number of working hours per shift, shifts per day, or days per week; the amount of construction equipment; the forms for concrete work; etc., or any combination of the foregoing to substantially eliminate the backlog of Work.

3. Reschedule activities to achieve maximum practical concurrence of accomplishment of activities, and comply with the revised schedule.

4. Submit to the ENGINEER, the OWNER or OWNER's Authorized Representatives for review, a written statement of the steps proposed to be taken to remove or arrest the delay to the schedule. Failure to submit a written statement of the steps to be taken or failure to take such steps as required by the Contract, may result in the OWNER directing the level of effort in labor (trades), equipment, and work schedule (overtime, weekend and holiday work, etc.) to be employed by the CONTRACTOR in order to remove or arrest the delay to the critical path in the accepted schedule. Promptly provide such level of effort at no additional cost to the OWNER. In addition, should schedule delays persist, the CONTRACTOR's surety will be asked to attend meetings at which schedule is updated.

5. If the requirements of this provision are not complied with, the OWNER at the OWNER's sole discretion, will withhold, partially or in total, payments otherwise due for work performed under this Contract. Any withholding of monies is not a penalty for noncompliance, but is an assurance to the OWNER that funds will be available to implement these requirements should the CONTRACTOR fail to do so.

1.7 SCHEDULE UPDATES

A. Monthly Meetings: If determined by the OWNER, a monthly Schedule Update Meeting will be held 1 week prior to the progress meeting at the construction site to review and update the CPM Schedule. The Schedule Update Meeting will be chaired by the ENGINEER and attended by the OWNER and the CONTRACTOR. Actual progress of the previous month will be recorded and future activities will be reviewed. The duration of activities and their logical connections may be revised

as needed. Decisions made at these meetings and agreed to by all parties are binding with the exception that no contract completion dates will be modified without formal written requests and acceptance as specified herein. In the event a monthly Schedule Update Meeting is not required by the ENGINEER, the CONTRACTOR shall submit the update information to the OWNER and the update worksheets provided with each previous update. In either case the CONTRACTOR must provide the following information for each update at a minimum:

1. Actual start and finished dates for all completed activities.

2. Actual start dates for all started but uncompleted activities including remaining durations.

B. Withholding of Payments: Failure to provide specified updated information or failure to attend progress meetings may result in the withholding of progress payments.

C. Time Extensions: If in accordance with the provisions of General Condition GC-14, the OWNER or ENGINEER finds that the CONTRACTOR is entitled to any extension of the Contract completion date under the provisions of the Contract, the OWNER's determination as to the total number of Days extension will be based upon the current accepted and updated CPM Schedule and on all data relevant to the extension. Such data shall be included in the next monthly updating of the schedule. Actual delays in activities which, according to the CPM Schedule, do not affect any contract completion date shown by the critical path in the network, do not have any effect on the Contract completion date or dates and therefore, will not be the basis for a change in Contract completion time.

D. Schedule Adjustments: From time to time it may be necessary for the Contract schedule and completion time to be adjusted by the OWNER to reflect the effects of job conditions, acts or omissions of other contractors not directly associated with this Contract, weather, technical difficulties, strikes, unavoidable delays on the part of the OWNER or OWNER's representatives, and other unforeseeable conditions. Under such conditions, the OWNER will direct the CONTRACTOR to reschedule the Work to reflect the changed conditions and will grant, in writing, schedule extensions affecting the Contract completion time. No additional compensation will be made to the CONTRACTOR for such schedule adjustments.

E. Acceleration Costs: Additional compensation will be made to the CONTRACTOR in the event the OWNER requires the project completion prior to the completion date shown on the CONTRACTOR's accepted schedule. The OWNER, therefore, has the right to accelerate the schedule and the CONTRACTOR will be compensated for such acceleration as long as such acceleration is not required through fault of the CONTRACTOR. Available total float in the CPM Schedule may be used by the OWNER and OWNER's representatives as well as by the CONTRACTOR.

F. Float: Without obligation to extend the overall completion date or any intermediate completion dates set out in the CPM network, the OWNER may initiate changes to the Contract Work that absorb float time only. OWNER-initiated changes that affect the critical path on the CPM network shall be the sole grounds for extending (or shortening) said completion dates. CONTRACTOR initiated changes that encroach on the float time identified in the CPM network may be accomplished with the OWNER's concurrence. Such changes, however, shall give way to OWNER-initiated changes competing for the same float time.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 01 33 00

SUBMITTALS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Description

B. Definitions

C. Contractor's FTP or Share File Website

D. Submittal Procedures

E. ENGINEER'S Actions on Submittals

F. Repetitive Reviews

G. Example Format for CONTRACTOR's Approval and Certification Stamp

H. CONTRACTOR's Submittal Transmittal Form

1.2 DESCRIPTION

A. This Section specifies procedural requirements for submittals made by the CONTRACTOR to the ENGINEER. Specific submittals required for individual elements of the Work are specified in the associated, individual Specification Sections. Except as otherwise indicated in other Specification Sections, comply with the requirements specified herein for each type of submittal.

1.3 DEFINITIONS

A. Shop Drawings: The term "Shop Drawings", as used in the General Conditions includes all "Action Submittals" and "Information Submittals" as defined below.

B. Action Submittals: The following submittals require approval by the ENGINEER as described in Subsection 3.2 of this Section:

1. Manufacturer's Documents: Technical data, drawings and other similar information specially prepared for this Project by product manufacturers and suppliers, including fabrication and installation drawings, diagrams, actual performance curves, data sheets, schedules, templates, patterns, reports,

instructions, design mix formulas, measurements, and similar information not in standard printed form.

2. Product Data: Stock or standard printed information on materials and equipment that has not been specially prepared for this Project, including specifications, installation instructions, catalog cuts, wiring diagrams, and color charts.

3. Working Drawings: Technical data, drawings and other similar information specially prepared for this Project by the CONTRACTOR or Subcontractors, including fabrication and installation drawings, diagrams, and other similar information.

4. Samples: Physical examples of materials, equipment, or workmanship that are representative of some portion of the Work and which establish the standards by which such portion of the Work will be judged.

5. Mock-Ups: Special types of samples that are too large or otherwise inconvenient for handling in the manner specified for transmittal of sample submittals.

6. "Or Equal" or Substitution Requests: Wherever a proprietary item is identified by the product, manufacturer or supplier name and/or model number, an “Or Equal” (“equal to” or “equivalent”) item may be submitted unless the description of the item contains a prohibition against an ”Or Equal”.

    a. An item may be determined “Or Equal” only at the sole discretion of the ENGINEER, based upon the following criteria:

        (1) The item is equal in quality, durability, appearance, strength, and design characteristics.

        (2) The item will perform to meet the design concept.

        (3) No changes to other work will be required to accommodate the item.

        (4) No addition to the Contract Price or Contract Times will be required as a result of the use of the item.

        (5) OWNER will not incur any additional cost as a result of the use of the item.

    b. If the ENGINEER, at its sole discretion, determines that a proposed item is not an “Or Equal”, the proposed item may be considered as a “Substitute” item.

C. Information Submittals: The following submittals require acknowledgement by the ENGINEER as described in Subsection 3.2 of this Section:

1. CONTRACTOR's Licensed Professional Submittals: Certificates and other documents required by the Contract Documents to be prepared and submitted by the CONTRACTOR's Licensed Professionals.

2. Inspection and Test Reports

3. Mill reports

4. Guarantees

5. Warranties

6. Certifications

7. Experience records

8. Maintenance agreements

9. Survey data and reports: property surveys, building or structure condition surveys, field measurements, quantitative records of actual Work, damage surveys, photographs, and similar data required by Specification sections.

10. Physical work records

11. Quality testing and certifying reports

12. Industry standards

13. Record drawings

D. Other Submittals: For submittals concerning the following refer to the indicated Contract Document Section:

1. Listing of manufacturers – Section 01 60 00

2. Suppliers, and subcontractors – Section 01 60 00

3. Construction progress schedule – Section 01 32 16

4. Warranty Log – Section 01 32 16

5. Schedule of shop drawing submissions – Section 013 33 00

6. Bonds – General Condition GC-12

7. Schedule of values – Section 01 29 00

8. Payment applications– Section 01 29 00 and General Condition GC-29

9. Insurance certificates – General Condition GC-12

E. Clarifications and Interpretations: Refer to the General Conditions

1. The CONTRACTOR is responsible to review the Contract Documents, determine the type and extent of the Work and make all necessary field measurements before starting the Work. If any conflict, error, ambiguity, or discrepancy is discovered the CONTRACTOR is to submit a written request for interpretation or clarification from ENGINEER. The ENGINEER will issue a written clarification or interpretation of the requirements of the Contract Documents as ENGINEER may determine necessary, consistent with the intent of and reasonably inferable from the Contract Documents. Such written clarifications and interpretations will be binding on the CONTRACTOR.

2. If the CONTRACTOR submits a written request for information that does not, in the sole discretion of the ENGINEER, require clarification or interpretation of the Contract Documents, ENGINEER will notify CONTRACTOR that such information is contained (or could otherwise be reasonably determined) in the Contract Documents. The CONTRACTOR shall reimburse OWNER for ENGINEER's charges for evaluating and responding to such a request for information.

1.4 CONTRACTOR'S FTP OR SHARE FILE WEBSITE

A. CONTRACTOR is responsible for developing and maintaining an FTP or Share File website for the duration of the project. Submittals will be sent and returned electronically.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 SUBMITTAL PROCEDURES

A. Scheduling:

1. Submit, for approval by the ENGINEER, a preliminary schedule of submittals, in duplicate, within 15 calendar days after the starting date of the contract. ENGINEER will review no submittals until an acceptable schedule of submittals has been submitted. If the CONTRACTOR intends to request a substitute(s) for the materials or equipment specified, schedule substitution request(s), along with any related, subsequent submittals, in the schedule of submittals and submit as scheduled.

2. Schedule, prepare and transmit each submittal to ENGINEER sufficiently in advance of scheduled performance of related Work and other applicable activities.

B. Coordination:

1. Coordinate the preparation and processing of submittals with the performance of the Work. Coordinate each submittal with other submittals and related activities, such as substitution requests, testing, purchasing, fabrication, delivery, and similar activities that require sequential performance. Coordinate submissions for different items of interrelated work so that one submittal will not be delayed by ENGINEER's need to review a related submittal.

2. ENGINEER may return any submittal requiring coordination with other submittals without review and marked “Revise and Resubmit”. This type of returned submittal will be counted as a submittal subject to the provisions of 3.3 –REPETITIVE REVIEWS of this Section.

3. The ENGINEER will not hold a submittal awaiting additional information from the CONTRACTOR.

C. Submittal Preparation:

1. All Submittals: Review each submittal to determine, as applicable, that:

a. The submittal is required by the Contract Documents. The ENGINEER will only review submittals required by the Contract Documents.

b. The materials and equipment depicted in the submittal are intended for incorporation into the Work.

c. The submittal is complete and in sufficient detail to allow ready determination of compliance with the Contract Documents.

d. The items depicted in the submittal will fit in the space available.

e. The information in the submittal has been coordinated with the requirements of the Contract Documents; work to be performed by all trades involved; field measurements and other requirements of the Work.

f. The submittal does not contain standard printed information unless full identification of the project-specific portions and any project-specific supplementary information is shown thereon in ink or typewritten form.

g. The submittal does not encompass more than one Section of the Specifications.

h. The submittal presents, where applicable, such data as dimensions, weights, and performance characteristics on drawings for mechanical and electrical equipment. Show conformance with the performance characteristics and other criteria included in the Contract Documents.

i. Variations from the Contract Documents have been specifically noted on the Submittal Transmittal Form and highlighted on all relative documents within the submittal that are affected by the variation.

(1) At the time of each submittal, CONTRACTOR shall give ENGINEER specific written notice of such variations, if any, that the Shop Drawing or Sample submitted may have from the requirements of the Contract Documents, such notice to be in a written communication separate from the submittal; and, in addition, shall cause a specific notation to be made on each Shop Drawing and Sample submitted to ENGINEER for review and approval of each such variation.

(2) ENGINEER's review and approval of Shop Drawings or Samples shall not relieve CONTRACTOR from responsibility for any variation from the requirements of the Contract Documents unless CONTRACTOR has in writing called ENGINEER's attention to each such variation at the time of each submittal as required by paragraph (1) above and ENGINEER has given written approval of each such variation by specific written notation thereof incorporated in or accompanying the Shop Drawing or Sample approval; nor will any approval by ENGINEER relieve CONTRACTOR from responsibility for complying with the requirements of the Contract.

j. The submittal is in compliance with the Contract Documents and a completed approval and certification stamp has been placed on each submittal document. Use a rubber stamp containing the information shown in the sample stamp at the end of this section. ENGINEER

will rely upon CONTRACTOR's certification of compliance that the CONTRACTOR has reviewed and approved the submittal and has confirmed that the submittal conforms to all the requirements of the Contract Documents except for variations specifically noted on the Submittal Transmittal Form and all attached documents. Submittals will be returned to CONTRACTOR without action if certification is not provided and the submittal will be counted as a submittal subject to the provisions of 3.3 –REPETITIVE REVIEWS of this Section.

2. Manufacturer's Documents and Working Drawing submittals:

   a. Accurately and distinctly present the following:

      (1) Graphical information at accurate scale

      (2) Name, address and telephone number of manufacturer or supplier

      (3) Materials and equipment that are to be included in the Work

      (4) Compliance with standards

      (5) All dimensions, clearly identifying those dimensions based on field measurement

      (6) Arrangements and sectional views

      (7) Necessary details, including complete information on making connections between Work in this project, work in other related projects and existing facilities

      (8) Electrical wiring connections between all equipment provided including all internal wiring between internal components of equipment

      (9) Kinds of materials and finishes

      (10) Parts list and descriptions thereof

      (11) Spare parts, lubricants or special tools required by the Contract Documents

   b. Include the following on each drawing or page:

      (1) Preparation date and revision dates

      (2) Project name

(3) Specification Section number and page number

(4) Identification of equipment or materials

(5) Name of CONTRACTOR (and Subcontractor if applicable)

(6) Name of Supplier and/or Manufacturer

(7) Field dimensions, clearly identified

(8) Standards or industry specification references

(9) Identification of variations from the Contract Document requirements

(10) Physical location and location relative to other facilities that the Work-related equipment or materials are to be installed adjacent to or connected with

(11) Provide 8-inch wide by 3-inch high blank space for CONTRACTOR's and ENGINEER's stamps

c. Submit 3 blue or black line prints, or 2 reverse-sepia reproducibles with 1 blue or black line print. One reproducible or one print will be returned with review comments.

3. Product Data:

a. Assemble all data into a single submittal for each element of work or system. Where product data has been printed to include information on several similar products, some of which are not required for use on the subject Project, clearly mark copies to show such information is not applicable.

b. Where data must be specially prepared for required materials or equipment because standard printed data are not suitable for use, submit the data as a Manufacturer's Document and not as Product Data.

c. Submit product data with appropriate Manufacturer's Document or Working Drawing, when applicable.

d. Submit 3 copies.

4. Samples:

a. Whenever possible, provide samples physically identical with the materials proposed for incorporation into the Work. Where variations in color, pattern or texture and the like are inherent in materials represented by samples, submit multiple samples (not less than 3) showing the approximate range of variations.

b. Submit samples for visual review of generic kind, color, pattern, texture, and for a final check of coordination of these characteristics with other related elements of the Work and existing facilities.

c. Include information with each sample to provide a generic description of the item, and its name, manufacturer, limitations, and compliance with standards.

d. Submit 3 sets of samples, where specifications indicate selection of color, pattern, texture or similar characteristics from manufacturer's range of standard choices is necessary.

5. Mock-Ups:

a. Mock-ups and similar samples are recognized as special types of samples. Comply with samples submittal requirements to the greatest extent possible. Process Submittal Transmittal Forms to provide a record of activity.

6. Requests for "Or Equal" or Substitution

a. ENGINEER will, at its sole discretion, determine if the item is "Or Equal" or an acceptable Substitution. Prepare submittals as described above. CONTRACTOR shall reimburse OWNER for ENGINEER's Charges for evaluating a proposed "Or Equal" submittal that receives a negative determination. CONTRACTOR shall reimburse OWNER for ENGINEER's charges for evaluating a proposed Substitution, whether or not a positive determination is made or the CONTRACTOR withdraws the request for Substitution, and for changes resulting from an approved Substitution.

b. For Substitution Requests submit sufficient written information including the following:

(1) Certify that the proposed Substitution is functionally equivalent to the specified item and its performance characteristics, when it is incorporated into the Work, will be equivalent to the specified item.

(2) State the extent, if any, to which the use of the proposed Substitution will affect the performance of the construction work and/or the characteristics of the completed work.

(3) Describe all differences between the proposed Substitution and the specified item.

(4) Describe the sources of supplies, replacement parts, repair services and technical support.

(5) Provide an itemized estimate of all costs or credits directly or indirectly attributable to the use of such Substitution, including redesign engineering, construction and energy costs.

(6) Furnish additional information as requested by the ENGINEER.

(7) CONTRACTOR may be required to furnish a guarantee or other surety for any Substitution at no addition to the Contract Time or Price.

c. Substitute means, methods, techniques, sequences, or procedures of construction may be used in place of those required by the Contract Documents if approved by ENGINEER, at ENGINEER's sole discretion. Follow the procedure described in b. above, submitting appropriate information.

d. Provide sufficient time for ENGINEER to evaluate each "Or Equal" and Substitution Request. Do not order, install or utilize any "Or-Equal" or Substitution until ENGINEER's determination is complete. ENGINEER's approval will be in the form of an approved submittal for an "Or Equal" item or in the form of a Change Order for a Substitution. CONTRACTOR will be advised in writing of any negative determination.

e. Provide all information and documents in support of any proposed "Or-Equal" or Substitution at no addition to the Contract Times or Price.

7. CONTRACTOR's Licensed Professional Submittals

a. Submit 3 copies of certificates and other documents required by the Contract Documents to be prepared and submitted by the CONTRACTOR's Licensed Professionals.

8. Inspection and Test Reports:

a. Identify each inspection and test report as either specially prepared for the Project or a standard publication of workmanship control testing at point of production. Submit in accordance with the requirements

for Manufacturer's Documents or Product Data, respectively as described in this Section.

9. Mill Test Reports, Experience Records, Physical Work Records, Guarantees, Warranties, and Maintenance Agreements:

    (1) Refer to the Contract Documents sections for specific requirements.

10. Survey Data:

    a. Refer to the various Contract Documents for specific requirements. Furnish 2 copies. Provide 10 copies of final property survey (if any).

11. Certifications, Quality Testing and Certifying Reports:

    a. Refer to Specification sections for specific requirements on submittal of certifications. Submit 7 copies. Certifications are submitted for review of conformance with specified requirements and information. Submittal is final when reviewed and returned by ENGINEER with no further action required.

12. Closeout Submittals:

    a. Refer to Specification sections and Section 01789 for specific requirements on submittal of closeout information, materials, tools, and similar items such as:

        (1) Warranties and Bonds

        (2) Record Drawings

        (3) Special Tools

D. Submittal Transmittal Form: Use the Submittal Transmittal Form found at the end of this Section to forward each specific submittal package to the ENGINEER. Provide all the information indicated on the Form and answer each question. Submittals with incomplete information on the Submittal Transmittal Form will be returned to the CONTRACTOR marked "Revise and Resubmit" and will be counted as a submittal subject to the provisions of 3.3 –REPETITIVE REVIEWS of this Section.

E. Submittal Numbering:

1. Number all submittals as follows:

(A) - (B)

Where:
(A) = Specification Section Number
(B) = Consecutive submittal number for the Specification Section Number listed in (A), with an alphabetic suffix indicating the sequential version of the submittal.

Examples: 01300-001A indicates the initial version of submittal number 001 for Specification Section 01300.
01300-001B indicates the second version of submittal number 001 for Specification Section 01300.
01300-002A indicates the initial version of submittal number 002 for Specification Section 01300.

2. When a document(s) is resubmitted for any reason, use a new Submittal Transmittal Form with the same submittal number and a new, sequential alphabetic suffix.

F. Resubmittal Preparation:

1. Comply with the requirements described in the Submittal Preparation subsection above. In addition:

a. Identify on the Submittal Transmittal Form that submittal is a resubmission.

b. Make and clearly identify any corrections or changes required by ENGINEER's notations on the previous, returned submittal.

c. Respond to ENGINEER's notations:

(1) On the Submittal Transmittal Form or on a separate page(s) attached to the Submittal Transmittal Form, answer or acknowledge, in writing, all notations or questions indicated by ENGINEER on the ENGINEER's response to the previous submittal.

(2) Identify each response by the corresponding question or notation number established by ENGINEER.

(3) If CONTRACTOR does not respond to each notation or question, the ENGINEER will return the resubmission without action. Additional resubmittals will be required until the CONTRACTOR provides a written response to all of the ENGINEER's notations or questions.

d. Indicate CONTRACTOR initiated revisions or variations:

(1) On the Submittal Transmittal Form identify variations or revisions from the previously reviewed submittal, other than those called for by ENGINEER.

(2) ENGINEER's responsibility for variations or revisions is established in Section 3.1.C.i.

G. Distribution

1. Manufacturer's Documents, Working Drawings, Product Data and Samples and Mock-ups:

a. After a submittal is stamped "Approved" (See Subsection 3.2), place the date of approval on five additional copies of the submittal and transmit to the ENGINEER together with one copy of a Submittal Transmittal Form indicating the submittal is a "Distribution of Approved Submittal". For Mockups, distribute a Submittal Transmittal Form only.

After a submittal is stamped "Approved as Noted" (See Subsection 3.2), make the changes noted by ENGINEER and place the date of approval on five additional copies of the submittal and transmit to the ENGINEER together with one copy of a Submittal Transmittal Form indicating the submittal is a "Distribution of Approved as Noted Submittal".

b. If changes other than those marked by the ENGINEER are made, follow the requirements of Paragraph 3.1, F to obtain ENGINEER approval.

c. Unless required elsewhere, provide distribution of "Approved" and "Approved as Noted" submittals to subcontractors, suppliers, governing authorities, and others as necessary for proper performance of the Work.

d. Maintain one set of "Approved" and revised "Approved as Noted" submittals at the Project site, available for use by the ENGINEER and others.

e. Maintain returned final set of samples at the Project site, in suitable condition and available for quality control comparisons throughout the course of performing the Work. Incorporate only undamaged samples into the Work, when permitted by the Contract Documents.

H. CONTRACTOR's Licensed Professional Submittals

1. After a submittal is acknowledged by the ENGINEER (See Subsection 3.2,2), place the date of acknowledgement on five additional copies of the submittal and transmit to the ENGINEER together with one copy of a Submittal Transmittal Form indicating the submittal is a “Distribution of Acknowledged Submittal”.
2. Maintain one set of submittals at the Project site, available for use by the ENGINEER and others.

3.2 ENGINEER’S ACTIONS ON SUBMITTALS

A. General:

1. Review and approval by the ENGINEER of Action Submittals will be subject to the provisions of General Conditions. ENGINEER’s review and approval will be only to determine if the items covered by the submittals will, after installation or incorporation in the Work, conform to the requirements of the Contract Documents and be compatible with the design concept of the completed Project as a functioning whole. ENGINEER’s review or approval of any submittal does not authorize a change to the Contract Time or Price.

2. ENGINEER’s review and approval of Action Submittals will not extend to means, methods, techniques, sequences, or procedures of construction (except where a particular means, method, technique, sequence, or procedure of construction is specifically and expressly called for by the Contract Documents) nor to safety precautions or programs incident thereto. The review and approval of a separate item will not indicate approval of the assembly in which the item is a part.

3. ENGINEER will stamp each Action Submittal except Requests for Interpretation or Clarification with an appropriate action stamp.

B. ENGINEER’s Action

1. Stamps:

a. Approved:

(1) Where submittals are stamped "Approved", Work covered by submittal may proceed <u>PROVIDED THE WORK COMPLIES WITH THE CONTRACT DOCUMENTS</u>. Acceptance of Work will depend upon that compliance.

b. Approved As Noted:

(1) When submittals are stamped "Approved as Noted", Work covered by submittal may proceed PROVIDED IT COMPLIES WITH ENGINEER'S NOTATIONS AND CORRECTIONS ON SUBMITTAL AND WITH THE CONTRACT DOCUMENTS. Acceptance of Work will depend on that compliance.

c. Revise and Resubmit:

(1) When submittals are stamped "Revise and Resubmit" do not proceed with Work covered by submittal. Do not permit Work covered by submittal to be used at Project site or elsewhere where Work is in progress.

(2) Revise submittal in accordance with ENGINEER's notations and corrections and resubmit in accordance with Subsection 3.1F of this Section.

2. Acknowledgements of Information Submittals

a. When Information Submittals conform to the format requirements in the Contract Documents ENGINEER will acknowledge such submittals via a response transmittal.

b. If an Information Submittal does not conform to the format requirements of the Contract Documents, ENGINEER will return the submittal with comments or questions. Do not proceed with Work covered by the submittal and do not permit Work covered by the submittal to be used at Project site or elsewhere where Work is in progress. Resubmit the Information Submittal until the ENGINEER acknowledges that the submittal conforms to the format required.

3.3 REPETITIVE REVIEWS

A. Cost of Repetitive Reviews: Submittals will be reviewed no more than twice at the OWNER's expense. All subsequent reviews will be performed at times convenient to the ENGINEER and at the CONTRACTOR's expense based on the ENGINEER's then prevailing rates including all direct and indirect costs and fees. Reimburse the OWNER for all such costs and fees invoiced to the OWNER by the ENGINEER for third and subsequent submittals. ENGINEER will keep a submittal log and present it during monthly progress meetings. Log will note approvals, first rejection, second rejection and review time associated with reimbursable expenses.

B. Time Extension: Any need for more than one resubmission, or any other delay in ENGINEER's review of submittals, will not entitle CONTRACTOR to an extension of the Contract Time.

3.4 EXAMPLE FORMAT FOR CONTRACTOR'S APPROVAL AND CERTIFICATION STAMP

A. An example format for the CONTRACTOR's approval and certification stamp is as follows:

CONTRACTOR'S NAME

_____ Approved and Certified to comply with the Contract Documents.

_____ Approved and Certified to comply with the Contract Documents, except for variations specifically noted on the Submittal Transmittal Form and the associated documents.

PRINTED NAME: _____

TITLE: _____

SIGNATURE: _____

DATE: _____

3.5 CONTRACTOR'S SUBMITTAL TRANSMITTAL FORM

A. The format for the CONTRACTOR's Submittal Transmittal Form is as follows:

CONTRACTOR'S NAME

SUBMITTAL TRANSMITTAL FORM

Project Name

TO:_____ DATE:_____

SITE:_____

ATTN:_____ SPEC. REF. NO._____

DRAWING REF. NO._____

FROM:_____ SUBMITTAL NO. _____

1. The following documents are forwarded for your review:

No. of Repros/Copies	Document Originator	Description	Document No.	Date
/				
/				
/				
/				
/				
/				

2. Will item submitted for review fit in space provided in the Contract Documents? _____ Yes _____ No _____ Not Applicable

3. Has work indicated in this submittal been coordinated with all trades? _____ Yes _____ No _____ Not Applicable

4. Has the Contractor approved submittal and affixed completed approval and certification stamp? _____ Yes _____ No

5. Contractor's description and justification for variations from the Contract Documents. (Use additional pages, if necessary)

_____
_____
_____
_____

6. Remarks:_____
_____
_____
_____

Printed Name: _____

Signature:_____

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 01 45 00

QUALITY CONTROL

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Inspection Services

B. Inspection of Materials

C. Quality Control

D. Costs of Inspection

E. Acceptance Tests

F. Failure to Comply with Contract

1.2 RELATED SECTIONS

A. Section 01 33 00 - Submittals: Specific Submittal Requirements

1.3 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 1.

B. Certificate Submittals: Furnish the ENGINEER authoritative evidence in the form of Certificates of Manufacture that the materials and equipment to be used in the Work have been manufactured and tested in conformity with the Contract Documents. Include copies of the results of physical tests and chemical analyses, where necessary, that have been made directly on the product or on similar products of the manufacturer.

1.4 INSPECTION SERVICES

A. OWNER's Access: At all times during the progress of the Work and until the date of final completion, afford the OWNER and ENGINEER every reasonable, safe, and proper facility for inspecting the Work at the site. The observation and inspection of any work will not relieve the CONTRACTOR of any obligations to perform proper and satisfactory work as specified. Replace work rejected due to faulty design, inferior, or defective materials, poor workmanship, improper installation, excessive wear, or nonconformity with the requirements of the

Contract Documents, with satisfactory work at no additional cost to the OWNER. Replace as directed, finished or unfinished work found not to be in strict accordance with the Contract, even though such work may have been previously approved and payment made therefor.

B. Rejection: The OWNER and the OWNER's Authorized Representatives have the right to reject materials and workmanship which are defective or require correction. Promptly remove rejected work and materials from the site.

C. Inferior Work Discoveries: Failure or neglect on the part of the OWNER or the OWNER's Authorized Representatives to condemn or reject bad or inferior work or materials does not imply an acceptance of such work or materials. Neither is it to be construed as barring the OWNER or the OWNER's Authorized Representatives at any subsequent time from recovering damages or a sum of money needed to build anew all portions of the Work in which inferior work or improper materials were used.

D. Removal for Examination: Should it be considered necessary or advisable by the OWNER or the OWNER's Authorized Representatives, at any time before final acceptance of the Work, to make examinations of portions of the Work already completed, by removing or tearing out such portions, promptly furnish all necessary facilities, labor, and material, to make such an examination. If such Work is found to be defective in any respect, defray all expenses of such examination and of satisfactory reconstruction. If, however, such work is found to meet the requirements of the Contract, the cost of examination and restoration of the Work will be considered a change in the Work to be paid for in accordance with applicable provisions of the Contract.

E. Operation Responsibility: Assume full responsibility for the proper operation of equipment during tests and instruction periods. Make no claim for damage which may occur to equipment prior to the time when the OWNER accepts the Work.

F. Rejection Prior to Warranty Expiration: If at anytime prior to the expiration of any applicable warranties or guarantees, equipment is rejected by the OWNER, repay to the OWNER all sums of money received for the rejected equipment on progress certificates or otherwise on account of the Contract lump sum prices, and upon the receipt of the sum of money, OWNER will execute and deliver a bill of sale of all its rights, title, and interest in and to the rejected equipment. Do not remove the equipment from the premises of the OWNER until the OWNER obtains from other sources, equipment to take the place of that rejected. The OWNER hereby agrees to obtain other equipment within a reasonable time and the CONTRACTOR agrees that the OWNER may use the equipment furnished by the CONTRACTOR without rental or other charge until the other new equipment is obtained.

1.5 INSPECTION OF MATERIALS

A. Premanufacture Notification: Give notice in writing to the ENGINEER sufficiently in advance of the commencement of manufacture or preparation of materials especially manufactured or prepared for use in or as part of the permanent construction. When required, notice to include a request for inspection, the date of commencement, and the expected date of completion of the manufacture or preparation of materials. Upon receipt of such notice, ENGINEER will arrange to have a representative present at such times during the manufacture or testing as may be necessary to inspect the materials, or will notify CONTRACTOR that the inspection will be made at a point other than the point of manufacture or testing, or that the inspection will be waived. Comply with these provisions before shipping any materials. Such inspection will not constitute a release from the responsibility for furnishing materials meeting the requirements of the Contract Documents.

B. Testing Standards: Tests of electrical and mechanical equipment and appliances shall be conducted in accordance with recognized, applicable test codes except as may otherwise be stated herein.

1.6 QUALITY CONTROL

A. Testing

1. Field and Laboratory

a. Perform the following periodic observation and associated services.

(1) Soils: Observe and test excavations, placement and compaction of soils. Determine suitability of excavated material. Observe subgrade soils and foundations.

(2) Concrete: Observe forms and reinforcement; observe concrete placement; witness air entrainment tests, facilitate concrete cylinder preparation and assist with other tests performed by ENGINEER.

(3) Masonry: Sample and test mortar and grout; inspect brick and block samples and sample panels; inspect placement of reinforcement and grouting.

(4) Structural Steel: Verify that all welders are certified by AWS; visually inspect all structural steel welds; mechanically test high-tensile bolted connections.

b. When specified in Divisions 2 through 16 of the Contract Documents, provide an independent laboratory testing facility to perform required

testing. Qualify the laboratory as having performed previous satisfactory work. Prior to use, submit to the ENGINEER for approval.

c. Cooperate with the ENGINEER and laboratory testing representatives. Provide at least 24 hours notice prior to when specified testing is required. Provide labor and materials, and necessary facilities at the site as required by the ENGINEER and the testing laboratory.

d. Provide an independent testing agency, a member of the National Electrical Testing Association, to perform inspections and tests specified in Division 16 of these Specifications.

e. Soils, concrete, and masonry testing of material placed under this Contract, including field sampling and delivery to the laboratory, will be performed by the ENGINEER or laboratory testing representative as specified. ENGINEER will determine the exact time, location, and number of tests to be performed.

2. Equipment: Coordinate and demonstrate test procedures as specified in the Contract Documents or as otherwise required during the formal tests.

3. Pipeline and Other Testing: Conform to test procedures and requirements specified in the appropriate Specification Section.

4. Testing Costs: Include the costs of all testing other than soils and concrete testing of material placed under this Contract in the Contract Item 2. Include the costs of strength chloride ion and shrinkage tests specified in Division 3.

B. Reports

1. Certified Test Reports: Where transcripts or certified test reports are required by the Contract Documents, meet the following requirements:

a. Before delivery of materials or equipment submit and obtain approval of the ENGINEER for all required transcripts, certified test reports, certified copies of the reports of all tests required in referenced specifications or specified in the Contract Documents. Perform all testing in an approved independent laboratory or the manufacturer's laboratory. Submit for approval reports of shop equipment tests within thirty days of testing. Transcripts or test reports are to be accompanied by a notarized certificate in the form of a letter from the manufacturer or supplier certifying that tested material or equipment meets the specified requirements and the same type, quality,

manufacture and make as specified. The certificate shall be signed by an officer of the manufacturer or the manufacturer's plant manager.

2. Certificate of Compliance: At the option of the ENGINEER, or where not otherwise specified, submit for approval a notarized Certificate of Compliance. The Certificates may be in the form of a letter stating the following:

   a. Manufacturer has performed all required tests

   b. Materials to be supplied meet all test requirements

   c. Tests were performed not more than one year prior to submittal of the certificate

   d. Materials and equipment subjected to the tests are of the same quality, manufacture and make as those specified

   e. Identification of the materials

1.7 COSTS OF INSPECTION

A. CONTRACTOR's Obligation: Include in the Contract Price, as stated in 1.6 above, the costs of all shop and field tests of materials and equipment and other tests specifically required by the Contract Documents except those tests described above under "OWNER's Obligation". The OWNER may perform tests on any material or equipment furnished under this Contract at any time during the Contract. If tests performed by the OWNER result in failure or rejection for noncompliance, reimburse the OWNER for expenditures incurred in making such tests. Tests performed by the OWNER shall prevail in determining compliance with Contract requirements.

B. Reimbursements to OWNER:

1. Materials and equipment submitted by the CONTRACTOR as the equivalent to those specifically named in the Contract may be tested by the OWNER for compliance. Reimburse the OWNER for expenditures incurred in making such tests on materials and equipment which are rejected for noncompliance.

2. When a witness or shop test is performed at the manufacturer's facilities or an operational test is performed at the site of work, the ENGINEER'S services associated with the first test of each material or equipment item will be furnished by the OWNER. Reimburse the OWNER for the costs for the ENGINEER'S services associated with retests or failed original tests or test extensions due to failure to complete the original tests as scheduled. Any

costs so incurred will be billed by the OWNER and deducted from the CONTRACTOR'S subsequent partial payment.

1.8 ACCEPTANCE TESTS

A. Preliminary Field Tests: As soon as conditions permit, furnish all labor and materials and services to perform preliminary field tests of all equipment provided under this Contract. If the preliminary field tests disclose that any equipment furnished and installed under this Contract does not meet the requirements of the Contract Documents, make all changes, adjustments and replacements required prior to the acceptance tests.

B. Final Field Tests: Upon completion of the Work and prior to final payment, subject all equipment, piping and appliances installed under this Contract to specified acceptance tests to demonstrate compliance with the Contract Documents.

1. Furnish all labor, fuel, energy, water and other materials, equipment, instruments and services necessary for all acceptance tests.

2. Conduct field tests in the presence of the ENGINEER. Perform the field tests to demonstrate that under all conditions of operation each equipment item:

a. Has not been damaged by transportation or installation
b. Has been properly installed
c. Has been properly lubricated
d. Has no electrical or mechanical defects
e. Is in proper alignment
f. Has been properly connected
g. Is free of overheating of any parts
h. Is free of all objectionable vibration
i. Is free of overloading of any parts
j. Operates as intended

3. Operate work or portions of work for a minimum of 100 hours or 14 days continuous service, whichever comes first. For those items of equipment which would normally operate on wastewater or sludge, plant effluent may be used if available when authorized by ENGINEER. If water can not properly exercise equipment, conduct 100-hour test after plant startup. Conduct test on those systems which require load produced by weather (heating or cooling) exercise only when weather will produce proper load.

C. Failure of Tests: If the acceptance tests reveal defects in material or equipment, or if the material or equipment in any way fails to comply with the requirements of the Contract Documents, then promptly correct such deficiencies. Failure or refusal to correct the deficiencies, or if the improved materials or equipment, when

tested again, fail to meet the guarantees or specified requirements, the OWNER, notwithstanding its partial payment for work and materials or equipment, may reject said materials or equipment and may order the CONTRACTOR to remove the defective work from the site at no addition to the Contract Price, and replace it with material or equipment which meets the Contract Documents.

1.9 FAILURE TO COMPLY WITH CONTRACT

A. Unacceptable Materials: If it is ascertained by testing or inspection that the material or equipment does not comply with the Contract, do not deliver said material or equipment, or if delivered remove it promptly from the site or from the Work and replace it with acceptable material without additional cost to the OWNER. If the Contractor fails to remove unacceptable materials and equipment from the site, or make satisfactory progress in doing so, within forty-eight (48) hours after the service of a written notice from the ENGINEER ordering such removal, the unacceptable material or equipment may be removed by the OWNER and the cost of such removal to be taken out of money that may be due or become due the CONTRACTOR on account of or by virtue of this Contract. Fulfill all obligations under the terms and conditions of the Contract even though the OWNER or the OWNER's Authorized Representatives fail to ascertain noncompliance or notify the CONTRACTOR of noncompliance.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 01 50 00

CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. General Requirements

B. Temporary Utilities

C. Temporary Construction

D. Barricades and Enclosures

E. Fences

F. Security

G. Temporary Controls

H. Traffic Regulation

I. Field Offices and Sheds

1.2 GENERAL REQUIREMENTS

A. Plant and Facilities: Furnish, install, maintain and remove all false work, scaffolding, ladders, hoistways, braces, pumping plants, shields, trestles, roadways, sheeting, centering forms, barricades, drains, flumes, and the like, any of which may be needed in the construction of any part of the Work and which are not herein described or specified in detail. Adequately shore, sheet, and brace excavations or slope the sides of excavations in accordance with State of Oklahoma Department of Labor Requirements. Accept responsibility for the safety and efficiency of such works and for any damage that may result from their failure or from their improper construction, maintenance or operation.

B. First Aid: Maintain a readily accessible, completely equipped first aid kit at each location where work is in progress.

C. Safety Responsibility: Accept sole responsibility for safety and security at the site. Indemnify and hold harmless the OWNER and the OWNER's Authorized

Representatives, including Greeley and Hansen/TYLin for any safety violation, or noncompliance with governing bodies and their regulations, and for accidents, deaths, injuries, or damage at the site during occupancy or partial occupancy of the site by CONTRACTOR's forces while performing any part of the Work.

D. Hazard Communication: Furnish two copies of the CONTRACTOR's Hazard Communication Program required under OSHA regulations before beginning on site activities. Furnish two copies of amendments to Hazard Communications Program as they are prepared.

E. Power Lines: Prevent any person, materials, and equipment from coming within six feet of any power line carrying more than 440 volts, unless the electric power service has been first discontinued.

F. Fire Prevention and Protection: Take all necessary measures to prevent fire and provide satisfactory fire fighting means at the location of work.

G. Condition of Equipment and Materials: Only handle and operate all of the equipment, tools, appliances, and materials, used in connection with the project when they are in safe operating condition and in accordance with a standard safety procedure.

H. Damage Survey: Conduct a damage survey of the Work site and adjacent properties prior to commencing the Work and before making application for final payment for the Work. Notify OWNER and Resident Project Representative in advance of videotaping so that OWNER and Resident Project Representative may choose to be present. Provide OWNER with two copies of a DVD recording of all planned construction areas. The purpose of the video is to document existing site conditions and to provide a fair measure of required restoration. Care should be taken to record all existing conditions which exhibit deterioration, imperfections, structural failures, or situations that would be considered substandard. The video image shall be of sufficient detail to delineate important features and conditions of the project area. Submit copies of the videos to the OWNER prior to commencing construction.

Provide DVDs that are high quality and in color. The video portion of the recording shall reproduce bright, sharp, clear pictures with accurate colors and shall be free from distortion, tearing, rolling, or any other form of imperfection. The audio portion of the recording shall reproduce precise and concise explanatory notes by the camera operator with proper volume, clarity and freedom from distortion.

At the start of production an identification summary shall be read into the record while using a wide-angle view of the video to display numeric displays for visual record. This summary shall include: (1) DVD number; (2) project

name; (3) location; (4) positional location at start of job; (5) date and time; (6) weather; (7) direction of camera; (8) any other notable conditions.

No separate payment will be made for the damage survey, but shall be included in the cost of Contract Item No. 3.

I. Correction: CONTRACTOR is responsible for replacing or repairing damage to existing buildings, structures, sidewalks, jogging paths, biking lanes, roads, curbs and gutters, parking areas, utilities, lawns and landscaping and other existing assets. Pay all claims, costs, losses, and damages arising out of or relating to such correction.

1.3 TEMPORARY UTILITIES

A. Water: Provide all necessary and required water without additional cost, unless otherwise specified. If necessary, provide and lay water lines to the place of use; secure all necessary permits; pay for all taps to water mains and hydrants and for all water used at the established rates.

B. Light and Power: Provide without additional cost to the OWNER temporary lighting and power facilities required for the proper construction and inspection of the Work. If, in the ENGINEER's opinion, these facilities are inadequate, do NOT proceed with any portion of the Work affected thereby. Maintain temporary lighting and power until the Work is accepted.

C. Heat: Provide temporary heat, whenever required, for work being performed during cold weather to prevent freezing of concrete, water pipes, and other damage to the Work or existing facilities.

D. Sanitary Facilities: Provide sufficient sanitary facilities for construction personnel. Prohibit and prevent nuisances on the site of the Work or on adjoining property. Discharge any employee who violates this rule. Abide by all environmental regulations or laws applicable to the Work.

E. Connections to Existing Utilities:

1. Unless otherwise specified or indicated, make all necessary connections to existing facilities including structures, drain lines, and utilities such as water, sewer, gas, telephone, and electricity. In each case, obtain permission from the OWNER or the owning utility prior to undertaking connections. Protect facilities against deleterious substances and damage.

2. Thoroughly plan in advance all connections to existing facilities. Have on hand at the time of undertaking the connections, all material, labor and required equipment. Proceed continuously to complete connections in

minimum time. Arrange for the operation of valves or other appurtenances on existing utilities, under the direct supervision of the owning utility.

1.4 TEMPORARY CONSTRUCTION

A. Bridges: Design and place suitable temporary bridges where necessary for the maintenance of vehicular and pedestrian traffic. Assume responsibility for the sufficiency and safety of all such temporary work or bridges and for any damage which may result from their failure or their improper construction, maintenance, or operation. Indemnify and save harmless the OWNER and the OWNER's representatives, including Greeley and Hansen, from all claims, suits or actions, and damages or costs of every description arising by reason of failure to comply with the above provisions.

1.5 BARRICADES AND ENCLOSURES

A. Protection of Workmen and Public: Effect and maintain at all times during the prosecution of the Work, barriers and lights necessary for the protection of Workmen and the Public. Provide suitable barricades, lights, "danger" or "caution" or "street closed" signs and watchmen at all places where the Work causes obstructions to normal traffic, excavation sites, or constitutes in any way a hazard to the public.

B. Barricades and Lights:

1. Protect all streets, roads, highways, excavations and other public thoroughfares which are closed to traffic; use effective barricades which display acceptable warning signs. Locate barricades at the nearest public highway or street on each side of the blocked section.

2. Statutory Requirements: Install and maintain all barricades, signs, lights, and other protective devices within highway rights-of-way in strict conformity with applicable statutory requirements by the authority having jurisdiction.

1.6 TEMPORARY CONSTRUCTION FENCES AND GATES

A. Install temporary construction fencing and gates as required for the project. Keep gates closed and locked at all times when not in use. Provide adequate bracing and fence posts to secure the fences and gates throughout the duration of construction.

B. Restoration: Remove all temporary fences and gates, fill in temporary construction fence posts to original grade, and restore areas surrounding the posts to their original or better condition on completion of the Work.

1.7 SECURITY

A. Preservation of Property:

1. Preserve from damage, all property along the line of the Work, in the vicinity of or in any way affected by the Work, the removal or destruction of which is not called for by the Drawings. Preserve from damage, public utilities, trees, lawn areas, building monuments, fences, pipe and underground structures, and public streets. Note: Normal wear and tear of streets resulting from legitimate use by the CONTRACTOR are not considered as damage. Whenever damages occur to such property, immediately restore to its original condition. Costs for such repairs are incidental to the Contract.

2. In case of failure on the part of the CONTRACTOR to restore property or make good on damage or injury, the OWNER may, upon 24 hours written notice, proceed to repair, rebuild, or otherwise restore such property as may be deemed necessary, and the cost thereof will be deducted from any moneys due or which may become due the CONTRACTOR under this Contract. If removal, repair or replacement of public or private property is made necessary by alteration of grade or alignment authorized by the OWNER and not contemplated by the Contract Documents, the CONTRACTOR will be compensated, in accordance with the General Conditions, provided that such property has not been damaged through fault of the CONTRACTOR or the CONTRACTOR's employees.

B. Public Utility Installations and Structures:

1. Public utility installations and structures include all poles, tracks, pipes, wires, conduits, vaults, manholes, and other appurtenances and facilities, whether owned or controlled by public bodies or privately owned individuals, firms or corporations, used to serve the public with transportation, gas, electricity, telephone, storm and sanitary sewers, water, or other public or private utility services. Facilities appurtenant to public or private property which may be affected by the Work are deemed included hereunder.

2. The Contract Documents contain data relative to existing public utility installations and structures above and below the ground surface. Existing public utility installations and structures are indicated on the Drawings only to the extent such information was made available to, or found by, the ENGINEER in preparing the Drawings. These data are not guaranteed for completeness or accuracy, and the CONTRACTOR is responsible for making necessary investigations to become fully informed as to the character, condition, and extent of all public utility installations and

structures that may be encountered and that may affect the construction operations.

3. Contact utility locating service sufficiently in advance of the start of construction to avoid damage to the utilities and delays to the completion date.

4. Remove, replace, relocate, repair, rebuild, and secure any public utility installations and structures damaged as a direct or indirect result of the Work under this Contract. Costs for such work are incidental to the Contract. Be responsible and liable for any consequential damages done to or suffered by any public utility installations or structures. Assume and accept responsibility for any injury, damage, or loss which may result from or be consequent to interference with, or interruption or discontinuance of, any public utility service.

5. Repair or replace any water, electric, sewer, gas, or other service connection damaged during the Work with no addition to the Contract price.

6. At all times in performance of the Work, employ proven methods and exercise reasonable care and skill to avoid unnecessary delay, injury, damage, or destruction to public utility installations and structures. Avoid unnecessary interference with, or interruption of, public utility services. Cooperate fully with the owners thereof to that end.

7. Give written notice to the owners of all public utility installations and structures affected by proposed construction operations, sufficiently in advance of breaking ground in any area or on any unit of the Work, to obtain their permission before disrupting the lines and to allow them to take measures necessary to protect their interests. Advise the Chiefs of Police, Fire and Rescue Services of any excavation in public streets or the temporary shut-off of any water main. Provide at least 24 hours notice to all affected property owners whenever service connections are taken out of service.

8. Do not operate a valve or other control on any utility main or building service line for any purpose.

9. At places where construction operations are adjacent to or crossing the plant of railway, telegraph, telephone, electric and gas companies or water lines, sanitary sewers and storm sewers, and damage to which might result in expense, loss or inconvenience, do not commence work until all arrangements necessary for the protection thereof have been made. Notify the Notification Center of Oklahoma One-Call System, Inc. of any excavation or demolition prior to the commencement of such work. Make

notification no sooner than ten (10) days no later than forty-eight (48) hours prior to start of work, excluding Saturdays, Sundays, and legal holidays.

10. Cooperate with the owners or any underground or overhead utility lines in their removal and rearrangement operations in order that these operations may progress in a reasonable manner and duplication or rearrangement work may be reduced to a minimum, and that services rendered by those parties will not be unnecessarily interrupted. Make revision and crossings of the various types of lines as follows:

    a. Remove storm sewers and culverts at the time of crossing or adequately brace and hold them in position while the pipe is placed beneath them. If the storm sewer or culvert is removed, replace it with pipe of the same type and size as that removed, and re-join it to the undisturbed line with a joint satisfactory to the ENGINEER. Thoroughly compact the backfill over the pipe, up to and around the storm sewer, in order that no settlement will occur. The revision and crossing shall be at the expense of the Contractor. In the event lines, other than those shown on the Drawings, are encountered and fall within the standard trench limit and, in the opinion of the ENGINEER, revision of the line is necessary for the construction of the project, the Contractor will be reimbursed for the extra cost of the crossing or revision as extra work.

    b. Protect all overhead and buried telephone and electrical conduits, and gas mains to be revised or crossed by the construction of this project in accordance with the directions of the utility company owning the conduits and/or mains. Notify the companies and obtain their permission before making any crossing or revisions. The revisions and crossing shown on the Drawings are at the expense of the Contractor. In the event lines, other than those shown on the Drawings, are encountered and fall within the standard trench limit and, in the opinion of the ENGINEER, revision of the line is necessary for the construction of the project, the Contractor will be reimbursed for the extra cost of the crossings or revision as extra work. Repair, to the satisfaction of the ENGINEER and of the utility owner and at no additional compensation, any overhead cables or buried cables or conduits or gas mains damaged.

    c. Do not remove any water or sanitary sewer lines except as directed by the ENGINEER or as required by the Drawings and Specifications, and adequately brace and protect them from any damage during construction. Any existing water main or sewer main or lateral damaged by the Contractor's operations will be repaired at the Contractor's expense.

11. The locations of utility service lines serving individual properties may or may not be shown on the Drawings, but assume that such service lines exist whether or not they are shown on the Drawings, and be responsible for making any necessary changes in the line and/or grade of such services, or to secure the necessary changes therein to be made by the particular utility company involved or other owner thereof, or by an agent or individual contractor approved by such utility company or other owner. Pay the cost of all such revisions whether performed by contractor, the utility company, or other owner, or an approved contractor. In the event of interruption of a utility service as a result of accidental breakage, promptly notify the ENGINEER and the owner of the utility, and repair or cause the same to be repaired, in the same manner as necessary changes above provided for, and do all things necessary to see to the restoration of services as promptly as may be reasonable done.

12. Replace all damaged sanitary sewer service lines with cast iron pipe, regardless of type or kind damaged.

13. In the event the Contractor in any way fails to comply with the requirements of protecting, repairing, and restoring any utility or utility service, the OWNER may, upon forty-eight (48) hours written notice, proceed to protect, repair, rebuild or otherwise restore such utility or utility service as may be deemed necessary, and the cost thereof will be deducted from any money due or which may become due the Contractor pursuant to the terms of his contract.

14. Refer to General Condition GC-22 for related requirements.

C. Miscellaneous Structures: Assume and accept responsibility for all injuries or damage to culverts, building foundations and walls, retaining walls, or other structures of any kind met with during the prosecution of the Work. Assume and accept liability for damages to public or private property resulting therefrom. Adequately protect against freezing all pipes carrying liquid.

D. Protection of Trees and Lawn Areas:

1. Protect with boxes, trees and shrubs, except those ordered to be removed. Do not place excavated material so as to cause injury to such trees or shrubs. Replace trees or shrubs destroyed by accident or negligence of the CONTRACTOR or CONTRACTOR's employees with new stock of similar size and age, at the proper season, at no additional cost to the OWNER.

2. Leave all existing lawn areas in as good condition as before the start of the Work. Restore all existing lawn areas damaged, removed or destroyed during the Work and that are to remain lawn areas by seeding or sodding.

1.8 TEMPORARY CONTROLS

A. During Construction:

1. Keep the site of the Work and adjacent premises free from construction materials, debris, and rubbish. Remove this material from any portion of the site if such material, debris, or rubbish constitutes a nuisance or is objectionable.

2. Remove from the site all surplus materials and temporary structures when they are no longer needed.

3. Neatly stack construction materials such as concrete forms and scaffolding when not in use. Promptly remove splattered concrete, asphalt, oil, paint, corrosive liquids, and cleaning solutions from surfaces to prevent marring or other damage.

4. Properly store volatile wastes in covered metal containers and remove from the site daily.

5. Do not bury or burn on the site or dispose of into storm drains, sanitary sewers, streams, or waterways, any waste material. Remove all wastes from the site and dispose of in a manner complying with applicable ordinances and laws.

B. Smoke Prevention:

1. Strictly observe all air pollution control regulations.

2. Open fires will be allowed only if permitted under current ordinances.

C. Noises:

1. Maintain acceptable noise levels in the vicinity of the Work. Limit noise production to acceptable levels by using special mufflers, barriers, enclosures, equipment positioning, and other approved methods.

2. Supply written notification to the OWNER sufficiently in advance of the start of any work which violates this provision. Proceed only when all applicable authorizations and variances have been obtained in writing.

D. Hours of Operation:

1. Operation of construction equipment between the hours of 7:00 p.m. and 6:00 a.m. the following day is prohibited. For operation of this equipment during this period obtain written consent from the OWNER.

2. Do not carry out emergency work, including equipment moves, on Sundays without prior written authorization by OWNER.

E. Dust Control:

1. Take measures to prevent unnecessary dust. Keep earth surfaces exposed to dusting moist with water or a chemical dust suppressant. Cover materials in piles or while in transit to prevent blowing or spreading dust.

2. Adequately protect buildings or operating facilities which may be affected adversely by dust. Protect machinery, motors, instrument panels, or similar equipment by suitable dust screens. Include proper ventilation with dust screens.

F. Temporary Drainage Provisions:

1. Provide for the drainage of stormwater and any water applied or discharged on the site in performance of the Work. Provide adequate drainage facilities to prevent damage to the Work, the site, and adjacent property.

2. Supplement existing drainage channels and conduits as necessary to carry all increased runoff from construction operations. Construct dikes as necessary to divert increased runoff from entering adjacent property (except in natural channels), to protect the OWNER's facilities and the Work, and to direct water to drainage channels or conduits. Provide ponding as necessary to prevent downstream flooding.

3. Maintain excavations free of water. Provide, operate, and maintain pumping equipment.

G. Erosion Control: Provide erosion control in accordance with Section 02370 – Slope Protection and Erosion Control.

H. Pollution: Prevent the pollution of drains and watercourses by sanitary wastes, sediment, debris, and other substances resulting from construction activities. Do not permit sanitary wastes to enter any drain or watercourse other than sanitary sewers. Do not permit sediment, debris, or other substances to enter sanitary sewers. Take reasonable measures to prevent such materials from entering any drain or watercourse.

1.9 TRAFFIC REGULATION

A. Parking: Provide and maintain suitable parking areas for the use of all construction workers and others performing Work or furnishing services in

connection with the Contract, to avoid any need for parking personal vehicles where they may interfere with public traffic or construction activities.

B. Access: Conduct Work to interfere as little as possible with public travel, whether vehicular or pedestrian. Provide and maintain suitable and safe bridges, detours, or other temporary expedients for the accommodation of public and private travel. Whenever it is necessary to cross, obstruct, or close roads, driveways, and walks, whether public or private, give reasonable notice to owners of private drives before interfering with them. Such maintenance of traffic will not be required when the CONTRACTOR has obtained permission from the owner or tenant of private property, or from the authority having jurisdiction over the public property involved, to obstruct traffic at the designated point.

1.10 FIELD OFFICES AND SHEDS

A. CONTRACTOR's Office: Erect, furnish, and maintain a field office with a telephone. Have an authorized agent present at this office at all times while the Work is in progress. Keep readily accessible copies of the Contract Documents, required record documents, and the latest approved shop drawings at this field office.

B. Material Sheds and Temporary Structures: Provide material sheds and other temporary structures of sturdy construction and neat appearance.

C. Location: Coordinate location of field offices, material sheds and temporary structures with ENGINEER and OWNER.

D. Utility Connections: Connect the water and sanitary sewer to existing lines.

Arrange for the local power company to provide separate, complete and metered electrical service to the field office. Provide a suitable meter installation as approved. Connect the electrical service to the trailer to provide a complete operating installation. Pay each monthly power cost for the ENGINEER’S field office.

Arrange with the local telephone company to provide four incoming telephone lines for the field office. Provide two lines for telephone, one line for a fax machine and one line for the desktop computer. Provide two telephones. Pay each monthly telephone charge.

Arrange with the local internet service provider to provide either DSL or cable modem service to the field office. If DSL service is provided include a third telephone line. Pay each monthly internet connection charge.

E. Final Ownership: At the completion of construction, the trailer and furnishings with the exception of the printer and camera listed above shall remain the property

of the CONTRACTOR. Deliver printer and camera to the OWNER at the end of the project.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

END OF SECTION

SECTION 01 60 00

MATERIAL AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Description

B. Substitutions

C. Manufacturer's Written Instructions

D. Transportation and Handling

E. Storage, Protection and Maintenance

F. Manufacturer's Field Quality Control Services

G. Special Tools and Lubricating Equipment

H. Lubrication

1.2 DESCRIPTION

A. Proposed Manufacturers List: Within 15 calendar days of the date of the Notice to Proceed, submit to the ENGINEER a list of the names of proposed manufacturers, material men, suppliers and subcontractors, obtain approval of this list by OWNER prior to submission of any shop drawings. Upon request submit evidence to ENGINEER that each proposed manufacturer has manufactured a similar product to the one specified and that it has previously been used for a like purpose for a sufficient length of time to demonstrate its satisfactory performance.

B. Furnish and install Material and Equipment which meets the following:

1. Conforms to applicable specifications and standards.

2. Complies with size, make, type, and quality specified or as specifically approved, in writing, by ENGINEER.

3. Will fit into the space provided with sufficient room for operation and maintenance access and for properly connecting piping, ducts and services, as applicable. Make the clear spaces that will be available for operation and maintenance access and connections equal to or greater than those shown

and meeting all the manufacturers' requirements. Make all provisions for installing equipment furnished at no increase in Contract Price.

4. Manufactured and fabricated in accordance with the following:

    a. Design, fabricate, and assemble in accordance with best engineering and shop practices.

    b. Manufacture like parts of duplicate units to standard sizes and gauges, to be interchangeable.

    c. Provide two or more items of same kind identical, by same manufacturer.

    d. Provide materials and equipment suitable for service conditions.

    e. Adhere to equipment capabilities, sizes, and dimensions shown or specified unless variations are specifically approved, in writing, in accordance with the Contract Documents.

    f. Adapt equipment to best economy in power consumption and maintenance. Proportion parts and components for stresses that may occur during continuous or intermittent operation, and for any additional stresses that may occur during fabrication or installation.

    g. Working parts are readily accessible for inspection and repair, easily duplicated and replaced.

5. Use material or equipment only for the purpose for which it is designed or specified.

6. Whenever materials and equipment are specified in both descriptive terms and by the manufacturer’s or supplier’s product name, model number, catalog number, and the like and there appears to be a conflict between the descriptions and the manufacturer’s or supplier’s number or name for the product, the descriptions shall govern.

7. Provide equipment that is safeguarded in accordance with applicable federal, state and local codes.

8. Provide materials and equipment whose protruding members, joints, corners, gear covers, and the like are finished in appearance. Grind smooth all exposed welds and miter the corners of structural shapes.

1.3 SUBSTITUTIONS

A. Substitutions:

1. CONTRACTOR'S requests for changes in equipment and materials from those required by the Contract Documents are considered requests for substitutions and are subject to CONTRACTOR'S representations and review provisions of the Contract Documents when one of following conditions are satisfied:

a. Where request is directly related to an "or equal" clause or other language of same effect in Specifications.

b. Where required equipment or material cannot be provided within Contract Time, but not as result of CONTRACTOR'S failure to pursue Work promptly or to coordinate various activities properly.

c. Where required equipment or material cannot be provided in manner compatible with other materials of Work, or cannot be properly coordinated therewith.

2. CONTRACTOR'S Options:

a. Where more than one choice is available as options for CONTRACTOR'S selection of equipment or material, select option compatible with other equipment and materials already selected (which may have been from among options for other equipment and materials).

b. Where compliance with specified standard, code or regulation is required, select from among products which comply with requirements of those standards, codes, and regulations.

c. "Or Equal": For equipment or materials specified by naming one or more equipment manufacturer and "or equal", submit request for substitution for any equipment or manufacturer not specifically named.

B. Conditions Which are Not Substitution:

1. Requirements for substitutions do not apply to CONTRACTOR options on materials and equipment provided for in the Specifications.

2. Revisions to Contract Documents, where requested by OWNER or ENGINEER, are "changes" not "substitutions".

3. CONTRACTOR'S determination of and compliance with governing regulations and orders issued by governing authorities do not constitute substitutions and do not constitute basis for a Change Order, except as provided for in Contract Documents.

1.4 MANUFACTURER'S WRITTEN INSTRUCTIONS

A. Instruction Distribution: When the Contract Documents require that installation, storage, maintenance and handling of equipment and materials comply with manufacturer's written instructions, obtain and distribute printed copies of such instructions to parties involved in installation, including six copies to ENGINEER.

1. Maintain one set of complete instructions at jobsite during storage and installation, and until completion of work.

B. Manufacturer's Requirements: Store, maintain, handle, install, connect, clean, condition, and adjust products in accordance with manufacturer's written instructions and in conformity with Specifications.

1. Should job conditions or specified requirements conflict with manufacturer's instructions, consult ENGINEER for further instructions.

2. Do not proceed with work without written instructions.

C. Performance Procedures: Perform work in accordance with manufacturer's written instructions. Do not omit preparatory steps or installation procedures, unless specifically modified or exempted by Contract Documents.

1.5 TRANSPORTATION AND HANDLING

A. Coordination with Schedule: Arrange deliveries of materials and equipment in accordance with Construction Progress Schedules. Coordinate to avoid conflict with work and conditions at site.

1. Deliver materials and equipment in undamaged condition, in manufacturer's original containers or packaging, with identifying labels intact and legible.

2. Protect bright machined surfaces, such as shafts and valve faces, with a heavy coat of grease prior to shipment.

3. Immediately upon delivery, inspect shipments to determine compliance with requirements of Contract Documents and approved submittals and that material and equipment are protected and undamaged.

B. Handling: Provide equipment and personnel to handle material and equipment by methods recommended by manufacturer to prevent soiling or damage to materials and equipment or packaging.

1.6 STORAGE, PROTECTION, AND MAINTENANCE

A. On-site storage areas and buildings:

1. Conform storage buildings to requirements of Section 01500.

2. Coordinate location of storage areas with ENGINEER and OWNER.

3. Arrange on site storage areas for proper protection and segregation of stored materials and equipment with proper drainage. Provide for safe travel around storage areas and safe access to stored materials and equipment.

4. Store loose granular materials in a well-drained area on solid surfaces to prevent mixing with foreign matter.

5. Store materials such as pipe, reinforcing and structural steel, and equipment on pallets, blocks or racks, off ground.

6. Store fabricated materials and equipment above ground, on blocking or skids, to prevent soiling or staining. Cover materials and equipment which are subject to deterioration with impervious sheet coverings; provide adequate ventilation to avoid condensation.

B. Interior Storage:

1. Store materials and equipment in accordance with manufacturer's instructions, with seals and labels intact and legible.

2. Store materials and equipment, subject to damage by elements, in weathertight enclosures.

3. Maintain temperature and humidity within ranges required by manufacturer's instructions.

C. Accessible Storage: Arrange storage in a manner to provide easy access for inspection and inventory. Make periodic inspections of stored materials or equipment to assure that materials or equipment are maintained under specified conditions and free from damage or deterioration.

1. Perform maintenance on stored materials of equipment in accordance with manufacturer's instructions, in presence of OWNER or ENGINEER.

2. Submit a report of completed maintenance to ENGINEER with each Application for Payment.

3. Failure to perform maintenance, to notify ENGINEER of intent to perform maintenance or to submit maintenance report may result in rejection of material or equipment.

D. OWNER'S Responsibility: OWNER assumes no responsibility for materials or equipment stored in buildings or on-site. CONTRACTOR assumes full responsibility for damage due to storage of materials or equipment.

E. CONTRACTOR'S Responsibility: CONTRACTOR assumes full responsibility for protection of completed construction. Repair and restore damage to completed Work equal to its original condition.

F. Special Equipment: Use only rubber-tired wheelbarrows, buggies, trucks, or dollies to wheel loads over finished floors, regardless if the floor has been protected or not. This applies to finished floors and to exposed concrete floors as well as those covered with composition tile or other applied surfacing.

G. Surface Damage: Where structural concrete is also the finished surface, take care to avoid marking or damaging surface.

1.7 MANUFACTURER'S FIELD QUALITY CONTROL SERVICES

A. General:

1. Provide manufacturer's field services in accordance with this subsection for those tasks specified in other sections.

2. Provide training as specified in Section 01 79 00.

3. Include and pay all costs for suppliers' and manufacturers' services, including, but not limited to, those specified.

B. Installation Instruction: Provide instruction by competent and experienced technical representatives of equipment manufacturers or system suppliers as necessary to resolve assembly or installation procedures which are attributable to, or associated with, the equipment furnished.

C. Installation Inspection, Adjustments and Startup Participation:

1. Provide competent and experienced technical representatives of equipment manufacturers or system suppliers to inspect the completed installation as follows.

a. Verify that each piece of equipment or system has been checked for proper lubrication, drive rotation, belt tension, control sequence, or for other conditions which may cause damage.

b. Verify that tests, meter readings, and specified electrical characteristics agree with those required by the equipment or system manufacturer.

c. Verify that wiring and support components for equipment are complete.

d. Verify that equipment or system is installed in accordance with the manufacturer's recommendations, approved shop drawings and the Contract Documents.

e. Verify that nothing in the installation voids any warranty.

2. Provide manufacturer's representatives to perform initial equipment and system adjustment and calibration conforming to the manufacturer's recommendations and instructions, approved shop drawings and the Contract Documents.

3. Obtain ENGINEER'S approval before start-up of equipment. Execute start-up under supervision of applicable manufacturer's representative in accordance with manufacturers' instructions.

4. Furnish ENGINEER with three copies of the following. When training is specified, furnish the copies at least 24 hours prior to training.

   a. "Certificate of Installation, Inspection and Start-up Services" by manufacturers' representatives for each piece of equipment and each system specified, certifying:

      (1) That equipment is installed in accordance with the manufacturers' recommendations, approved shop drawings and the Contract Documents.

      (2) That nothing in the installation voids any warranty.

      (3) That equipment has been operated in the presence of the manufacturer's representative.

      (4) That equipment, as installed, is ready to be operated by others.

   b. Detailed report by manufacturers' representatives, for review by ENGINEER of the installation, inspection and start-up services performed, including:

      (1) Description of calibration and adjustments if made; if not in Operation and Maintenance Manuals, attach copy.

(2) Description of any parts replaced and why replaced.

(3) Type, brand name, and quantity of lubrication used, if any.

(4) General condition of equipment.

(5) Description of problems encountered, and corrective action taken.

(6) Any special instructions left with CONTRACTOR or ENGINEER.

D. Field Test Participation: Provide competent and experienced technical representatives of all equipment manufacturers and system suppliers as necessary to participate in field testing of the equipment specified in Section 01 45 00.

E. Trouble-Free Operation: Provide competent and experienced technical representatives of all equipment manufacturers and system suppliers as necessary to place the equipment in trouble-free operation after completion of start-up and field tests.

1.8 SPECIAL TOOLS AND LUBRICATING EQUIPMENT

A. General: Furnish, per manufacturer's recommendations, special tools required for checking, testing, parts replacement, and maintenance. (Special tools are those which have been specially designed or adapted for use on parts of the equipment, and which are not customarily and routinely carried by maintenance mechanics.)

B. Time of Delivery: Deliver special tools and lubricating equipment to OWNER when unit is placed into operation and after operating personnel have been properly instructed in operation, repair, and maintenance of equipment.

C. Quality: Provide tools and lubricating equipment of a quality meeting equipment manufacturer's requirements.

1.9 LUBRICATION

A. General: Where lubrication is required for proper operation of equipment, incorporate in the equipment the necessary and proper provisions in accordance with manufacturer's requirements. Where possible, make lubrication automated and positive.

B. Oil Reservoirs: Where oil is used, supply reservoir of sufficient capacity to lubricate unit for a 24-hour period.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

END OF SECTION

CERTIFICATE OF INSTALLATION, INSPECTION AND START-UP SERVICES

Project _____

Equipment _____

Specification Section _____

Contract _____

I hereby certify that the named equipment has been inspected, adjusted and operated by the Manufacturers' Representative and further certify:

1. That the equipment is installed in accordance with the manufacturer's recommendations, approved shop drawings and the Contract Documents.
2. That nothing in the installation voids any warranty.
3. That equipment has been operated in the presence of the manufacturer's representative.
4. That equipment, as installed, is ready to be operated by others.

MANUFACTURERS' REPRESENTATIVE

Signature _____ Date _____

Name (print) _____

Title_____

Representing_____

CONTRACTOR

Signature _____ Date _____

Name (print) _____

Title_____

Attach the detailed report called for by Specification Section 01600.

Complete and submit three copies of this form with the detailed report to ENGINEER as specified.

END OF SECTION

SECTION 01 71 23

LINES AND GRADES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. General

B. Surveys

C. Datum Plane

D. Protection of Survey Data

1.2 GENERAL

A. Construct all work in accordance with the lines and grades shown on the Drawings. Assume full responsibility for keeping all alignment and grade.

1.3 SURVEYS

A. Control Points: Base horizontal and vertical control points will be established or designated by the ENGINEER and used as datum for the Work. Perform all additional survey, layout, and measurement work.

1. Keep ENGINEER informed, sufficiently in advance, of the times and places at which work is to be performed so that base horizontal and vertical control points may be established and any checking deemed necessary by ENGINEER may be done, with minimum inconvenience to the ENGINEER and at no delay to CONTRACTOR. It is the intention not to impede the Work for the establishment of control points and the checking of lines and grades set by the CONTRACTOR. However, when necessary, suspend working operations for such reasonable time as the ENGINEER may require for this purpose. Costs associated with such suspension are deemed to be included in the Contract Price, and no time extension or additional costs will be allowed.

2. Provide an experienced survey crew including an instrument operator, competent assistants, and any instruments, tools, stakes, and other materials required to complete the survey, layout, and measurement of work performed by the CONTRACTOR.

1.4 DATUM PLANE

A. All elevations indicated or specified are based on the North American Vertical Datum (NAVD 1988). Bearings and coordinates are based on the Oklahoma State Plane Coordinate System, North Zone, North American Datum 1983 (NAD 83) and are expressed in feet and decimal parts thereof, or in feet and inches.

1.5 PROTECTION OF SURVEY DATA

A. General: Safeguard all points, stakes, grade marks, known property corners, monuments, and bench marks made or established for the Work. Reestablish them if disturbed, and bear the entire expense of checking reestablished marks and rectifying work improperly installed.

B. Records: Keep neat and legible notes of measurements and calculations made in connection with the layout of the Work. Furnish copies of such data to the ENGINEER for use in checking the CONTRACTOR's layout. Data considered of value to the OWNER will be transmitted to the OWNER by the ENGINEER with other records on completion of the Work.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

END OF SECTION

SECTION 01 73 29

CUTTING AND PATCHING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. General Requirements

B. Scheduling of Shutdown

1.2 RELATED SECTIONS

Related Work Specified in Other Sections Includes, But is Not Limited to, the Following

A. Section 01110 - Summary of Work

1.3 GENERAL REQUIREMENTS

A. Coordination: Perform all cutting, fitting or patching of the Work that may be required to make the several parts thereof join in accordance with the Contract Documents. Perform restoration with competent workmen skilled in the trade.

B. Improperly Timed Work: Perform all cutting and patching required to install improperly timed work, to remove samples of installed materials for testing, and to provide for alteration of existing facilities or for the installation of new Work in the existing construction.

C. Limitations: Except when the cutting or removal of existing construction is specified or indicated, do not undertake any cutting or demolition which may affect the structural stability of the Work or existing facilities without the ENGINEER's concurrence.

1.4 SCHEDULING OF SHUTDOWN

A. Connections to Existing Facilities: If any connections, replacement, or other work requiring the shutdown of an existing facility is necessary, schedule such work at times when the impact on the OWNER's normal operation is minimal. Overtime, night and weekend work without additional compensation from the OWNER, may be required to make these connections, especially if the connections are made at times other than those specified.

B. Request for Shutdowns: Submit a written request for each shutdown to the OWNER and the ENGINEER sufficiently in advance of any required shutdown.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 PREPARATION

A. Safeguards: Provide all shoring, bracing, supports, and protective devices necessary to safeguard all work and existing facilities during cutting and patching operations.

B. Location of Embedments: Employ impulse radar (non x-ray type) nondestructive testing prior to core drilling or cutting of existing walls, floors and ceilings to identify location of embedded pipes or conduits.

C. Material Removal: Cut and remove all materials to the extent shown or as required to complete the Work. Remove materials in a careful manner with no damage to adjacent facilities. Remove materials which are not salvageable from the site.

3.2 RESTORATION

A. Final Appearance and Finish: Restore all work and existing facilities affected by cutting operations, with new materials, or with salvaged materials acceptable to the ENGINEER, to obtain a finished installation with the strength, appearance, and functional capacity required. If necessary, patch and refinish entire surfaces.

END OF SECTION

SECTION 01 74 00

CLEANING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Cleaning During Construction

B. Final Cleaning

C. Final Inspection

1.2 CLEANING DURING CONSTRUCTION

A. During construction of work, at all times, keep the site work and adjacent premises as free from material, debris, and rubbish as is practicable and remove it from any portion of the site, if in the opinion of the ENGINEER, such material, debris, or rubbish constitutes a nuisance or is objectionable.

B. Remove from the site all surplus materials and temporary structures when no further need therefore exists.

C. Immediately upon installation of any portion of the work, restore all fills, topsoil, and utilities to their location and condition prior to construction.

1.3 FINAL CLEANING

A. Requirements: At the completion of work and immediately prior to final inspection, clean the entire project as follows:

1. Thoroughly clean, sweep, wash, and polish all work and equipment provided under the Contract, including finishes. Leave the structures and site in a complete and finished condition to the satisfaction of the ENGINEER.

2. Direct all subcontractors to similarly perform, at the same time, an equivalent thorough cleaning of all work and equipment provided under their contracts.

3. Remove all temporary structures and all debris, including dirt, sand, gravel, rubbish and waste material.

4. Should the CONTRACTOR not remove rubbish or debris or not clean the structures and site as specified above, the OWNER reserves the right to have the cleaning done at the expense of the CONTRACTOR.

B. Employ experienced workers, or professional cleaners, for final cleaning.

C. Use only cleaning materials recommended by manufacturer of surface to be cleaned.

D. In preparation for substantial completion or occupancy, conduct final inspection of sight-exposed interior and exterior surfaces, and of concealed spaces.

E. Remove grease, dust, dirt, stains, labels, fingerprints, and other foreign materials from sight-exposed interior and exterior finished surfaces. Polish surfaces so designated to shine finish.

F. Repair, patch, and touch up marred surfaces to specified finish, to match adjacent surfaces.

G. Remove snow and ice from access to structures.

H. Handle materials in a controlled manner with as few handlings as possible. Do not drop or throw materials from heights.

I. Schedule cleaning operations so that dust and other contaminants resulting from cleaning process will not fall on wet, newly-painted surfaces.

J. Broom clean exterior paved surfaces; rake clean other surfaces of the grounds.

K. Remove erection plant, tools, temporary structures and other materials.

L. Remove and dispose of all water, dirt, rubbish or any other foreign substances.

1.4 FINAL INSPECTION

A. After cleaning is complete the final inspection may be scheduled. The inspection will be done with the OWNER and ENGINEER.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

END OF SECTION

SECTION 01 78 00

CONTRACT CLOSE OUT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Warranties and Bonds

B. Record Drawings

C. Substantial Completion

D. Special Tools

1.2 WARRANTIES AND BONDS

Prior to final payment deliver to the OWNER the original and one copy of all bonds, warranties, guarantees and similar documents, including those customarily provided by manufacturers and suppliers which cover a period greater than the one year correction period. Show OWNER as beneficiary of these documents.

1.3 RECORD DRAWINGS

At the site keep and maintain one record copy of all Contract Documents, reference documents and all technical documents submitted in good order. Annotate Contract Drawings to show all changes made during the construction period. Annotated drawings are to be made available to ENGINEER for reference at all times.

At completion of the CONTRACT and before final payment is made, deliver to the ENGINEER one set of clearly readable, reproducible Contract Drawings reflecting all changes made during construction. Mark each drawing "Record Drawing" in ink.

1.4 SUBSTANTIAL COMPLETION

A. When the CONTRACTOR considers the work to be substantially completed in accordance with the Contract Documents so that the work may be beneficially occupied for the purposes for which it was intended, the CONTRACTOR shall, in writing to the OWNER and ENGINEER, certify that the work is substantially complete and request that the ENGINEER issue a Certificate of Substantial Completion for the work. The OWNER, the CONTRACTOR and ENGINEER shall make an inspection of the work to determine the status of completion. If the

ENGINEER does not consider the work substantially complete, the ENGINEER will notify the CONTRACTOR in writing giving his reasons therefore. If the ENGINEER considers the work substantially complete, the ENGINEER will prepare and deliver to the OWNER a Certificate of Substantial Completion which shall fix the date of Substantial Completion. There shall be attached to the Certificate a tentative list of items to be completed or corrected before final payment. It is mutually agreed that the CONTRACTOR will be responsible for security, operation, safety, maintenance, heat utilities, and insurance until final payment

B. INSPECTION

1. General: The work shall be subjected to continuous inspection and in addition two formal Substantial Completion inspections; Preliminary Substantial Completion Inspection and Substantial Completion Inspection. Each inspection shall be performed by the CONTRACTOR in the presence of the ENGINEER. All required labor, materials, equipment, instruments, lubricants and incidentals necessary to perform these inspections shall be furnished by the CONTRACTOR. Before proceeding to the next inspection, all discrepancies and deficiencies observed during each inspection shall be noted and corrected and, if directed by the ENGINEER, the inspection shall be rescheduled and repeated at no additional cost to the OWNER.

    a. Refer to individual specification sections for specific requirements for placing equipment and systems in operation.

    b. Notification: When the CONTRACTOR considers the Work ready for each inspection, the CONTRACTOR shall so notify the ENGINEER in writing for each inspection. Each inspection shall be performed by the ENGINEER within 10 days after receipt of the request.

2. Preliminary Substantial Completion Inspection:

    a. Perform a preliminary inspection to demonstrate that individual components of the work and equipment have been completed in accordance with the Contract Documents. Perform required tests, identify deficiencies to be corrected and incomplete Contract items to be completed prior to the SUBSTANTIAL COMPLETION INSPECTION. This may require one or a series of preliminary inspections and test procedures for each component included in the Contract.

    b. All project Operation and Maintenance Manuals shall be received prior to beginning the PRELIMINARY SUBSTANTIAL COMPLETION INSPECTION.

c. The ENGINEER will prepare a TENTATIVE LIST OF DEFICIENT ITEMS to be accomplished prior to performing the SUBSTANTIAL COMPLETION INSPECTION.

3. Substantial Completion Inspection:

a. Perform a SUBSTANTIAL COMPLETION INSPECTION to fully demonstrate to the ENGINEER that all individual project components function as required by the Contract Documents and that all systems are internally coordinated, as well as coordinated with other systems. Verify to the ENGINEER that correction of the deficiencies noted in the PRELIMINARY SUBSTANTIAL COMPLETION INSPECTION, have been accomplished. Equipment shall be operated and required system tests performed. In addition, it shall demonstrate that all major site work has been brought to final configurations and restoration initiated.

b. Manufacturer's authorized representatives shall be present at this inspection.

c. All project Record Drawings shall be received prior to beginning the SUBSTANTIAL COMPLETION INSPECTION.

d. The ENGINEER will prepare a LIST OF DEFICIENT ITEMS to be accomplished prior to performing the Final Inspection.

1.5 SPECIAL TOOLS

Special tools are considered to be those tools which, because of their limited use, are not normally available but which are necessary for maintenance of particular equipment.

For each type of equipment provided under this CONTRACT, furnish a complete set of all special tools including grease guns and other lubricating devices, which may be needed for the adjustment, operation, maintenance, and disassembly of such equipment. Furnish only tools of high grade, smooth forged alloy tool steel. Manufacture grease guns of the lever type.

Furnish and erect one or more neat and substantial steel wall cases or cabinets with flat key locks and clips or hooks to hold each special tool in a convenient arrangement.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

END OF SECTION

SECTION 01 79 00

TRAINING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Training

1.2 RELATED SECTIONS

A. Section 01 60 00 – Material and Equipment

1.3 TRAINING

A. Training: Provide the services of knowledgeable, technically competent, factory trained specialists to instruct OWNER's personnel in the operation and maintenance of the equipment and system components listed in Paragraph B. The OWNER will furnish training classroom space.

1. Coordinate services with the OWNER, with a minimum of 14 days prior notice.

2. Provide a combination of classroom and "hands-on" instruction designed to completely familiarize operating and maintenance personnel with the systems theory, standard operating procedures, safety features and emergency procedures, and general maintenance of all components.

3. Conduct all training during regular hours on weekdays, and coordinate the scheduling of all training with the OWNER.

B. Provide training for the following:

Specification	Equipment Name	Total Minimum Hours
23 09 00	HVAC Controls	4
26 05 80	Electric Motors	4
26 29 23	Adjustable Frequency Drive	8
26 32 13	Packaged Engine Generator	4
40 80 50	Process Control System Commissioning	As Specified
40 98 00	Process Control System Training	As Specified

C. Length of Training: The minimum lengths of training sessions are listed in Paragraph B. above.

D. Credentials: Submit for approval, credentials of equipment manufacturer representatives who are to be course instructors at least 14 days prior to a proposed training session.

E. Scheduling: Submit training outline and other information described in paragraphs G through K for approval at least 14 days prior to the proposed date for the training sessions. Verify scheduling with the OWNER at least 14 days prior to the training sessions.

F. Number of Copies: For each training class, provide instructional material for at least ten attendees plus five extra copies, plus duplicate copies of all audio-visual aids utilized during each training course.

G. Training Outline Submission: Provide a proposed training outline including the topics presented in Paragraph K. Identify specific components and procedures in the proposed training outline.

H. Training Topic Detail: Detail specific training topics. Describe "hands-on" demonstrations planned for the training. Reference training aids to be utilized in the training (i.e. video tapes, slides, transparencies) and attach where applicable.

I. Training Handouts: Attach training handouts to the proposed training outline.

J. Training Segment Duration: Indicate the duration of each training segment.

K. Training Outline:

1. Equipment Operation

a. Describe equipment's operating (process) function.

b. Describe equipment's fundamental operating principles and dynamics.

c. Identify equipment's mechanical, electrical and electronic components and features.

d. Identify all support equipment associated with the operation of the subject equipment.

2. Detailed Component Description

a. Identify and describe in detail each component's function.

b. Where applicable, group related components into subsystems.

c. Identify, and describe in detail, equipment safety features and control interlocks.

3. Equipment Preventive Maintenance

a. Describe preventive maintenance inspection procedures required to perform and inspect the equipment in operation, and spot potential trouble symptoms (anticipate breakdowns).

b. Outline recommended routine lubrication and adjustments (preventive maintenance).

4. Equipment Troubleshooting

a. Define recommended systematic troubleshooting procedures.

b. Provide component specific troubleshooting checklists.

c. Describe applicable equipment testing and diagnostic procedures to facilitate troubleshooting.

5. Equipment Corrective Maintenance

a. Describe recommended equipment preparation requirements.

b. Identify and describe the use of special tools required for maintenance of the equipment.

c. Describe component removal/installation and disassembly/ assembly procedures.

d. Perform at least two "hands-on" demonstrations of common corrective maintenance repairs.

e. Describe recommended measuring instruments and procedures, and provide instruction on interpreting alignment measurements, as appropriate.

f. Define recommended torquing, mounting, calibration, and alignment procedures and settings, as appropriate.

g. Describe recommended procedures to check/test equipment following corrective repair.

L. Certificate: Provide "Certificate of Instructional Services" signed by ENGINEER and equipment representative, verifying that training has been accomplished to satisfaction of all parties. Use form provided in this section, and furnish ENGINEER with three (3) copies.

M. Recording: Record and video each equipment training session. After training is complete provide one (1) DVD copy of each training session for OWNER.

N. Substantial Completion: Training provided by manufacturers' representative, ENGINEER and OWNER does not constitute substantial completion.

O. Equipment Use: Use of equipment for training will not void manufacturers' or contract warranties.

P. Commissioning Binder

1. Upon completion of training for each equipment item, and prior to Final Completion, provide one (1) commissioning binder. Identify each section based on the equipment item using heavy sections dividers with reinforced holes and numbered plastic index tabs. Use 3-ring, slant ring, hard-back binders, Binder size shall be 3-inch maximum. Punch all loose data for binding. Arrange composition and printing so that punching does not obliterate any data.

2. At a minimum for each section, i.e. equipment item, provide the following:

a. Certificate of Installation, Inspection and Start-up Services

b. Equipment Data Summary

c. Equipment Preventative Maintenance Data Summary

d. Manufacturer’s Operating and Maintenance Instructions

e. Certificate of Instructional Services

f. Manufacturer’s Start-up and Installation Checklists

g. Warranty

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

END OF SECTION

CERTIFICATE OF INSTRUCTIONAL SERVICES

Project_____

Equipment_____

Specification Section_____

Contract_____

I hereby certify the equipment Manufacturers' Representative has instructed OWNER's personnel in startup operation and maintenance of this equipment as required in the Contract Documents.

MANUFACTURER'S REPRESENTATIVE

Signature _____

Name: (print) _____

Title: _____

Representing _____

CONTRACTOR

Signature _____ Date _____

Name (print) _____

Title _____

ENGINEER

Signature _____ Date _____

Name (print) _____

Title _____

COMMENTS:

Complete and submit three copies of this form to ENGINEER upon completion of training as required by Specification Section 01 79 00.

SECTION 02 41 00

DEMOLITION

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: All work necessary for the removal and disposal of buildings, structures, foundations, piping, equipment and roadways, or any part thereof including masonry, steel, reinforced concrete, plain concrete, electrical facilities, and any other material or equipment shown or specified to be removed.

B. Basic Procedures and Schedule: Carry out demolition so that adjacent structures, which are to remain, are not endangered. Schedule the work so as not to interfere with the day to day operation of the existing facilities. Do not block doorways or passageways in existing facilities.

C. Additional Requirements: Provide dust control and make provisions for safety.

1.2 SUBMITTALS

A. Provide all submittals, including the following, as specified in Division 1.

B. Site Inspection: Visit the site and inspect all existing structures. Observe and record any defects which may exist in buildings or structures adjacent to but not directly affected by the demolition work. Provide the OWNER with a copy of this inspection record and obtain the ENGINEER's approval prior to commencing the demolition.

1.3 QUALITY ASSURANCE

A. Limits: Exercise care to remove pumps from the facility. Where only parts of a structure are to be removed, cut the concrete along limiting lines with a suitable saw so that damage to the remaining structure is held to a minimum.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 EXAMINATION OF EXISTING DRAWINGS

A. Drawings of existing structures and equipment will be available for inspection at the office of the OWNER.

3.2 PROTECTION

A. General Safety: Provide warning signs, protective barriers, and warning lights as necessary adjacent to the work as approved or required. Maintain these items during the demolition period.

B. Existing Services: Undertake no demolition work until all mechanical and electrical services affected by the work have been properly disconnected. Cap, reroute or reconnect interconnecting piping or electrical services that are to remain in service either permanently or temporarily in a manner that will not interfere with the operation of the remaining facilities.

C. Hazards: Perform testing and air purging where the presence of hazardous chemicals, gases, flammable materials or other dangerous substances is apparent or suspected, and eliminate the hazard before demolition is started.

3.3 DEMOLITION REQUIREMENTS

A. Explosives: The use of explosives will not be permitted.

B. Protection: Carefully protect all mechanical and electrical equipment against dust and debris.

C. Removal: Remove all debris from the structures during demolition and do not allow debris to accumulate in piles.

D. Access: Provide safe access to and egress from all working areas at all times with adequate protection from falling material.

E. Protection: Provide adequate scaffolding, shoring, bracing railings, toe boards and protective covering during demolition to protect personnel and equipment against injury or damage. Cover floor openings not used for material drops with material substantial enough to support any loads placed on it. Properly secure the covers to prevent accidental movement.

F. Lighting: Provide adequate lighting at all times during demolition.

G. Closed Areas: Close areas below demolition work to anyone while removal is in progress.

H. Material Drops: Do not drop any material to any point lying outside the exterior walls of the structure unless the area is effectively protected.

3.4 DISPOSAL OF MATERIALS

A. Final Removal: Remove all debris, rubbish, scrap pieces, equipment, and materials resulting from the demolition unless otherwise indicated. Take title to all demolished materials and remove such items from the site.

B. OWNER's Property: In addition to any items which may be shown, the following items remain the property of the OWNER. Remove carefully, without damage, all items listed or shown, and stockpile as directed. CONTRACTOR to coordinate with OWNER to confirm items to be salvaged before disposal.

1. Engines W1 and W2
2. Engine Starting Batteries and Racks
3. Cooling Water Pumps
4. Jacket Water Cooler
5. Existing PLCs
6. Control Cabinets and Appurtenances

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 03 10 00

CONCRETE FORMWORK

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Provide concrete formwork for architectural concrete and structural concrete as specified to form concrete to profiles shown.

1. Architectural concrete is defined as concrete for the following exposed reinforced concrete surfaces:

a. Interior walls
b. Exterior walls to 6 inches below finish grade
c. Interior tank walls to 6 inches below normal operating water level
d. Beams
e. Columns
f. Undersides of floor slabs, roof slabs and stairs

2. Provide concrete finish with rubber or broom finish.

3. Structural concrete is defined as all concrete that is not architectural concrete.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 03 20 00 - Concrete Reinforcement
2. Section 03 15 00 - Concrete Accessories
3. Section 03 31 00 - Cast-In-Place Concrete

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. ACI 318 - Building Code Requirements for Reinforced Concrete
2. ACI SP-4 - Formwork for Concrete
3. ACI 303R - Guide to Cast-in-Place Architectural Concrete

1.3 SUBMITTALS

A. Provide all submittals, including the following, as specified in Division 1.

1. CONTRACTOR'S Shop Drawings: Drawings of proposed formwork for Concrete. Review of these drawings by the ENGINEER does not relieve the CONTRACTOR of the responsibility for adequately designing and constructing forms.

2. Samples: Pieces of each type of sheeting, chamfer strips, form ties, form liners and rustication strips.

1.4 QUALITY ASSURANCE

A. Formwork Compliance: Use formwork complying with ACI SP-4 and ACI 303R.

PART 2 PRODUCTS

2.1 MANUFACTURER

A. Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted.

1. Release Agent
Magic Kote VOC by Symons Corporation

2. Form coating
A.C. Horn Corporation, Brooklyn, NY

3. Form liners
Dura-Tex by Symons Corporation, Des Plaines, IL

4. Rustications
Symons Corporation, Des Plaines, IL

2.2 MATERIALS

A. Structural Concrete: Provide structural concrete form materials as follows:

1. Obtain approval for form material before construction of the forms.

2. Use a barrier type form release agent.

3. Use form ties, hangers, and clamps of such type that, after removal of the forms, no metal will be closer than one inch from concrete surface. Wire ties will not be permitted.

4. Provide ties with swaged washers or other suitable devices to prevent seepage of moisture along the ties. Leave the ties in place.

5. Use lugs, cones, washers, or other devices which do not leave holes or depressions greater than 7/8-inch in diameter.

B. Architectural Concrete: Provide architectural concrete form materials as follows:

1. Construct forms using 3/4-inch thick, High Density Overlay (HDO) Plyform, Class 1 or 2, meeting the requirements of the American Plywood Association. Use surfacing materials having a minimum weight of 60-60.

2. Use form coating, and use thinner as recommended by manufacturer of the form coating, to coat cut or raw edges.

3. Use she-bolts with water seals for form ties.

4. Use form liners having one inch deep relief, elastomeric Dura-Tex in a fractured rib pattern to match existing. Furnish form liners in full height lengths with no horizontal joints, except where shown. Use wood for forms to be used with form liners.

5. Use elastomeric vertical "V-groove" rustications in the concrete bands and the horizontal rustication joints shown in the form liner concrete of the profile shown.

6. Use a barrier type VOC compliant form release agent.

PART 3 EXECUTION

3.1 DESIGN

A. Design Responsibility: Be responsible for the design, engineering and construction of the architectural concrete formwork and the structural concrete formwork. Conform the work to the recommendations of ACI SP-4 and ACI 303R.

B. Setting Time and Slag Use: The presence of fly ash or ground granulated blast furnace slag in the concrete mix for architectural concrete and structural concrete will delay the setting time. Take this into consideration in the design and removal of the forms.

C. Responsibility During Placement: Assume and take sole responsibility for adequate design of all form elements for support of the wet concrete mixtures specified and delivered.

D. Consistency: Design forms to produce concrete members identical in shape, lines and dimensions to members shown.

3.2 CONSTRUCTION DETAILS FOR FORMWORK

A. Structural Concrete Details: Follow the following details for all structural concrete:

1. Provide forms which are substantial, properly braced, and tied together to maintain position and shape and to resist all pressures to which they may be subjected. Make forms sufficiently tight to prevent leakage of concrete.

2. Determine the size and spacing of studs and wales by the nature of the work and the height to which concrete is placed. Make forms adequate to produce true, smooth surfaces with not more than 1/8-inch variation in either direction from a geometrical plane. Provide horizontal joints which are level, and vertical joints which are plumb.

3. Supply forms for repeated use in sufficient number to ensure the required rate of progress.

4. Thoroughly clean all forms before reuse and inspect forms immediately before concrete is placed. Remove deformed, broken, or defective forms from the work.

5. Provide temporary openings in forms at convenient locations to facilitate cleaning and inspection.

6. Coat the entire inside surfaces of forms with a suitable form release agent just prior to placing concrete. Form release agent is not permitted on the reinforcing steel.

7. Assume and take responsibility for the adequacy of all forms and remedying any defects resulting from their use.

B. Architectural Concrete Details: Follow the following details for all Architectural Concrete:

1. Conform all construction details for formwork to “Construction Details for Formwork,” subsections A1, A2, A3, A4, A6 and A7 and the requirements of this section.

2. Thoroughly clean and lightly recoat HDO plywood panels before each additional use. Do not use forms more than three times.

3. Install form liners and rustication strips in strict accordance with the manufacturer's written instructions and recommendations. Clog the ends of the form liner pattern and tape all form joints and edges using 1/8-inch thick by 3/4-inch wide foam tape centered on the joints, then caulk in accordance with the manufacturer's recommendations each time forms are set. Have a representative of the manufacturer present at the site to supervise the installation of the form liner for the entire project.

4. Install forms for smooth concrete in such a manner that there will be no horizontal form joints, and align the forms so that vertical joints occur only at "V-Groove" rustications. Space form ties in a uniform pattern vertically and horizontally. Position form ties in smooth concrete bands and in panels between "reveal" rustications, if any.

5. Erect beam and girder soffits with a camber of 1/2-inch in 20 feet and sufficiently braced, shored, and wedged to prevent deflection. Clamp column sides in accordance with this specification with metal column clamps, spaced according to the manufacturer's directions.

6. Provide external angles of walls, beams, pilasters, columns, window openings and girders with 3/4-inch bevel strips.

7. Give surfaces of concrete panel forms one thinned coat of form film.

8. Apply the release agent in strict accordance with the manufacturer's instructions.

3.3 FORM REMOVAL

A. General: Do not remove forms, form ties and bracing for structural and architectural concrete without specific permission of the CONTRACTOR's Registered Professional Engineer.

B. Structural Concrete Form Removal: Do not remove forms for structural concrete until the concrete has hardened sufficiently to support its own load safely, plus any superimposed load that might be placed thereon. Leave the forms in place for the minimum length of time indicated below or until the concrete has reached the minimum strength indicated as determined by testing, whichever time is reached first.

1. The times indicated represent cumulative days or hours, not necessarily consecutive, during which the air surrounding the concrete is above 50 degrees F. These times may be decreased if reshores are installed.

		Minimum Time	Minimum Strength (psi)
a.	Columns	12 hrs.	1300
b.	Columns	12 hrs.	1300
c.	Side forms for girders and beams	12 hrs.	1300
d.	Walls	12 hrs.	1300
e.	Bottom forms of slabs		
	Under 10 feet clear span	4 days	2300
	10 to 20 feet clear span	7 days	2700
	Over 20 feet clear span	10 days	2900
f.	Bottom forms of beams and girders		
	Under 10 feet clear span	7 days	2700
	10 to 20 feet clear span	14 days	3000
	Over 20 feet clear span	21 days	3500

2. Increase form removal times as required if concrete temperature following placement is permitted to drop below 50 degrees F or if fly ash or ground granulated blast furnace slag is used in the concrete mix.

3. Withdraw the removable portion of form ties from the concrete immediately after the forms are removed. Clean and fill holes left by such ties with grout as specified in Cast-In-Place Concrete, Subsection Structural Concrete Surfaces.

4. Plug tie holes flush with the surface using portland cement mortar. Prewet tie holes with clean water and apply a neat cement slurry bond coat. Densely tamp mortar of a dry-tamp consistency into the tie holes exercising care so as not to smear mortar onto the finished concrete surface. Include sufficient white cement in the mortar mix to cause the plugged holes to blend in with the adjacent surfaces. Make sample patches with different mixes to assure that this requirement is met.

C. Architectural Concrete Form Removal: Remove forms for architectural concrete in accordance with the above subsection 3.03 A and B, except that do not remove forms for vertical surfaces sooner than 12 hours nor longer than 36 hours after placement of concrete.

3.4 RESHORING

A. Reshoring Method: Develop a system for reshoring and early removal of forms, in the event early stripping of forms becomes necessary. Include details and schedules in this system for each element which is to be reshored.

B. Construction Load Support: Do not support construction loads upon any unshored portion of the structure exceeding the structural design loads.

3.5 TOLERANCES

A. Tolerance Limits: Design, construct and maintain concrete form and place the concrete to provide completed concrete work within the tolerance limits set forth in ACI SP-4.

3.6 SURVEY OF FORMWORK

A. Field Survey: Employ an engineer or surveyor to check by instrument survey the lines and levels of the completed formwork before concrete is placed and make whatever corrections or adjustment to the formwork are necessary to correct deviations from the specified tolerances.

B. Placement Surveying Requirements: Check formwork during the placement of the concrete to verify that the forms, braces, tie rods, clamps anchor bolts, conduits, piping, and the like, have not been knocked out of the established line, level or cross section by concrete placement or equipment.

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 03 15 00

CONCRETE ACCESSORIES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for providing concrete accessories shown and specified herein such as waterstops, dovetail anchor slots, cast-in-place reglets, inserts, joint filler, preformed joint seal, joint sealant and neoprene pads.

B. Products Installed: Waterstops, dovetail anchor slots, cast-in-place reglets, inserts, joint filler, preformed joint seal, joint sealant and neoprene pads.

C. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 03 10 00 - Concrete Formwork
2. Section 03 20 00 - Concrete Reinforcement
3. Section 03 31 00 - Cast-in-Place Concrete

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. AASHTO - Standard Specifications for Highway Bridges

2. ASTM A 240 - Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels

3. ASTM A 536 - Standard Specifications for Ductile-Iron Castings

4. ASTM D 412 - Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers - Tension

5. ASTM D 3545 - Test Methods for Alcohol Content and Purity of Acetate esters by Gas Chromatography

6. ASTM D 3575 - Test Methods for Flexible Cellular Materials Made From Olefin Polymers

7. CRD-C513 - Specifications for Rubber Waterstops

8. CRD-C572 - Specifications for Polyvinyl Chloride Waterstop

9. Fed. Spec. TT-S-00227 - Sealing Compound, Elastomeric Type, Multicomponent (for Calking, Sealing, and Glazing in Buildings and Other Structures)

10. Fed. Spec. TT-S-00230 - Sealing Compound, Elastomeric Type, Single Component (for Calking, Sealing, and Glazing in Buildings and Other Structures)

1.3 SUBMITTALS

A. General: Provide all Work related submittals, including the following, as specified in Division 1.

B. Product Data and Information:

1. Manufacturer's Data and Specifications: Submit printed manufacturer's data and specifications for each item used on this project.

2. Samples: Provide one sample of each item used.

3. Joint Sealant and Preformed Joint Seal: Indicate special procedures, surface preparation and perimeter conditions requiring special attention. All products in contact with potable water, shall be "NSF Standard 61" certified. Submit certified material records indicating approval for use with potable water.

1.4 DELIVERY, STORAGE AND HANDLING

A. Deliver, store and handle all products and materials as specified in Division 1 (and as follows:)

PART 2 PRODUCTS

2.1 MANUFACTURER

A. Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted.

1. Joint Filler

a. Sonoflex F Foam by Sonneborn Building Products
b. PVC Joint Filler No. 327 by A.C. Horn

2. Sealant Backup Material

a. Sealtight Backer Rod
b. Sonofoam Backer Rod

3. Preformed Joint Seal

a. Evazote 380, ESF by Epoxy Industries

4. Wedge Inserts

a. Type F-7 by Dayton Superior, Miamisburg, OH

5. Dovetail Anchor

a. A.A. Wire Products Co.
b. Dur-O-Wal Inc.

6. Flashing Reglets

a. Standard reglets by Beehive Anchoring System

2.2 MATERIALS

A. Extruded Waterstops: Provide waterstops made of extruded polyvinyl chloride unless otherwise shown or specified.

1. Do not use any reclaimed plastic material in their manufacture.

2. Provide plastic waterstops meeting the requirements of CRD-C572, except as modified herein. Provide a Shore A/10 durometer hardness between 73 and 79, the tensile strength not less than 1850 psi, and specific gravity not more than 1.38.

3. Unless otherwise shown, use waterstops for construction joints which are flat, at least 6 inches wide, and not less than 3/8-inch thick at the thinnest section. Provide these waterstops with ribbed longitudinal strips.

4. Unless otherwise shown, provide waterstops for expansion joints at least 9 inches wide and not less than 1/4-inch thick at the narrowest point and not less than 3/8-inch thick immediately adjacent to the center of the waterstop. Provide the waterstop with ribbed longitudinal strips with a 3/4-inch inside

diameter hollow bulb center. Limit joint movement to 1/4-inch under a tensile force of not more than 500 pounds per lineal inch.

B. Stainless Steel Waterstops: Provide stainless steel waterstops where shown or specified.

1. Fabricate stainless steel waterstops from ASTM A 240 Type 316, 20 gauge stainless steel, conforming to the dimensions and profiles shown.

2. Prefabricate and miter corners and intersections for all stainless steel waterstops. Make only butt joints in the field.

C. Rubber Waterstops: Provide rubber water stops where shown or specified.

1. Provide rubber water stops of either the molded or extruded type, fabricated from a high grade tread type compound, either SBR or natural rubber, conforming to CRD-C513.

2. Provide water stops for construction joints at least 6 inches wide and 3/8-inch thick and with solid end bulbs 3/4-inch in diameter.

3. Provide water stops for expansion joints 9 inches wide and 3/8-inch thick and with solid end bulbs 1-inch in diameter and a hollow center bulb 1-1/2 inches in diameter with a 3/4-inch diameter center cavity.

D. Expansion Joint Filler: Use joint filler for all expansion joints.

1. Provide a closed cell polyethylene or PVC joint filler of the thickness shown.

E. Joint Sealant Requirements: Finish expansion joints with a joint sealant where shown or specified.

1. Joint sealant materials may be either a single component urethane compound meeting the requirements of Fed. Spec. TT-S-00230C, or a 2-component urethane compound meeting the requirements of Fed. Spec. TT-S-00227E, except as modified in this specification.

2. Provide the urethane sealant of 100 percent polymer, non-extended, containing no solvent, lime, or coal tar. Color as selected by the ENGINEER, but not black. Conform sealant properties to the following:

Property	Value	Test Method
a. Maximum final cure	3 days	--

b.	Minimum tensile strength	140 to 200 psi	ASTM D 412
c.	Minimum elongation	400%	ASTM D 412
d.	Modulus at 100% elongation	40-60 psi	ASTM D 412
e.	Shore A hardness	25-40	ASTM D 2240
f.	Solid content	98-100%	--
g.	Peel strength	20-40 lb/in.	Fed. Spec. TT-S-00230C Fed. Spec. TT-S-00227E
h.	Minimum recovery	80-90%	Fed. Spec. TT-S-00230C Fed. Spec. TT-S-00227E
i.	Initial tack-free cure	24-48 hrs.	Fed. Spec. TT-S-00230C Fed. Spec. TT-S-00227E

3. Provide primer as recommended by the manufacturer of the sealant, subject to approval.

4. Provide fillers and backup materials in contact with sealant which are nonimpregnated and free from asphalt, creosote, oil or extractable plasticizers. Use a backup material of a closed cell polyethylene foam rod with a diameter 1/4-inch larger than the joint width.

F. Preformed Joint Seal: Provide a preformed joint seal where shown or specified.

1. Provide joint material which is resilient, non-extrudable, impermeable, closed-cell, cross-linked, ethylene vinyl acetate, low density, polyethylene copolymer, nitrogen blown material which is ultraviolet light, weather and wear resistant, and which is concrete beige in color.

2. Conform material properties with the following:

	Property	Value	Test Method
a.	Density, pcf	2.8 to 3.4	ASTM D 3575 Suffix: W, Method A
b.	Water Absorption total immersion 3 months	0.02% by volume	ASTM D 3575 Suffix: L
c.	Tensile Strength	125 psi	ASTM D 3575 Suffix: T
d.	Elongation before breaking	255%	ASTM D 3575 Suffix: T
e.	Working Temperature	-94 to 160 F	--

G. Neoprene Pads: Use neoprene pads as shown or required where slabs or beams must be prevented from bonding to footings, walls, columns or other rigid parts of the structure.

1. Use neoprene pads of a structural grade meeting the requirements of Section 25, Division 2 of the AASHTO Standard Specifications for Highway Bridges.

2. Do not use neoprene pads thinner than 1/4-inch.

H. Wedge Inserts: Make wedge inserts for 5/8-inch and 3/4-inch bolts of ductile iron conforming to ASTM A 536.

I. Dovetail Anchors: Provide dovetail anchors of one of the following types:

1. Dovetail anchors having a 3/16-inch by 1-inch by 1/2-inch stainless steel dovetail section with 3/16-inch diameter stainless steel wire.

2. Dovetail anchor slots of 24 gauge galvanized steel 1-inch by 1-inch by 5/8-inch throat. Fill anchor slots.

J. Flashing Reglets: Provide flashing reglets of 24 gauge galvanized steel foam filled reglets.

PART 3 EXECUTION

3.1 INSTALLING OF WATERSTOPS

A. Assembly of Extruded Waterstops: Prefabricate corners and intersections for all waterstops. Make only butt joints in the field. Miter and assemble corners and intersections with approved equipment, as described for field joints.

1. Make field joints by cutting the ends of the sections to be spliced so they will form a smooth even butt joint. Heat the cut ends with the splicing tool until the plastic melts. Press the two ends together until the plastic cools. Do splicing in a way that limits damage to the continuity of the ribbed strips.

2. Carry waterstops in the walls into lower slabs and join them to the waterstops in the slabs. Make all waterstops continuous. Set waterstops accurately to the position and line shown. Hold edges securely fixed in position at intervals of not more than 24 inches so that they will not move during the placing of the concrete. Do not drive nails through the waterstops.

B. Prefabricated Stainless Steel Waterstops: Prefabricate corners and intersections for all stainless steel waterstops. Make only butt joints in the field. Miter and weld corners and intersections.

1. Provide field joints having a nominal 1-inch lap joint, with the exposed edge welded or brazed on each side.

2. Make field joints with PVC waterstops as shown.

3. At expansion joints, seal the base of the expansion section of the waterstop with at least one layer of 2-inch wide duct tape.

4. Carry waterstops in the walls into lower slabs and join them to the waterstops in the slabs. Make all waterstops continuous. Set waterstops accurately to the position and line shown. Hold edges securely fixed in position at intervals of not more than 24 inches so that they will not move during the placing of the concrete. Do not drive nails through the waterstops.

C. Splices: Use splices made in the manufacturer's plant where possible for rubber waterstops.

1. Use a preformed rubber union or fitting and splicing cement as recommended by the manufacturer when splices are made.

2. Carry waterstops in the walls into lower slabs and join them to the waterstops in the slabs. Make all waterstops continuous. Set waterstops accurately to the position and line shown. Hold edges securely fixed in position at intervals of not more than 24 inches so that they will not move during the placing of the concrete. Do not drive nails through the waterstops.

D. Joint Filler Placement: Place joint filler for expansion joints against the completed portion of the work before the concrete for the next section is placed.

1. Fasten the filler to the hardened concrete with a compatible adhesive in accordance with manufacturer's instructions. Extend the filler through the thickness of the wall or slab and make it flush with the finished surface, except where a preformed joint seal or joint sealant is shown.

2. In joints having a waterstop, fit the filler accurately on each side of the waterstop to prevent the intrusion of concrete.

E. Preparation of 2-Component Sealants: Mix 2-component joint sealant using a slotted paddle and slow speed mixer for 5 to 8 minutes, continually working paddle from top to bottom until the sealant color is uniform. Scrape down the side

of the container and paddle blade several times during the mixing operation to ensure uniform mixing.

1. Properly prepare joint surfaces by removing all foreign matter and concrete laitance so that concrete surfaces are structurally sound, clean, dry, and free of all oil, grease, wax, waterproofing compounds or form release materials prior to the application of primer and sealant.

2. Prime all concrete joint surfaces and all surfaces exposed to water prior to sealing, with no exceptions. Prime all other surfaces as recommended by the manufacturer of the sealant. Provide the prime as recommended by the manufacturer of the sealant, subject to approval. Apply the primer by either brushing or spraying on the joint surfaces. Apply and install the sealant within 2 to 24 hours after the application of primer.

3. For horizontal joints, install the sealant by pouring directly from a suitable shaped can or by flowing from a bulk-loading gun.

4. Fill vertical joints from a gun, starting from the bottom, to avoid bridging and the formation of air voids.

5. Fill overhead joints from a gun, by laying a bead along each side of the joint and then filling the middle. Immediately after installation, tool in the sealant in order to establish firm contact with joint surfaces and to provide a smooth sealant surface. Tool in accordance with the manufacturer's instructions.

6. Control joint depth with the use of joint fillers and backup materials. Make joint widths and sealant depths as shown. Do not exceed 1/2-inch for sealant depth.

F. Preformed Joint Seal Surface Preparation: Properly prepare joint surfaces by removing all foreign matter and concrete laitance so that concrete surfaces are structurally sound, clean, dry, and free of all oil, grease, wax, water-proofing compounds or form release materials.

1. Blast clean or saw cut all existing concrete surfaces to expose a clean bare concrete surface. Allow new concrete to be well cured, and attain a minimum of 80 percent of the specified strength before installing sealant.

2. Apply bonding adhesive, as recommended by the manufacturer to the concrete surfaces in strict compliance with the manufacturer's recommendations. Install the joint material under a compression of 25 percent and in one continuous operation, in accordance with manufacturer's recommendations. Do all splices and directional changes using heat welding method as recommended by the manufacturer.

G. Unbonded Joints: Use unbonded horizontal joints as shown or required where slabs of beams must be prevented from bonding to footings, walls, columns or other rigid parts of the structure.

1. Prevent bonding by use of structural grade neoprene pads placed over the bearing surface of the footing, wall or other supporting part of the structure so as to isolate it from the new concrete being placed.

H. Encasing Inserts: Encase wedge inserts, flashing reglets and dovetail anchor slots in the concrete as shown. Take special care to place and maintain them to the proper lines and grades and to compact concrete thoroughly around them to prevent the passage of water. Set these items before placing concrete and thoroughly brace them to prevent movement during the progress of the work. Provide dovetail anchor slots spaced not more than 16 inches apart for all concrete walls faced with masonry.

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 03 20 00

CONCRETE REINFORCEMENT

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for providing concrete reinforcement as shown and specified herein. Reinforcement includes all steel bars, wire and welded wire fabric as shown and specified.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 03 10 00 - Concrete Formwork
2. Section 03 31 00 - Cast-In-Place Concrete

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1.	ACI SP66	-	ACI Detailing Manual
2.	ACI 318	-	Latest edition "Building Code Requirements for Reinforced Concrete"
3.	ASTM A 185	-	Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
4.	ASTM A 615/A615M	-	Deformed and Plains Billet-Steel Bars for Concrete
5.	ASTM A 706/A706M	-	Low Alloy Steel Deformed Bars for Concrete Reinforcement
6.	ASTM A 775/A775M	-	Epoxy Coated Reinforcing Steel Bars
7.	AWS D1.4	-	Structural Welding Code - Reinforcing Steel

1.3 SUBMITTALS

A. Provide all submittals, including the following, as specified in Division 1.

1. Product Data and Information: Submit manufacturers literature with product data, and material description of fusion bonded epoxy coating for reinforcement and reinforcement accessories, including manufacturer's recommendations for field touch-up of mars and cut ends.

2. CONTRACTORS' Shop Drawings: Submit checked Working Drawings, including bar lists, schedules, bending details, placing details and placing plans and elevations for fabrication and placing reinforcing steel conforming to "ACI Detailing Manual - 88".

    a. Do not bill wall and slab reinforcing in sections. Show complete elevations of all walls and complete plans of all slabs, except that, when more than one wall or slab are identical, only one such elevation or plan is required. These plans and elevations need not be true views of the walls or slabs shown. Bill every reinforcing bar in a slab on a plan. Bill every reinforcing bar in a wall on an elevation. Take sections to clarify the arrangement of the steel reinforcement. Identify all bars, but do not bill on such sections.

    b. For all reinforcing bars, unless the location of a bar is clear, give the location of such bar or bars by a dimension to some structural feature which will be readily distinguishable at the time bars are placed.

    c. Make the reinforcing steel placing drawings complete for placing reinforcement including the location of support bars and chairs, without reference to the design drawings.

    d. Submit Detailer certification that every reinforcing steel placing drawing and bar list is completely checked and corrected before submittal for approval.

    e. If, after reinforcing steel placing drawings and bar lists have been submitted for approval, a review reveals that the drawings and lists obviously have not been checked and corrected they will be returned for checking and correcting by the Detailer.

3. Samples: Submit the following samples when epoxy coated reinforcement is specified to be used.

    a. 12-inch long epoxy-coated steel reinforcing bar, of any size typical to this Project

    b. One of each type of epoxy-coated reinforcement accessory used on this Project

    c. 12-inch long, nylon coated tie wire

4. Certificates: Test certificates of the chemical and physical properties covering each shipment of reinforcing steel bars.

1.4 DELIVERY, STORAGE AND HANDLING

A. Deliver, store and handle all products and materials as specified in Division 1 (and as follows:)

1. Delivery Requirements: Have reinforcing steel delivered to the work in strongly tied bundles. Identify each group of both bent and straight bars with a metal tag giving the identifying number corresponding to the reinforcing steel placing drawings and bar lists.

2. Storage: Properly store all bars in an orderly manner, with all bars completely off the ground. Keep bars clean after delivery to the site of the work.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted.

1. Mechanical connections

a. Dowel Bar Splicer/Dowel-In System and Coupler Splice System of the Richmond Screw Anchor System

b. Cadweld Rebar Splice by Erico Products Inc.

c. Bar Grip Splice by Barsplice Products Inc.

2.2 MATERIALS

A. Steel Bars: Use new billet steel bars, deformed bars, meeting the requirements of ASTM A 615/A625M Grade 60 for reinforcing steel bars.

1. Roll all reinforcing steel bars with special deformations or identifying marks indicating the ASTM Specification and Grade.

2. Use bars free from defects, kinks and from bends that cannot be readily and fully straightened in the field.

3. Supply reinforcing bars in lengths which will allow convenient placement in the work and provide the required lap of joints as shown. Provide dowels of proper length, size and shape for tying walls, beams, floors, and the like together.

B. Epoxy Coating: Conform fusion bonded epoxy coated reinforcing steel bars to ASTM A 775/A775M when used. Leave portions of the reinforcing steel bars uncoated where mechanical connections are shown.

C. Welded Wire Fabric: Use welded wire fabric of the electrically welded type, with wires arranged in rectangular patterns, of the sizes shown or specified and meeting the requirements of ASTM A 185.

D. Supports and Accessories: Provide bar supports and other accessories and, if necessary, additional supports to hold bars in proper position while concrete is being placed.

1. Use side form spacers against vertical or sloping forms to maintain prescribed side cover and cross position of bars.

2. Use individual hi-chairs with welded cross ties or circular hoops to support top bars in slabs thicker than 8 inches.

3. Bolsters, chairs and other accessories:

a. Use hot-dipped galvanized or provide plastic coated legs when in contact with forms for surfaces of concrete other than architectural surfaces.

b. Use stainless steel when in contact with forms for architecturally exposed surfaces.

c. Use epoxy coated bolsters, chairs and accessories including wire ties for epoxy coated reinforcing bars.

d. Use chairs of an approved type and space them properly to support and hold reinforcing bars in position in all beams and slabs including slabs placed directly on the subgrade or work mat. Do not use continuous hi-chairs for supporting of top bars in slabs over 8 inches in thickness.

E. Mechanical Connections: Provide mechanical connections that develop at least 125 percent of the specified yield strength of the bar in tension.

2.3 FABRICATION

A. Drawing Review Prior to Fabrication: Do not fabricate any material before final review and approval of shop drawings.

B. Bending and Cutting: Cut bars to required length and bend accurately before placing. Bend bars in the shop unless written approval for field bending is obtained. If field bending is permitted, do it only when the air temperature, where the bending operation is performed, is above 30 degrees F. Do not field bend bars which have been partially embedded in concrete.

C. Splices: Use lapped splices for tension and compression splices unless otherwise noted.

D. Cleaning: Clean and bend reinforcement in accordance with ACI 315 and ACI 318.

PART 3 EXECUTION

3.1 INSTALLATION

A. Placement: Place all bars in accordance with CRSI "Recommended Practice for Placing Reinforcing Bars".

B. Tolerances: Place bars used for top reinforcement in slabs to a vertical tolerance of plus or minus 1/4-inch. Place all other reinforcement to the tolerances given to ACI 318.

C. Cleaning: Have reinforcing steel delivered without rust other than that accumulated during transportation to the work. At all times, fully protect reinforcing steel from moisture, grease, dirt, mortar and concrete. Before being placed in position, thoroughly clean reinforcing steel of all loose mill scale and rust and of any dirt, oil, grease coatings, or other material that might reduce the bond. If there is a delay in depositing concrete, inspect and satisfactorily clean the steel immediately before the concrete is placed.

D. Bar Positioning: Place bars in the exact positions shown with the required spacing and cross wire bars securely in position at intersections to prevent displacement during the placing of the concrete. Fasten the bars with annealed wire of not less than 17 gauge or other approved devices.

E. Bar Extension Beyond Formwork: On any section of the work where horizontal bars extend beyond the length of the forms, perforate the form or head against which the work ends or at the proper places to allow the bars to project through a distance at least equal to the lap specified.

F. Unacceptable Materials: Do not place reinforcing steel with damaged, unsuitably bonded epoxy-coating or rusting. If approved, mars, exposed threads of mechanical connections and cut ends may be field coated with approved epoxy coating material.

G. Review of Placement: Have reinforcing placement reviewed by the ENGINEER before concrete is placed.

H. Welding - Not Approved: Do not use reinforcing bar assemblies made by welding of any kind, or accessories of any kind which require field welding to reinforcing bars.

I. Welding - Approved: Where welding of reinforcing steel is shown, AWS D1.4 "Structural Welding Code - Reinforcing Steel" applies.

J. Tension and Compression Lap Splices: Conform tension and compression lap splices to ACI 318 with all supplements. Avoid splices at points of maximum tensile stress wherever possible. Provide temperature bars with the clear spacing shown. Stagger all bar splices in hoop tension bars in circular tanks with not more than 50 percent of the bars spliced in any one direction. Have welded splices made by certified welders in accordance with AWS D1.4.

K. Welded Wire Fabric: Place welded wire fabric in the positions shown, specified or required to fit the work. Furnish and place suitable spacing chairs or supports, as specified for bars, to maintain the fabric in the correct location. Where a flat surface of fabric is required, provide flat sheets, when available. Otherwise reverse roll the fabric or otherwise straighten to make a perfectly flat surface before placing. Obtain approval for the length of laps not indicated.

L. Concrete Cover: Place reinforcing steel and welded wire fabric and hold in position so that the concrete cover, as measured from the surface of the bar or wire to the surface of the concrete, is as shown or specified.

END OF SECTION

SECTION 03 31 00

CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Providing cast-in-place concrete as specified herein to form concrete to profiles as shown on the plans including the following work:

1. Setting of anchor bolts, base plates, floor grating and plate, frames, stop log grooves, and other steel and aluminum members embedded in concrete as indicated

2. Furnishing and setting of sleeves, inserts and other embedded accessories for mechanical and electrical equipment.

3. Furnishing concrete fill for steel pan stair treads, landings and associated items.

B. Architectural Concrete: Architectural concrete is defined as concrete for the following exposed reinforced concrete surfaces:

1. Interior walls

2. Exterior walls to 6 inches below finish grade

3. Interior tank walls to 6 inches below normal operating water level

4. Beams

5. Columns

6. Undersides of floor slabs, roof slabs and stairs

C. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 03 10 00 - Concrete Formwork
2. Section 03 20 00 - Concrete Reinforcement
3. Section 03 15 00 - Concrete Accessories
4. Section 03 60 00 - Grout

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. ACI 212 - Chemical Admixtures for Concrete
2. ACI 301 - Specifications for Structural Concrete for Buildings
3. ACI 303R - Guide to Cast-In-Place Architectural Concrete
4. ACI 304R - Guide for Measuring, Mixing, Transporting and Placing Concrete
5. ACI 305R - Hot Weather Concreting
6. ACI 306R - Cold Weather Concreting
7. ACI 308 - Practice for Curing Concrete
8. ACI 503R - Use of Epoxy Compounds with Concrete
9. ASTM C 31 - Practice for Making and Curing Concrete Test Specimens in the Field
10. ASTM C 33 - Specifications for Concrete Aggregates
11. ASTM C 39 - Test Method for Compressive Strength of Cylindrical Concrete Specimens
12. ASTM C 42 - Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
13. ASTM C 94 - Specifications for Ready Mixed Concrete
14. ASTM C 143 - Test Method for Slump of Hydraulic Cement Concrete
15. ASTM C 150 - Specifications for Portland Cement
16. ASTM C 157 - Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
17. ASTM C 171 - Specification for Sheet Materials for Curing Concrete
18. ASTM C 172 - Practice for Sampling Freshly Mixed Concrete

19. ASTM C 173 - Test Method for Air Content of Freshly Mixed Concrete by Volumetric Method

20. ASTM C 309 - Specification for Liquid Membrane-Forming Compounds for Curing Concrete

21. ASTM C 618 - Specification for Coal Fly Ash and Raw Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete

22. ASTM C 881 - Specification for Epoxy-Resin-Base Bonding Systems for Concrete

23. ASTM C 989 - Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars

24. ASTM C 1116 - Specification for Fiber-Reinforced Concrete and Shotcrete

25. ASTM E 1155 - Standard Test Method for Determination of F_F

26. ASTM C 1218 - Test Method for Water-Soluble Chloride in Mortar and Concrete

27. ASTM C 1315 - Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete

1.3 SUBMITTALS

A. Provide all submittals, including the following, as specified in Division 1.

1. Notarized certificates of manufacture as evidence that the cement, fly ash and ground granulated blast furnace slag conform to the specified requirements. Include in these certificates the mill-test reports on the cement.

2. Samples of aggregates, sieve analyses and manufacturers data showing conformance to the specified requirements.

3. Concrete mix designs for each type of concrete.

4. Test reports for laboratory and field cured cylinders.

5. Air content tests in accordance with ASTM C 138 or C 173 with mix design data.

6. Drying shrinkage tests for each class of concrete with mix design data. Test shrinkage in accordance with Section 3.3.H.

7. Detailed field report records of ready-mixed-concrete.

8. Manufacturers' Literature: Material description and application or installation instructions for curing compound, vapor barrier, floor hardener, floor sealer, epoxy adhesives, synthetic fibers, admixtures, polymer modified nonsag mortar, and corrosion-resistant coatings.

9. Certified reports of tests made for maximum water soluble chloride ion concentration of design mix hardened concrete.

10. Test reports of floor flatness (F_F) and floor levelness (F_L) conforming to ASTM E 1155.

1.4 QUALITY ASSURANCE

A. Codes: The following specific codes and standards apply:

1. ACI 318 - Latest Edition, "Building Code Requirements for Reinforced Concrete".

2. ASTM - as referred to in the various subsections herein.

B. Testing Requirements: Testing as required in Division 1.

C. Testing Assistance: Cooperate with the laboratory personnel, provide access to Work, and manufacturer's operations. Provide and deliver to the laboratory adequate quantities of representational samples of materials proposed to be used which require testing.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver, store and handle all products and materials as specified in Division 1 (and as follows:)

1. Cement: Store cement delivered in bulk to the batching plant in weathertight bins and batch using an appropriate weighing device, in accordance with ASTM C 94.

a. Store cement in weathertight buildings, bins or silos which will exclude moisture and contaminants. Do not use cement that has deteriorated from storage. Retest, before use, cement stored for a period longer than 6 months after the previous testing and reject it if it

fails to meet all of the specified requirements. Do not use accepted cement that has been in storage for more than one year from the time of original acceptance.

2. Aggregates: Keep aggregates clean and free from all other materials during transportation and handling. Keep them separated from each other until measured in batches and placed in the mixer.

   a. Stockpile aggregates in a manner to prevent segregation unless finish screening is provided at the batch plant.

PART 2 PRODUCTS

2.1 MATERIALS

A. Cement Requirements: Provide a cement which is a domestic product from an approved source. Use standard portland cement meeting the requirements of ASTM C 150 Type I or Type II.

1. Provide portland cement used in the manufacture of concrete pressure pipe which does not have an air-entraining agent. Also, use a nonplastic (0 slump) mix if portland cement without air-entraining agent is used in the manufacture of concrete sewer pipe.

B. Cementitious Material Requirements:

1. Fly Ash Requirements: Provide fly ash with a uniform light color from a source approved by the ENGINEER and with cementitious properties conforming to the requirements of ASTM C 618 Class C or F, with the following exceptions:

   Loss on ignition - 5 percent maximum
   Sulfur trioxide - 4 percent maximum

   Store fly ash at the concrete mixing plant separate from the cement and do not intermix cement and fly ash prior to being added to the concrete mix.

2. Slag Requirements: Provide ground granulated blast furnace slag with cementitious properties conforming to the requirements of ASTM C 989, Grade 120, from an approved local product for normal weight concrete. Provide material having a uniform light color. Do not intermix cement and ground granulated blast furnace slag prior to being added to the concrete mix.

C. Synthetic Fiber Requirements: Provide synthetic fibers for inclusion in portland cement normal weight concrete of Caprolan -RC nylon fibers as manufactured by Allied Signal Inc., Petersburg, VA or approved equal.

1. Provide synthetic fibers exhibiting the following material, dimensional and strength characteristics:

a. Material: Nylon (100 percent)
b. Weight: 6 to 8 Denier per filament
c. Filament diameter: 23 microns
d. Specific gravity: 1.16
e. Fiber length: 3/4-inch minimum
f. Melting point: 435 degrees F
g. Tensile strength: 130,000 psi
h. Young's modulus: 750,000 psi
i. Toughness: 125,000 psi

2. Provide synthetic fibers manufactured by extrusion to the dimensions specified and not produced by slitting or chopping of sheet material or any other process.

D. Fine Aggregate Requirements: Provide fine aggregate of natural sharp sand meeting the requirements of ASTM C 33 for normal weight concrete, except as modified herein. Provide fine aggregate subjected to the test for organic impurities that will not produce a color darker than standard.

1. Provide fine aggregate meeting the requirements of the soundness test set forth in Paragraph 7.1 of ASTM C 33. The exceptions stated in Paragraphs 7.2 and 7.3 do not apply.

E. Coarse Aggregate Requirements: Provide coarse aggregate consisting of crushed stone, processed from natural rock or stones, meeting the requirements of ASTM C 33 for normal weight concrete.

1. The limits for deleterious substances and physical property requirements given in Table 3 of ASTM C 33 apply for each concrete class designation without exception.

2. Grade coarse aggregate according to Size No. 467 or No. 57 in Table 2 of ASTM C 33 for Class C concrete and Size No. 57 for Class B concrete.

F. Lightweight Aggregate Requirements: Provide lightweight aggregate meeting the requirements of ASTM C 330 for Class E Concrete as defined in Section 2. Design Mix.

G. Admixture Use: Limit the use of admixtures to the following:

1. Air-entraining admixture conforming to ASTM C 260

2. Water-reducing admixture conforming to ASTM C 494 Type A

3. Water reducing set retarders conforming to ASTM C 494 Type D

4. Use water-reducing and set-retarding admixtures only after obtaining written permission. Provide test data indicating that the concrete containing the admixtures has improved workability and does not show any abnormal behavior such as premature stiffening or slump loss for at least 30 minutes after mixing has been completed, or any other abnormal differences when compared with concrete made without the admixture. Base such test data on fresh concrete from the proposed supplier, using batching equipment proposed for use on the project.

5. Do not use admixtures containing calcium chloride, thiocyanates or more than 0.05 percent chloride ion. Obtain written conformance to the above requirements and the chloride ion content of each admixture from the admixture manufacturer prior to mix design review.

6. When more than one admixture is used, dispense each admixture separately into the mix, and at different times during mixing, in accordance with the recommendation of ACI Committee 212. After system approval, make no changes in batching equipment or concrete constituents without approval.

H. Water: Use clean water in mixing concrete which does not contain deleterious amounts of acids, alkalies or organic materials, furnished only from water from approved sources.

I. Curing Covers: Provide water curing blankets consisting of an outer covering of burlap or cotton or other approved material, and needled, punched or sandwiched inner layer of cotton batting or other approved material, in all weighing not less than 20 ounces per square yard. Use curing blankets by Midwest Canvas Corporation, Chicago, Illinois, by Max Katz, Indianapolis, IN or approved equal.

1. Use curing water having a temperature that is within 20 degrees F of the concrete's surface temperature.

J. Waterproof Paper and Film: Provide waterproof paper or polyethylene film both meeting the requirements of ASTM C 171 for use as sheet material curing covers**.**

1. Provide waterproof paper consisting of one ply of an approved type of fiber, reinforced waterproof building paper, consisting of cross fibers embedded in asphalt, between two layers of waterproof building paper, the whole being combined under heat and pressure to form a monolithic sheet.

2. Provide polyethylene film consisting of white opaque sheeting manufactured from virgin resin and containing no scrap or additives. Do not use a film of less than 4 mils in thickness.

K. Residual Acrylic Curing and Sealing Compound Membrane: Provide a clear curing and sealing compound: "Super Aqua-Cure VOX" by The Euclid Chemical Company; "Masterkure® N-Seal-HS" by ChemRex/ MBT®; or “Cure & Seal 1315” by Symons Corporation. Provide a compound of a clear styrene acrylate type, 25 percent solids content minimum, which shall have test data from an independent testing laboratory indicating a maximum moisture loss of 0.040 grams per square centimeter. when applied at a coverage rate of 300 square feet per gallon, in accordance with ASTM C 1315 Class B.

L. Dissipating Resin Type, Membrane Forming, Curing Compound: Provide a dissipating resin type curing compound, conforming to ASTM C 309 Type 1D Class B, "Kurez DR" with The Euclid Chemical Co., Resi-Chem Clear Cure by Symons or equal. Use film having a chemical break down of a four-to-six-week period.

M. Chemical Floor Hardener: Provide chemical floor hardener consisting of magnesium and zinc fluosilicate such as "Lapidolith as manufactured by L. Sonneborn Sons, Inc., "Saniseal" as manufactured by Master Builders Co., or Fluosilicate by Symons or equal.

1. Alternatively, where chemical hardening is required, substitute a natural, nonmetallic aggregate surface hardener at the time the floor is placed, in which case omit the latter application of chemical floor hardener. Obtain the hardening by incorporating into the surface of the freshly floated concrete a dry shake of Master Builders Mastercron Pre-Mixed, Procron as made by Protex Industries, Inc., Hard Top as made by Symons Corporation or equal, at the rate as recommended by the manufacturer. Perform all preparation, application procedures, curing and precautions in strict compliance with the manufacturer's recommendations and instructions submitted for approval prior to use. Use this material for interior applications only and limit air content for the design mix to 3 percent.

N. Nonslip Aggregate Finish: Provide fused aluminum oxide grits, or crushed emery, as abrasive aggregate for nonslip finish with emery aggregate containing not less than 40 percent aluminum oxide and not less than 25 percent ferric oxide. Use material that is factory-graded, packaged, rust-proof, and nonglazing, and is unaffected by freezing, moisture, and cleaning materials.

O. Epoxy Adhesives: Provide epoxy adhesives as follows:

1. Sikadur 32 Hi-Mod by Sika Corporation, Richmond, VA or Euco 452 MV by Euclid Chemical Co., Cleveland, OH, Rescon 649 by Rescon Technology Corporation or equal. Use a two component, solvent-free, moisture insensitive, structural epoxy adhesive, conforming to ASTM C 881, Type I and II, Grade 2, Class B and C, epoxy resin adhesive.

2. Sikadur 31, Hi-Mod Gel by Sika Corporation, Richmond, VA or Euco No. 452 Gel by Euclid Chemical Co., Cleveland, OH, Rescon R306 by Rescon Technology Corporation or equal. Use a 2-component solvent-free, moisture insensitive, high modulus, high strength, structural epoxy paste adhesive, conforming to ASTM C 881, Type I and II, Grade 3, Class B and C, epoxy resin adhesive.

P. Nonsag Mortar: Provide Polymer Modified Nonsag Mortar as follows:

1. Sikatop 123 by Sika Corporation, Richmond, VA, Rescon R626 by Rescon Technology Corporation or equal. Use a 2-component, fast setting, nonsag, patching mortar, specifically formulated for application by trowel on vertical and overhead surfaces.

Q. Corrosion-Resistant Coating: Use Sika Armatec 110 by Sika Corporation, Richmond, VA, Rescon R-504 by Rescon Technology Corporation or equal as a corrosion-resistant coating.

2.2 DESIGN MIX

A. Concrete Mix Classifications: Furnish and place concrete of the type divided into various classes according to use and compressive strength.

1. Use Class A concrete for all precast concrete units.

2. Use Class B concrete for all reinforced concrete structures designed for high strength and watertightness; and for columns, walls, beams, slabs, stairs, and, in general, wherever formwork other than simple forms are required.

3. Use Class C concrete for all reinforced concrete structures designed for high strength and watertightness; and for bottoms of structures, electrical duct encasement, and, in general, where concrete is deposited directly on the bottoms of slopes of excavations and where only simple forms are required.

4. Use Class D concrete for low-strength concrete, plain or reinforced, used for work mats beneath structures, soil stabilization, pipe cradles and encasement, filling, and other similar purposes. Clean boulders or fragments of rock excavated during construction may be embedded in large volumes of Class D concrete to provide added bulk. Use care in placing the boulders or rock fragments so that there will be no voids in the concrete.

5. Use Class E concrete for sand/lightweight concrete slabs placed over metal decks.

B. Compressive Strength: Provide, as a minimum, the specified compressive strength of concrete in pounds per square inch for the classes previously described as follows. Designate the 28-day strength as f'_c.

Class	7-Day Test	28-Day Test
A	3,400	5,000
B	2,700	4,000
C	2,700	4,000
D	1,300	2,000
E	2,700	4,000

1. Proportion and produce concrete to provide an average 28-day compressive strength in excess of the specified compressive strength, f'_c. Base the required proportions on tests of cylinders made, cured and tested as specified.

2. Prepare mix designs for each type of concrete required and submit for approval. Concrete which will be placed by pumping methods will require a separate mix design and mix design approval, as described herein, in addition to the mix design approval required for other placement methods.

C. Concrete Proportions: Select concrete proportions to provide the required strength and durability and to provide workability and consistency so that the concrete can be worked into forms and around reinforcement without segregation or excessive bleeding.

1. Provide concrete for all structures which is watertight. Do not allow the maximum water-cementitious material ratio to exceed 0.45 by weight of the total cementitious constituent. Measure the quantity of water to be the total quantity, including free surface moisture contained in the aggregates.

2. Do not allow the amount of fly ash to exceed 20 percent by weight of the cement plus fly ash, while maintaining a minimum cement content of 450 pounds per cubic yard.

3. Do not allow the amount of ground granulated blast furnace slag contained in Class B and C concrete to exceed 30 percent by weight of the cement plus slag, while maintaining a minimum cement content of 450 pounds per cubic yard.

4. Provide Class B and C concrete which also contains a minimum of 1-pound of synthetic fibers per cubic yard. Conform fiber reinforced concrete to the requirements of ASTM C 1116 unless otherwise specified.

5. Establish concrete proportions including the water-cementitious material ratio on the bases of field experience or trial mixtures with the materials to be used in accordance with Section 5.3 of ACI 318.

6. Provide sand/lightweight concrete with a dry weight not more than 115 pounds per cubic foot.

D. Air Entrainment:

1. Provide air entrained Class B and C concrete with an average total air content of 5 percent. Allow a tolerance of plus or minus 1.5 percent on air content as delivered.

E. Slumps: When tested in accordance with ASTM C 143, provide a concrete mix design with slumps within the following limits:

Concrete Placement	Minimum and Maximum Slump in Inches	
	Class B, C and E	Class D
Normal	3 to 4	3 to 5
Pumped	4 to 6	4 to 6

1. Base the mix design slump on the concrete mix with water reducing admixture. For production concrete, allow no more than 1-inch increase in slump by use of specified water reducing admixtures. Measure slump at the end of the hose for pumped concrete.

2. Grade the combined aggregates for the design mix such that when a sample of the mix is separated on No. 4 standard sieve, the weight passing the sieve is not less than 30 percent nor greater than 40 percent of the total, unless otherwise specified.

F. Chloride Ion Concentration: Provide a maximum water soluble chloride ion concentration, percent by weight of cementitious materials, with two 28 day tests of design mix hardened concrete as follows:

1. Cast-in place concrete, exposed to moisture, water or sewage in service 0.10.

2. Cast-in-place concrete that will be dry or protected from moisture in service 1.00.

G. Shrinkage Control: Select materials and proportion mix to achieve an average 21 day drying shrinkage less than:

1. 0.036% for liquid-containing structures.

2. 0.048% for all other structures.

Provide one test (3 specimens) for each design mix in accordance with Section 3.3.H.

H. Measurement and Mixing: Measure and mix concrete in accordance with the recommendations of ACI 304R, as modified.

1. Measure cement, and fine and coarse aggregates separately by weight by equipment providing an accuracy within one percent of the net load weighed. Measure cement and water within 1 percent accuracy by weight. Measure aggregates within 2 percent accuracy. Measure admixtures within 3 percent accuracy by weight.

2. Use weighing equipment meeting the requirements of the United States Bureau of Standards. Make available standard testing weights and other necessary equipment at all times for testing the equipment.

3. Mix concrete in a rotary, batch-type mixer of adequate design to produce a thorough mix, homogeneous in composition and uniform in color. Mix each batch of one cubic yard or less not less than 1-1/2 minutes after the last of the ingredients have been added to the mixer. Increase the mixing time 15 seconds for each cubic yard or fraction thereof.

2.3 CONCRETE WORKMATS

A. As a working base for all new, reinforced-concrete structural foundation elements supported on soil, rock, select fill, backfill stone, drainage stone and the like, provide a Class D concrete workmat having a minimum thickness of 2 inches.

2.4 READY MIX CONCRETE

A. Ready Mix Requirements: For ready-mixed concrete meet the requirements of ASTM C 94, except as modified in the following paragraphs, and subject the mix to all provisions herein relative to materials, strength, proportioning, consistency, and testing. Article 18 of ASTM C 94, however, does not apply. In the event of low strengths, procedures outlined in Section 3.01 "Low Concrete Strength Test Results" apply.

B. Delivery: Provide the rate of delivery of the mixed concrete such that the interval between placing of fresh concrete in contact with concrete already placed from previous batches does not exceed 45 minutes. Do not allow the elapsed time between the introduction of mixing water to the cement and aggregates and depositing concrete in the work to exceed 60 minutes, including mixing and agitating time.

C. Agitation: Do not deliver concrete in nonagitating equipment.

D. Field Records: Prepare a detailed concrete field record in which the following information is identified:

1. Number of concrete batches produced.

2. Proportions of materials used.

3. Approximate location of final deposit of each batch in the structure.

4. Time and date of mixing and placing.

PART 3 EXECUTION

3.1 PLACING CONCRETE

A. General: Place concrete only in the presence of the ENGINEER. Where the procedure is not specified, place concrete in accordance with the recommendations of ACI 304R.

B. Continuous Operation: Place no concrete after its initial set has occurred, and do not use retempered concrete under any conditions. Make concreting operations continuous until the section, panel, or scheduled placement is completed. Should the concreting operations be unavoidably interrupted, provide construction joints formed at proper locations as specified.

C. Minimum Handling: Convey and place concrete with minimum handling and deposit the concrete in the forms as close as possible to its final position and in no case more than 5 feet in a horizontal direction therefrom. Do not rehandle concrete.

D. Horizontal Layers: Place concrete in horizontal layers shallow enough so that the previous layer is still soft when the next layer is added and the two layers can be vibrated together. Do not exceed 18 inches in depth for each layer.

E. Use of Chutes: Deposit wall and column concrete through heavy duck canvas or galvanized steel chutes equipped with suitable hopper heads. Provide chutes of variable lengths so that the free fall of concrete does not exceed 3 feet. Provide illumination where required, inside the forms so that the concrete is visible from the deck and runways at the point of deposit.

F. Protection Against Elements: Protect freshly placed exposed concrete against damage from the elements or other sources.

G. Hot Weather Placement: For placement of concrete during hot weather, follow the recommendations of ACI 305R.

1. Place no concrete if the temperature of the concrete at the time of placement exceeds 90 degrees F.

2. When the temperature of the concrete at the time of placement is consistently above 75 degrees F and a noticeable decrease in slump or an increase in mixing water demand occurs, use a retarding admixture, after obtaining written permission to do so.

3. Protect unformed surfaces of concrete placed during hot weather from drying by continuous moist curing for at least 24 hours. Start curing as soon as the concrete has hardened sufficiently to withstand surface damage. If moist curing is not carried beyond 24 hours, cover the surface while damp with a suitable heat-reflecting plastic membrane or spray exterior surfaces with a white pigmented dissipating curing compound in accordance with Section 3.5 Curing. Use curing water having a temperature that is within 20 degrees F of the concrete's surface temperature.

4. Protect formed surfaces of concrete placed during hot weather from drying as recommended in ACI 305 R.

H. Cold Weather Placement: For placement of concrete during cold weather, follow the recommendations of ACI 306R, except that set-accelerators will not be permitted.

1. Before placement of concrete, completely remove all ice, snow and frost from all surfaces to be in contact with the concrete. Do not place concrete on a frozen subgrade. Heat surfaces to be in contact with the concrete to a temperature as near as practical to that of the concrete being placed.

2. When mean daily temperatures at the site are below 40 degrees F provide concrete at a temperature, as placed, of not less than 50 degrees F, except for mass concrete provide a temperature of the concrete as placed of not less than 45 degrees F. Heat aggregates or mixing water or both to obtain these placement temperatures. Do not permit the concrete temperatures as mixed

to exceed the placement temperature by more than 10 degrees F for air temperatures of 0 degrees to 30 degrees F, nor by more than 15 degrees F for air temperatures below 0 degrees F.

3. Maintain concrete in place at a temperature of 50 degrees F by keeping forms in place, covering with insulated blankets, heated enclosures or combinations of these for the following minimum time intervals, except that forms shall not be removed in less than the time specified in Section 03100.

a.	Footings and walls below grade and slabs on grade	2 days
b.	Exposed walls and columns carrying no load	3 days
c.	Exposed floor slab, beams and girders above grade and partially loaded	6 days

4. Protect exposed surfaces of new concrete from drying out. When dry heating is used for protection against low temperatures, cover exposed concrete surfaces with an approved sheet material or membrane as specified in Section 03310 subsection "Curing". Use water curing only if icing problems can be avoided. During periods of very cold weather, continue the protection against low temperature for an extended curing period as required to prevent freezing of the concrete.

5. Permit concrete which is to be exposed to freezing temperatures to undergo some drying just prior to and during the period of adjustment to ambient cold-weather conditions. When protection against low temperatures is removed, do not allow the resulting temperature drop in any part of the concrete to exceed 5 degrees per hour nor 40 degrees F for the first 24 hour period.

I. Concrete Embedments:

1. Encase pipes, anchor bolts, sleeves, steps, castings, floor drains, manhole frames, cast-in reglets, dovetail anchor slots, and other inserts in concrete as shown. Take special care to place and maintain them to the proper lines and grades and to compact concrete thoroughly around them to prevent the passage of water. Insofar as possible, set them before placing concrete and thoroughly brace to prevent movement during the progress of the work.

2. Space dovetail anchor slots vertically not more than 16 inches apart on all concrete walls faced with masonry.

3.2 VIBRATING CONCRETE

A. Use of Vibrators: Consolidate all concrete by means of mechanical internal vibrators applied directly into the concrete in a vertical position in accordance with the recommendations of ACI 309.

B. Vibrator Size: Provide a sufficient intensity and duration of vibration to cause concrete to combine with previously placed concrete, to fill corners, to compact thoroughly and to embed reinforcement, pipes, conduits, and similar work completely. Insert vibrators into and withdraw from the concrete vertically at close intervals. Do not use vibrators to move concrete laterally.

C. Spare Units: Have on hand a sufficient number of vibrators to assure that the incoming concrete can be properly compacted within 15 minutes after placing. Provide reserve vibrators for use when others are being serviced. Do not start the placement of any concrete unless more than one vibrator is available.

3.3 CONCRETE TESTS

A. Compression Testing: Test concrete test cylinders in compression at the laboratory designated.

B. Samples: Take samples for strength tests of laboratory cured cylinders for tests of each class of concrete placed each day consisting of four cylinders from the same batch of concrete. Test two cylinders at 7 days and two at 28 days. Determine concrete strength by the average of the two cylinder strengths determined at either age. Take samples not less than once a day nor less than once for each 150 cubic yards of concrete, or 5,000 square feet of area.

C. Field Curing: Take samples for field cured cylinders to determine concrete compressive strength for form removal time as required.

D. Laboratory Curing: Sample fresh concrete in accordance with ASTM C 172. Mold and laboratory cure cylinders for strength tests in accordance with ASTM C 31.

E. Slump Tests: Perform slump tests in accordance with ASTM C 143, at the same time cylinders are made. Make tests to determine air content of fresh concrete twice daily, at least 4 hours apart, in accordance with either ASTM 173 or with an approved testing device. Concrete with excessive slump or improper air content will be rejected. Deliver no additional concrete until the cause of the deficiency is determined and corrected.

F. Test Requirements: Test cylinders in accordance with ASTM C 39 for both the 7-day and the 28-day compressive strength.

G. Successful Testing Requirements: Consider the strength level of the concrete mix for each individual class of concrete satisfactory when:

1. The average of all sets of three consecutive 28-day strength tests (average of two cylinders) equal or exceed the specified compressive strength (f'_c).

2. No individual 28-day strength test (average of two cylinders) falls below f'_c by more than 500 psi.

3. If either of these requirements are not met, make changes in the mix proportions immediately to achieve the required strength.

H. Shrinkage Tests: Perform drying shrinkage test on each 1000 cubic yards placed. Test in accordance with ASTM C157, modified as follows:

1. Make three (3) 4-inch x 4-inch x 11-inch specimens for each test.

2. Remove specimens from molds at an age of 23 hours ∀ 1 hour. Immediately submerge in water at 73 degrees F ∀ 3 degrees F for at least 30 minutes and measure within 30 minutes thereafter to determine original length. Then immediately submerge in lime-saturated water in accordance with ASTM C 157. After 7 days, remove specimens from lime-saturated water and measure. Use this measurement as the base length to determine shrinkage deformation. After measuring, immediately store in a humidity-controlled room maintained at 73 degrees F ∀ 3 degrees F and 50% ∀ 4% relative humidity for the remainder of the test measurements. To determine shrinkage take measurements, expressed as percentage of base length, and report separately for 7, 14 and 21 days ∀ 4 hours.

3. Results of the drying shrinkage on test shall be reported to the nearest 0.001 percent. If drying shrinkage of any specimen deviates from the average for that test age by more than 0.004 percent, the results of that specimen shall be disregarded.

3.4 LOW CONCRETE STRENGTH TEST RESULTS

A. Test Cores: If it is determined that the serviceability of the concrete is significantly reduced by low concrete strength test results, take test cores from the area in question. Drill and test cores in accordance with ASTM C 42 except as noted. Take three cores for each strength test more than 500 psi below the specified f'_c.

B. Acceptable Levels of Strength: Concrete in the area represented by core tests will be accepted if the average of three cores is equal to or greater than 0.85 f'_c and no single core is less than 0.75 f'_c.

C. Unacceptable Concrete: Remove and replace concrete which does not meet the core test requirements or strengthen the concrete to the satisfaction of the ENGINEER.

3.5 CURING

A. General: Generally follow the recommendations of ACI 308 for curing concrete.

B. Protection: Protect concrete surfaces normally exposed to the atmosphere against too rapid drying by curing for a minimum period of 7 days. For hot weather concreting and cold weather concreting follow the recommendations of ACI 305R and ACI 306R for curing concrete. Commence the curing period immediately following the placing of the concrete. Accomplish curing by one of the following methods. Should there be any delay in the application of the method of curing used, cover the concrete with moistened burlap held in complete contact with the surface or kept wet by continuous sprinkling. Use curing water having a temperature that is within 20 degrees F of the concrete's surface temperature.

1. Accomplish water curing by the use of curing blankets wetted and applied to the concrete surface as soon as the forms have been removed, or in the case of slabs, as soon as the concrete has set up sufficiently to prevent marring of the surface. Maintain the covering material in a thoroughly saturated condition and maintain the presence of free water between the mat and the surface of the concrete at all times throughout the curing period.

2. Accomplish sheet material curing by use of waterproof paper or polyethylene film applied to the concrete surface as soon as it has set sufficiently hard to prevent marring. First, thoroughly wet the concrete surface, and then place the sheet materials in direct contact and anchor thereto in a manner to assure continuous contact throughout the curing period. Lap the sheet materials a minimum of 3 inches with the seams taped, cemented, or glued. Discoloration is objectionable on floors which have been steel troweled to a hard finish. Do not use polyethelene film on these floors.

3. Accomplish curing by using clear residual acrylic curing and sealing compound membranes on all interior concrete floor surfaces that do not receive a finish, overlays or hardener, and on stairs, landings and walking surfaces. Accomplish membrane curing immediately after removal of forms or in the case of unformed surfaces, immediately after final finishing. Uniformly coat the entire exposed surface with a clear curing compound membrane by means of an approved pressure spray distributor at the rate of 300 square feet per gallon of material. Apply the material so that the concrete surface is completely coated and sealed with one application. Do not apply the membrane to faces of construction joints or other surfaces

against which additional concrete will be placed. Keep such surfaces continuously wet by other means.

4. Accomplish curing by using dissipating resin type curing compounds. Apply to all concrete surfaces except those listed in paragraph 3.5.B.3. Start curing immediately after removal of forms as in the case of unformed surfaces, immediately after final finishing while the concrete surface is still moist. Coat the entire exposed surface by means of approved pressure spray distributor at the rate of 200 square feet per gallon of material. Apply the material so that the concrete surface is uniformly coated with one application. Do not apply to the faces of construction joints or other surfaces against which additional concrete will be placed. Keep such surfaces wet by other means.

3.6 JOINTS AND BONDING

A. Joints: Make construction joints where shown or permitted. Locate such joints to ensure stability, strength, and watertightness, and provide a waterstop where shown. Build all corners monolithically, and continuously concrete on either side to points shown.

B. Timing Between Placement: Provide at least 2 hours of elapsed time after placing concrete in the columns or walls before depositing concrete in beams, girders, or slabs supported thereon. Consider beams, girders, brackets, column capitals, and haunches as part of the floor system and place them integrally with the floor.

C. Horizontal Keyways: Build horizontal keyways to permit flushing water to escape from the keyways.

D. Keyway Description: Provide continuous, straight, and regular keys or grooves in joints. Bring exposed concrete surfaces to a true level line at the top of every horizontal construction joint. Provide the exposed construction joints with a row of form ties located in the concrete at from 4 to 6 inches from the joint to tighten the forms for subsequent sections. Set reinforcement to extend into subsequent sections of construction, as shown. If required, provide water stops having watertight splices and corner intersections and meet the requirements as specified. Remove all bulkheads or other joint forming material before placing adjacent concrete.

E. Continuous Placement Procedure: Carry on continuous placing of concrete between the construction joints shown. If for any reason it becomes necessary to stop the placing of concrete at locations other than those indicated, such locations and the manner of making the joint are subject to approval.

F. Grout Use Between Surfaces: Thoroughly clean and wet concrete surfaces against which the new concrete is to be placed. Just prior to placing new concrete, slush

horizontal surfaces and joints with at least 2 inches of cement grout of the same mixture as the concrete but with coarse aggregate omitted. Use special care in placing and puddling concrete at vertical joints to ensure a bond with existing concrete. Do not make vertical construction joints in watertight construction, unless shown or approved in writing.

G. Contraction (Control) Joints in Slabs-on-Ground (for walkways and pavements outside the structure or building): Construct contraction joints in slabs-on-ground to form panels of patterns as shown. Use saw cuts 1/8" x 1/4 slab depth or inserts 1/4" wide x 1/4 of slab depth, unless otherwise indicated.

1. Form contraction joints by inserting premolded plastic, hardboard or fiberboard strip into fresh concrete until top surface of strip is flush with slab surface. Tool slab edges round on each side of insert. After concrete has cured, remove inserts and clean groove of loose debris.

a. Contraction joints in unexposed floor slabs may be formed by saw cuts as soon as possible after slab finishing as may be safely done without dislodging aggregate.

2. If no joint pattern is shown, provide joints not exceeding 15 feet in either direction and located to conform to bay spacing wherever possible (at column centerlines, half bays, third-bays).

3.7 CONCRETE FLOOR SURFACES

A. Floor Surfaces: Construct the concrete floor surfaces monolithicly with the structural slab being finished as indicated in the following schedule, unless otherwise shown or as specified:

1. Interior working spaces such as screen rooms, motor rooms and pump rooms - screeded, wood floated, steel troweled, chemically hardened.

B. Panel Construction: Construct panels, where required, approximately 10 feet square using an edger to form dummy joints 1/4-inch deep.

C. Float Finish: Apply float finish to monolithic slab surfaces to receive trowel finish and other finishes as specified, and slab surfaces which are to be covered with membrane or elastic waterproofing, membrane or elastic roofing, as otherwise indicated.

1. After screeding, consolidating, and leveling concrete slabs, do not work surface until ready for floating. Begin floating when surface water has disappeared or when concrete has stiffened sufficiently to permit operation of power-driven floats, or both. Consolidate surface with power-driven floats, or by hand-floating if the area is small or inaccessible to power units.

For nonsloping level surfaces check and level the surface plane to tolerances of F_F 18 and as determined by ASTM E 1155. For sloping surfaces check the surface planes to a tolerance of F_F 18 as determined by ASTM E 1155. Cut down high spots and fill low spots. Uniformly slope surfaces to drains. Immediately after leveling, refloat surface to a uniform, smooth, granular texture. Check the floors flatness (F_F) and levelness (F_L) on an area of 400 square feet for level floors and 400 square feet of sloping floors or tanks to be selected by the ENGINEER.

D. Trowel Finish: Apply trowel finish to monolithic slab surfaces to be exposed-to-view, and slab surfaces to be covered with resilient flooring, carpet, ceramic or quarry tile, paint, or other thin film finish coating system.

1. After floating, begin first trowel finish operation using a power-driven trowel. For nonsloping level surfaces check and level the surface plane to tolerances as determined by ASTM E 1155. Cut down high spots and fill low spots. For sloping surfaces check the surface planes to a tolerance of $F_F = 20$ as determined by ASTM E 1155. Check the floor flatness (F_F) and levelness (F_L) on an area of 400 square feet for level floors 400 square feet for sloping floor or tanks to be selected by the ENGINEER. Begin final troweling when surface produces a ringing sound as trowel is moved over surface. Consolidate concrete surface by final hand-troweling operation, free of trowel marks, uniform in texture and appearance, and with surface leveled to tolerances specified. Grind smooth surface defects which would telegraph through applied floor covering system.

E. Trowel and Fine Broom Finish: Where ceramic or quarry tile is to be installed with thin-set mortar, apply trowel finish as specified, then immediately follow with slightly scarifying surface by fine brooming.

F. Nonslip Broom Finish: Apply nonslip broom finish to exterior concrete platforms, steps, and ramps, and elsewhere, where indicated.

1. Immediately after float finishing, slightly roughen concrete surface by brooming with fiber bristle broom perpendicular to main traffic route. Coordinate required final finish with the ENGINEER before application.

G. Chemical-Hardener Finish: Apply chemical-hardener finish to interior concrete floor slabs that do not receive a floor covering. Apply liquid chemical-hardener after complete curing and drying of the concrete surface. Dilute liquid hardener with water (parts of hardener/water as follows), and apply in 3 coats; first coat, 1/3-strength; second coat, 1/2-strength; third coat, 2/3-strength. Evenly apply each coat, and allow 24 hours for drying between coats.

1. Apply proprietary chemical hardeners, in accordance with the manufacturer's printed instructions.

2. After the final coat of chemical-hardener solution is applied and dried, remove surplus hardener by scrubbing and mopping with water.

H. Nonslip Aggregate Finish: Apply the nonslip aggregate finish to concrete stair treads, platforms, ramps, sloped walks, and elsewhere where indicated.

1. After completion of float finishing, and before starting trowel finish, uniformly spread 25 pounds of dampened nonslip aggregate per 100 square feet of surface. Tamp aggregate flush with surface using a steel trowel, but do not force it below the surface. After broadcasting and tamping, apply trowel finishing as specified.

2. After curing, lightly work the surface with a steel wire brush, or an abrasive stone and water to expose nonslip aggregate.

I. Protection: Cover all finished floors, walkways, and slabs with boards, canvas, heavy paper or similar covering to protect them from damage.

3.8 CONCRETE SURFACES

A. Beveling Edges: Finish top edges of walls and equipment pads with a 1/2-inch beveled edge, unless other details are shown, and rub off any burrs remaining upon removal of the forms.

B. Form Removal Inspection: Immediately after stripping the forms, inspect all concrete surfaces. Remove all fins, offsets, burrs, ridges, or other unsightly marks from the exposed concrete.

C. Patching: Patch placement joints, voids, stone pockets, or other defective areas before the concrete is thoroughly dry. Chip away defective areas to a depth of not less than 1 inch with all edges perpendicular to the surface. Wet the area to be patched, including at least 5 inches of the adjoining surface, prior to placing the patching mortar. Then scrub onto the surface a grout of equal parts of cement and sand mixed to a brushing consistency followed immediately by the patching mortar. Make the patch of the same material and of approximately the same proportions as used for the concrete, except omit the coarse aggregate. For exposed concrete, substitute white cement for part of the gray cement so that the patch will match the color of the surrounding concrete. Determine the proportion of white and gray cement by making a trial patch. Use as little water as consistent with requirements of handling and placing. Mortar: Do not retemper mortar. Thoroughly compact and screed off the mortar so as to leave the patch slightly higher than the surrounding surface. Then leave it undisturbed for a period of 1 to 2 hours to permit initial shrinkage before being finally finished. Finish the patch to match the adjoining surface and cure as specified for the original concrete.

D. Tie Hole Patching: Patch tie holes before the concrete is thoroughly dry. Plug tie holes flush with the surface using portland cement mortar. Prewet tie holes with clean water and apply a neat cement slurry bond coat. Densely tamp mortar of a dry-tamp consistency into the tie holes exercising care so as not to smear mortar onto the finished concrete surface. Included sufficient white cement in the mortar mix to cause the plugged holes to blend in with the adjacent surfaces. Make sample patches with different mixes to assure that this requirement is met.

3.9 EPOXY ADHESIVE

A. Epoxy Adhesives for Bonding: Use epoxy adhesive for bonding fresh concrete to existing concrete where shown and grouting dowels into vertical holes.

B. Recommendations: Mix and apply epoxy adhesive in accordance with the manufacturer's recommendations and in accordance with the requirements of the "Standard Specification for Bonding Plastic Concrete to Hardened Concrete with a Multi-Component Epoxy Adhesive - ACI 503R.

C. Surface Preparation: Roughen existing concrete, by sandblasting. Provide all surfaces free of standing water and clean as required.

3.10 EPOXY GEL

A. Epoxy Gels for Dowels: Use epoxy gel for grouting dowels into horizontal holes.

B. Application: Apply epoxy gels in accordance with the manufacturer's recommendations.

3.11 POLYMER MODIFIED NONSAG MORTAR

A. General: Mix and apply material in accordance with the manufacturer's recommendations.

B. Surface Preparation: Clean existing concrete that is to receive the material of all loose concrete, dirt, oil, grease and bond-inhibiting materials and mechanically roughen to obtain an aggregate-fractured surface with a minimum profile of 1/16-inch.

C. Mortar Placement: At the time of application, saturate existing concrete such that it is surface dry with no standing water. Scrub mortar into the substrate filling all pores and voids. Force the material against the edges of repairs, working it toward the center. After applying material, consolidate and then screed. Do not place the material in lifts greater than 1-inch. Where multiple lifts are required to achieve the required thickness, score the top surface of each lift to produce a roughened surface for the next lift. Allow the preceding lift to reach final set, 30 minutes minimum before applying fresh material. Scrub fresh mortar into the preceding

lift. Allow mortar to set to desired stiffness and then finish with wood or sponge float for a smooth surface.

D. Curing Requirements: Moist cure with a fine mist spray of water, wet burlap, or nonsolvent-based curing compound. If necessary, protect newly applied material from rain. To prevent freezing, cover with insulating material.

3.12 CORROSION-RESISTANT COATING

A. Blast Cleaning: Blast clean existing exposed reinforcing steel to white metal color and immediately coat reinforcement with two 10 mil thick coats of corrosion-resistant coating applied in accordance with the manufacturer's recommendations.

3.13 MISCELLANEOUS CONCRETE ITEMS

A. Filling-In: Fill-in holes and openings left in concrete structures for passage of work by other trades, unless otherwise shown or directed, after the work of other trades is in place. Mix, place, and cure concrete as specified, to blend with in-place construction. Provide other miscellaneous concrete filling shown or required to complete work.

B. Curbs: Provide a monolithic finish to interior curbs by stripping forms while concrete is still green and steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.

C. Equipment Bases and Foundations: Provide machine and equipment bases and foundations. Set anchor bolts for machines and equipment to template at correct elevations, complying with certified diagrams or templates of the manufacturer furnishing machines and equipment.

D. Vapor Barrier Installation: Install vapor barrier in accordance with manufacturer’s instruction and ASTM E 1643-98, and as specified below.

1. Following leveling and tamping of granular base, place vapor barrier, as shown and specified, and then place the slab on grade.

2. Unroll vapor barrier with longest dimension parallel with the direction of the concrete pour.

3. If grade beams or footings are provided, continue vapor barrier around the perimeters of grade beams and footings adjacent to grade or granular fill, and seal to foundation walls.

4. Overlap joints 6 inches and seal with manufacturer's tape.

5. Seal all penetrations (including pipes) with manufacturer's pipe boot.

6. No penetration of the vapor barrier is allowed except for reinforcing steel and permanent utilities. Use seam tape or mastic to seal around reinforcing steel penetrations and permanent utilities.

7. Repair damaged areas by cutting patches of vapor barrier, covering the damaged area and providing 6 inches of overlap. Tape all four sides with tape.

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 03 60 00

GROUT

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Furnishing non-shrink grout under column and beam bearings and under equipment bases.

2. Furnishing non-shrink grout around handrail posts and base plates of handrail posts.

3. Furnishing grout topping and fillet grout in bottoms of concrete tanks.

4. Furnishing grout around tunnel liners and around pipes in tunnels.

B. Related Work Specified in Other Sections Include, But is Not Limited to, the Following:

1. Section 03 10 00 - Concrete Formwork
2. Section 03 31 00 - Cast-In-Place Concrete

1.2 REFERENCES

A. Codes and Standards Referred to in this Section:

1. ASTM C 33 - Specifications for Concrete Aggregates

2. ASTM C 109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2 in. [or 50 mm] Cube Specimens).

3. CRD C-619 - Specification for Grout Fluidifier.

4. CRD C-621 - Specification for Non-Shrink Grout.

1.3 SUBMITTALS

A. Provide all submittals, including the following, as specified in Division 1:

1. Submit notarized certificate of manufacturer as evidence that pre-packaged non-shrink grout conforms to specified requirements. Include manufacturer's literature.

2. Submit mix design, for each class of grout, as specified in Section 03 31 00 "Cast-In-Place Concrete".

3. Submit the following test reports:

   a. Compression tests on cylinders for grout topping and fillet grout, as specified in Section 03 31 00, Subsection 3.3 "Concrete Tests".

   b. Compression tests, on mortar cubes for non-shrink grout and for tunnel liner and pipe grout, as specified in Section 03 31 00, Subsection 3.3 "Concrete Tests".

   c. Air content tests, for grout topping and fillet grout, as specified in Section 03 31 00 "Cast-In-Place Concrete".

   d. Slump tests, for grout topping and fillet grout and for tunnel liner and pipe grout, as specified in Section 03 31 00, Subsection 3.3 "Concrete Tests".

4. Test results showing that in projects of similar scope and size, the effective bearing area (EBA) under column bearings, beam bearings and equipment bases is between 95 and 100 percent.

5. Detailed field records for ready-mixed grout as specified in Section 03 31 00.

1.4 QUALITY ASSURANCE

A. Testing Requirements: Testing laboratory provided by OWNER is responsible for conducting tests required in Division 1.

B. Testing Assistance: Cooperate with the laboratory personnel, provide access to Work, and manufacturer's operations. Provide and deliver to the laboratory adequate quantities of representative samples of materials proposed to be used which require testing.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver, store and handle all products and materials as specified in Division 1, and as follows:

1. Pre-packaged, Non-shrink Grout:

Deliver in unopened packages. Store in a dry place protected from moisture.

2. Portland Cement, Aggregates:

Deliver, store and handle as specified in Section 03 31 00.

PART 2 PRODUCTS

2.1 MATERIALS

A. Non-Shrink Grout:

1. Furnish a flowable, pre-packaged non-shrink grout without dependence on gas expansion forces or enlargement of metal particles for its non-shrinkage characteristics and conforming to CRD C-621.

2. Furnish one of the following:

a. Masterflow 928, as manufactured by MasterBuilders, Incorporated.
b. Multipurpose, as manufactured by Symons Corporation.
c. Sika grout 212, as manufactured by Sika Corporation.
d. Or equal.

B. Grout Fluidifier:

Furnish grout fluidifier conforming to CRD C-619.

C. Portland Cement, Aggregates, Admixtures.

1. Furnish as specified in Section 03 31 00.

2. Use air-entraining admixture in all grout.

2.2 GROUT MIXES

A. Non-Shrink Grout:

1. Add water to pre-packaged grout material and mix, as recommended by the manufacturer, to produce a flowable, non-shrink grout having a minimum compressive strength of 3000 psi in 24 hours.

2. Provide grout which when exposed to weather will be free of discoloration, without the necessity of special surface treatments.

B. Bonded Grout Topping and Fillet Grout for Tank Bottoms:

1. Grout to be proportioned from cement, fly ash, fine aggregate and ASTM C33, size no. 7 coarse aggregate with a water-reducing admixture.

2. Proportion to provide a grout having the following properties:

a. A minimum compressive strength of 4000 psi in 28 days.

b. An average air content of 5 percent ∀ 1.5 percent.

c. Minimum and maximum slumps:

(1) Fillet grout: 2-4 inches.
(2) Grout topping: 3-5 inches.

d. A maximum water-cementitious material ratio of 0.45 by weight of the total cementitious material.

3. Prepare design mixes, for each class of grout, as specified in Section 03 31 00 “Cast-In-Place Concrete”.

C. Tunnel Liner and Pipe Grout:

1. Tunnel liner grout:

Mix grout for backfilling the space between the tunnel liner and tunnel or other locations as specified or directed in the proportion of 1 part Portland cement to 1 part sand by volume.

2. Pipe grout:

Mix lean grout for backfilling the space surrounding the pipe sections in tunnel or other areas as specified or directed in the proportion of 1 part Portland cement to 12 parts sand by volume.

3. Mix grout to a consistency that can be pumped into the space between the tunnel liner or pipe and tunnel. Use a grout fluidifier to reduce water quantity and improve workability.

4. Prepare design mixes, for each class of grout, as specified in Section 03 31 00 “Cast-In-Place Concrete”.

D. Measurement and Mixing

Measure and mix material as specified in Section 03 31 00 “Cast-In-Place Concrete.”

PART 3 EXECUTION

3.1 INSPECTION

A. Substrate Condition:

Examine the substrate and conditions under which grout is to be placed and notify the ENGINEER, in writing, of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to the OWNER.

3.2 INSTALLATION

A. General:

1. Place grout as shown and in accordance with the manufacturer’s instructions. Notify the OWNER if manufacturer’s instructions conflict with the Specifications. Do not proceed with installation until directed by the OWNER.

2. Drypacking will not be permitted.

3. Have manufacturers of proprietary products make available upon 72 hours notification the services of a qualified, full time employee to aid in assuring proper use of the product under job conditions. The cost of this service, if any, shall be borne by the Contractor.

4. Conform grout placement to temperature and weather limitations in Section 03 31 00 “Cast-In-Place Concrete”.

B. Columns, Beams and Equipment Bases:

1. After shimming columns, beams and equipment to proper grade, securely tighten anchor bolts. Properly form around the base plates allowing sufficient room around the edges for placing the grout. Adequate depth between the bottom of the base plate and the top of concrete base must be provided to assure that the void is completely filled with the non-shrink grout.

C. Handrails and Railings

1. After posts have been properly inserted into the holes or sleeves, fill the annular space between posts and sleeve with the non-shrink grout. Bevel grout at juncture with post so that moisture flows away from post.

D. Grout Topping and Fillet Grout for Concrete Tanks:

1. Prior to proceeding with Work, ensure that tank equipment has been checked for accurate adjustment.

2. Use a metal screed on the tank mechanism to check the surface elevation of the base slab and to ensure that at least the thickness of grout shown can be placed. If there is insufficient room for this grout, remove the high spots in the concrete or adjust the mechanism, or both, as necessary to provide proper grout thickness and equipment clearance.

3. Prior to placement of grout, remove all laitance, debris and loose and foreign material from the base slab. Use waterblasting, sandblasting or other methods acceptable to the City.

4. Thoroughly wet the base slab at least 24 hours before placing the grout.

5. Roughen the concrete surface to receive the grout with a rolling tamp. Prior to placing the grout, the surface must be wetted and cleaned as described above. Apply a cement water paste to the surface with a stiff broom.

6. Where recommended by manufacturer, use the tank mechanism to screed the grout on the tank floor and sweep grout into fillets as it is placed. Have a representative of the equipment manufacturer be present during the screeding operation, unless otherwise approved. Screed in accordance with manufacturer's instructions.

7. Cure and protect the grout as specified in Section 03 31 00 "Cast-In-Place Concrete".

8. Level the grout topping to comply with requirements of Section 03 31 00.

9. Float finish topping as specified in Section 03 31 00.

E. Grout Tunnel Liners and Pipes in Tunnels:

1. Force grout through pipes or holes located in the crown of the liner or pipe every 20 feet, to completely fill all voids between the liner or pipe and tunnel, using such pressure as necessary to ensure that the voids have been completely filled. Drill additional grout holes and grout at additional locations in necessary to facilitate completely filling all voids.

2. Grout tunnel liners immediately after installation of the liner.

3. Grout pipes or holes immediately after installation of the pipe.

3.3 TESTS

A. Sample and test grout for compressive strength, air content and slump as specified in Section 03 31 00 “Cast-In-Place Concrete”, except as follows:

1. Non-shrink grout and tunnel liner and pipe grout: Prepare and test standard 2-inch mortar cubes in accordance with the requirements of ASTM C109. Make a minimum of one set of 6 cubes for each day of work or each 150 cubic yards of grout for each type of grout. Test two cubes for compressive strength at 7 days, one at 14 days and two at 28 days.

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 09 96 00

HIGH PERFORMANCE COATINGS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Preparation of surfaces, shop painting of items furnished, field painting of new and existing structures, piping, conduit, ductwork and equipment.

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. SSPC - The Society for Protective Coatings

a. SSPC SP 1 - Solvent Cleaning

b. SSPC SP 3 - Power Tool Cleaning

c. SSPC SP 6 - Commercial Blast Cleaning

d. SSPC SP 10 - Near-White Blast Cleaning

2. FS-TT-V-51F - Asphalt Varnish

3. NSF/ANSI Standard 61 - Drinking Water System Components

4. ANSI/AWWA D102 - Standard for Coating Steel Water-Storage Tanks

1.3 SUBMITTALS

A. Provide all submittals, including the following, as specified in Division 1.

1. Submit manufacturer's standard color chart for color selection.

2. Where equipment is customarily shipped with a standard finish, submit samples of the proposed color and finish for approval prior to shipping.

3. Furnish affidavits from the manufacturer certifying that materials furnished conform to the requirements specified and that paint products have been checked for compatibility.

4. Submit a supplementary schedule of paint products with mil thickness and solids by volume, including all paint applied in the shop and in the field. Provide a schedule that is in accordance with the recommendations of the paint manufacturer.

5. Furnish affidavits from the manufacturer certifying that coatings in immersion service contain no water soluble solvents or corrosion inhibitive (active) pigments with slight water solubility.

1.4 PAINTING REQUIREMENTS

A. Shop Primed and Finished Items: Furnish the following items with the manufacturer's standard prime and finish coats applied in the shop: pumps, motors, gears, gear housings, temperature control and instrument panels, filters, strainers, meters, generators, switchgears, switchboards, motor control centers, panelboards, transformers, industrial control panels (except stainless steel or fiberglass). Coat steel reinforcing bars for concrete in accordance with Section 03 20 00.

B. Shop Primed and Field Painted Items: Furnish the following items shop primed and field painted: steel joists and joist girders.

C. Field Primed and Finished Items: Field prime and finish, where exposed to view, all items not shop primed or shop finished. This Work generally includes, but is not limited to, the following: pump bases, motor bases, and electrical conduit systems.

D. Unpainted Items: Do not paint the following items, unless otherwise specified: interior structural steel not exposed to view, registers, grilles, dampers and linkage, fire sprinklers, name and identification plates and tags, floor gratings, brass pipe and fittings, brass valves, stainless steel, fiberglass and fiber reinforced polymer enclosures, wood, cast-iron piping installed underground, stop log panels, spray-on fireproofing steel to receive spray-on fireproofing, surfaces to receive field welding, faying surfaces of high strength bolted connections, steel to be embedded or in contact with cast-in-place concrete.

1.5 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store and handle all products and materials as specified in Division 1 (and as follows:)

B. Delivery and Storage: Deliver and store paint at the site from the approved manufacturer only.

C. Packaging and Labeling: Prepare, pack and label paints, stains, varnish or ingredients of paints to be used on the job. Deliver all material to the site in original, unbroken containers.

D. Storage: Store the painting materials at the site in accordance with applicable codes and regulations and in accordance with manufacturer's instructions. Keep the storage space clean at all times. Take every precaution to eliminate fire hazards.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted.

1. Paint - General:

   a. AkzoNobel (Ceilcote, Devoe, Enviroline, International)

2. Protective Coating – Concrete and concrete-block parapet walls, concrete roofs of walkways and where indicated

   a. Mameco; Vulkum 450/451 over 171 primer

2.2 MATERIALS

A. General: Furnish paint and other materials of the type and quality of the manufacturer on which the painting schedule specified herein is based.

1. Provide compatible shop and field coats.

2. Provide all coats of paint for any particular surface from the same manufacturer.

3. Provide coatings, including paints, primers and materials in contact with potable water listed by NSF International under Standard 61 for materials and products in contact with potable water.

4. Provide paint of approved color as selected from the manufacturer's standard range of colors.

B. Paint Schedule: Provide all painting in accordance with the following schedule with the number of coats not less than the number shown on the schedule.

Class of Work	Surface Preparation	Field Coats 1st	2nd	3rd	Total DFT
Steel-Structural, Tanks, Pipe, and Equipment:					
Exterior	SSPC-SP 6	E	F	C	8.5-15.0
Nonferrous Metal and Galvanized Steel:					
Interior	SSPC-SP 16	G	F		6.0-11.0
Exterior	SSPC-SP 16	G	C		4.0-6.0
Immersion	SSPC-SP 1 & SSPC-SP 10	B	B		8.0-12.0
Ductile or Cast Iron,-Pipes, Pumps, and Valves:					
Interior & Exterior Exposed	NAFP 500-03	G	F	C*	8.0-14.0
Below Ground	NAFP 500-03	H	H		32.0-40.0
Immersion	NAFP 500-03	B	B		8.0-12.0
PVC:					
Exterior Exposed	Scarify	G	C		4.0-6.0
Interior Exposed	Scarify	G	F		6.0-11.0

C. Schedule of Paints: Alphabetical designations in the following list are given solely for the purpose of indicating the type and quality of materials desired. Equivalent material from other approved manufacturers may be submitted for approval.

Symbol	Product Name and Number	Volume Solids %	Dry Film Thickness Mils Per Coat	VOCs (g/L)
B	International Paint-Devoe Coatings Bar-Rust 233H	80	4.0-6.0	170
C	International Paint-Devoe Coatings Devthane 379	63	2.0-3.0	311
E	International Paint-Devoe Coatings Cathacoat 302H	78	2.5-4.0	282

F	International Paint-Devoe Coatings Devran 224V	77	4.0-8.0	28
G	International Paint-Devoe Coatings Devran 201H	58	2.0-3.0	327
H	International Paint-Devoe Coatings Devtar 5A-HS	79	16.0-20.0	98

D. Schedule of Equipment and Piping:

1. The refurbished pumping equipment shall have the internal surfaces of the pump suction bells, columns and discharge elbows ship primed and shop finish coated as required for the submerged steel and iron class of work. The external surfaces of the pump bowls, columns, discharge elbows and suction bells shall be shop primed and shop finish coated as required for the interior steel and iron class of work. The pump bases shall be touch-up primed and repainted as required for the interior steel and iron class of work. The compatibility of the paints shall be verified prior to coating.

2. Existing cooling water supply and return bypass piping that are capped shall be touch-up primed and repainted as required for the interior steel and iron class of work.

PART 3 EXECUTION

3.1 REPAIR

A. Fill all pits in concrete having a depth in excess of 1/8 of an inch with a 100 percent solids epoxy repair compound. Provide fill material in compliance with NSF Standard 61 for materials and products in contact with potable water and from the same manufacturer.

B. Notify the ENGINEER of all pits with a depth greater than 1/4 inch to determine whether structural repairs are necessary. Repair such pits in a manner approved by ENGINEER.

3.2 PREPARATION

A. Inspection: Prior to surface preparation perform the following:

1. Verify that surface substrate conditions are ready to receive Work as instructed by the product manufacturer.

2. Examine specifications for all Work and become thoroughly familiar with all provisions regarding painting.

3. Document conditions of substrate prior to beginning work. Indicate any damaged or deficient substrates requiring repair and report findings to the ENGINEER.

B. Surface Preparation: After inspection and prior to painting, perform the following:

1. Inspect all Work prior to application of any paint or finishing material.

2. Prepare the surface to be painted in accordance with the instructions of the manufacturer and as approved.

3. Brush and wash concrete and masonry surfaces. Remove all loose dirt, free lime, form oil, curing compounds and other foreign matter by approved methods such as SSPC SP13. Patch concrete surfaces requiring repair and spackle and repair surfaces to receive paint. Acid etch concrete surfaces to be painted as recommended by the manufacturer of the coating to be applied, to produce a slightly granular surface required for adherence of the paint to the concrete unless otherwise indicated. Determine that concrete and concrete masonry is thoroughly dry prior to painting per ASTM D4263.

4. Thoroughly clean surfaces to be given protective coatings.

5. Refinish shop-coated equipment that has scratches and abrasions.

6. Do not begin field painting prior to approval of the surface preparation.

7. Thoroughly clean wood surfaces to remove all foreign matter. Properly fill and smooth cracks and nail holes. Finish exposed wood with sandpaper to a fine finish and wipe clean of dust.

8. Prepare and clean all surfaces prior to painting, as specified and required. Verify that surfaces are dry before any paint is applied. Perform special surface preparation work as directed by the manufacturer of the paint specified to be applied to the surface.

9. Clean the surface of structural steel, exterior and interior dry surfaces of water storage tanks and steel encased in concrete, masonry or spray-on fireproofing by removing all rust, mill scale, oil, grease or dirt in accordance with SSPC-SP6.

10. Prior to painting steel and interior wet surfaces of water storage tanks, grind smooth all welds, beads, blisters or protuberances per NACE SP0178, other than identification markings and remove other imperfections. Remove all rust, mill scale, oil, grease and dirt by abrasive blasting in accordance with SSPC-SP-10 unless otherwise indicated.

11. Prior to painting metals other than steel, grind smooth all welds, beads, blisters of protuberances, other than identification markings, and remove other imperfections. Solvent clean all nonferrous metals, galvanized steel and stainless steel whether shop primed or field primed, in accordance with SSPC-SP-1 prior to the application of the primer.

12. Prime cleaned metal the same day immediately after sandblasting to prevent rusting.

13. Remove all adhering debris on pipe and duct covering and smooth out indentations or unsightly spots and brush clean.

14. Remove all bituminous or asphaltic coating from cast iron drain and soil pipe prior to painting.

15. Remove all adhering debris on PVC, roughen surface with sandpaper and brush clean.

3.3 INSTALLATION

A. General: Install all painting and coatings in accordance with the manufacturer's recommendations and approved shop drawings and as specified in Division 1.

1. Apply products in accordance with the manufacturer's instructions.

2. Refer to manufacturer’s guidelines as it relates to minimum/maximum allowable temperatures for application.

3. The surface temperature of the steel shall be at least 5 degrees F above the dew point.

4. Paint surfaces in accordance with the material painting schedule included in this Section.

5. Completely cover all surfaces to be painted. Cover by additional coats when color on undercoats shows through the final coat of paint, until paint is of uniform color and appearance and coverage is complete.

6. Do not apply exterior coatings during rain or snow, or when relative humidity is outside the humidity ranges required by the paint product manufacturer.

7. Provide sufficient temporary ventilation during painting operations in enclosed areas to remove moisture and solvents, and to keep the atmosphere safe from harmful or dangerous fumes and dust levels for personnel.

B. Touch-Up Shop-Primed and Finished Items: Touch-up all damaged portions and imperfections in shop-primed and finished items. Use the same paint as used for the shop prime and finish. Prepare the surface prior to touch-up by wire brushing and sanding to remove rust, scale and loose paint per SSPC SP 2, 3, or 11, as determined by each situation.

C. Aluminum and Incompatible Surfaces: Where aluminum surfaces come in contact with incompatible metals, lime, mortar, concrete or other masonry materials, apply one field coat of International Paint-Devoe Coatings Bar-Rust 231 Epoxy or two coats of asphalt varnish conforming to FS-TT-V-51F. The aluminum surface should be abraded to a 1.5-2.0 mil profile before coatings application is done to ensure maximum adhesion to the surface.

D. Castings: Castings, such as manhole covers, frames, curb and area inlets and valve boxes are as specified under Section 05 56 00.

E. Steel Pipe: Applicable to insulated and uninsulated steel pipe. Immediately after installation, prime pipe not furnished with a shop coat.

F. Field Painting: Perform field painting at the job site as follows:

1. Mix all paints and similar materials in approved containers of adequate capacity.

2. Mix all paint thoroughly before being taken from the containers. Keep mixed while painting. Apply all ready-mixed paint exactly as received from the manufacturer without addition of any kind of drier or thinner, except as specified, to mix colors to conform to approved color schedule. Tint successive coats of paint to make various coats easily distinguishable. Tint undercoats of paint to the approximate shade of the final coat of paint.

3. Use only skilled painters on the Work, and employ specialists where required. Apply paint by brush, roller or sprayer in accordance with the manufacturer's recommendation.

4. Paint top and bottom edges of doors. Thoroughly and uniformly sand undercoats on hollow metal Work with No. 00 sandpaper or equal abrasive to remove all surface defects and provide a smooth, even surface. Do not allow brush marks or other irregularities on finished surfaces.

5. Perform painting as a continuous and orderly operation to facilitate adequate inspection. Prime coat and paint materials subject to weathering or corrosion before erection. Perform all paint application methods in accordance with the instructions of the paint manufacturer and as approved. Do not field paint equipment, such as electrical control cabinets, motors, unit heaters and similar items which are shipped with a final baked enamel finish and having received

prior approval unless the finish is damaged in transit or installation. Paint access panels, pipe, pipe covering, ducts and other building appurtenances built into adjoining walls the same color as adjacent walls, unless color coding applies. Remove or protect hardware and accessories, fixtures and similar items placed prior to painting during painting and replace them upon completion of painting.

6. Paint piping up to and including the flanges attached to mechanical equipment. Paint electrical conduit up to and including the flexible conduit connected to equipment.

7. Paint all wall surfaces which will be concealed by equipment before equipment installation.

8. Paint all existing wall surfaces newly exposed to view due to removal of existing equipment or other demolition work. Paint to match adjacent surfaces.

9. Fully protect areas under and adjacent to painted work at all times and promptly remove dripped or spattered paint.

10. Repair, refinish and repaint any adjacent surfaces that have been damaged or discolored by overspray.

11. Do not paint when the air or surface temperature is below that recommended by the manufacturer, or in dust-laden air, or until moisture on the surface has completely disappeared. If necessary, provide sufficient heating and ventilation to keep the atmosphere and all surfaces to be painted dry and warm until each coat of paint has hardened.

12. Remove any painting found defective. Touch-up and provide remedial painting as directed and as required until completion and acceptance of final work.

G. Color Coding: For colors to be used for identification of mechanical and electrical piping, tubing and conduit see the following:

1. Section 40 05 03 - Mechanical Identification

2. Section 26 05 53 - Electrical identification

H. Equipment Colors: Furnish the following equipment in their respective groups to be shop or field painted in the colors herein specified.

Schedule For Equipment Color

Equipment Description (Groups)	Color
Pumps W1 and W2, pump bases	Indigo Blue
Instrumentation and Control	White 311

1. Provide chart of standard colors offered by each equipment manufacturer. Coordinate color selection.

2. Furnish all electrical equipment shop painted in a color selected from the manufacturer's standard colors.

3.4 HEALTH AND SAFETY

A. Introduction

1. Products listed in this specification and used in high-performance coatings situations contain high volume solids; the aerosol droplets/particulates produced during airless spray of some of these materials may form an explosive mixture with air and additionally may contain materials which may necessitate personal protection against potential health hazards. A summary of the main precautions to be taken includes:

   - Danger of explosion or fire
   - Provision of a suitable breathing environment for workers.
   - Prevention of skin irritation problems.
   - Use of paints which have been specially formulated for use in tanks.

B. Consult with manufacturer prior to commencing work to review recommended Health and Safety procedures.

3.5 QUALITY CONTROL

A. General Coatings:

1. At least daily, check temperature, humidity, and Dew Point as to time and readings obtained. Submit "Paint Inspection: Daily Coating Inspection Report" to ENGINEER on a daily basis. See Supplement below.

2. Perform daily wet film thickness readings or spreading rate checks to make certain that proper film thickness is being achieved. If proper film thickness is not being achieved more frequent checks may be required by the ENGINEER at their discretion. Provide daily written report to ENGINEER. Correct any deficiencies in film thickness by application of additional paint. See Supplement below.

3.6 CLEANING AND FINAL TOUCH UP PAINTING

A. Touch up and restore any damaged finish. Remove paint or other finishes spilled, splashed or splattered from all surfaces taking care not to mar any surface or item being cleaned.

3.7 SUPPLEMENT

A. The supplement listed below is a part of this Specification:

1. Paint Inspection: Daily Coating Inspection Report

Paint Inspection:

Daily Coating Inspection Report

Project/Client:	Date: / / M T W Th F S Su	Pg. Of
Location:	Project #:	COPY To: ☐ QC Mgr ☐ Owner
Description:	Inspector:	☐ Contr ☐ _____
Requirements:		Attachments: ☐ DFT Sheet ☐ NCR/CAR ☐ _____
Contractor:	Spec #	Revision #

Description of Areas & Work Performed

Hold Point Inspections Performed

- ☐ 1 Pre Surface Pep/Condition & Cleanliness
- ☐ 2 Surface Preparation Monitoring
- ☐ 3 Post Surface Preparation/Cleanliness & Profile
- ☐ 4 Pre Application Prep/Surface Cleanliness
- ☐ 5 Application Monitoring/Wet Film Thickness (WFT)
- ☐ 6 Post Application/Application Defects
- ☐ 7 Post Cure/Dry Film Thickness (DFT)
- ☐ 8 Nonconformance/Corrective Actions Follow-up
- ☐ 9 Final Inspection

Approved By: _____

Surface Conditions

- ☐ New ☐ Maint ☐ Primer/Paint ☐ Age/Dry/Cure_____
- ☐ Steel ☐ Galvanize ☐ Concrete ☐ Other_____
- ☐ Hazard _____ ☐ Sample Report # _____
- ☐ Degree of contamination: _____
- Test: ☐ Cl_____ µg/cm² / ppm ☐ Fe ____ppm ☐ pH _____
- ☐ Degree of Corrosion: _____
- ☐ Scale ☐ Pitting/Holes ☐ Crevices ☐ Sharp Edges
- ☐ Weld_____ ☐ Moisture ☐ Oils ☐ Other_____
- ☐ Painted Surface Condition: _____
- Dry to: ☐ Touch ☐ Handle ☐ Recoat
- ☐ Dry/Over Spray ☐ Runs/Sags ☐ Pinholes ☐ Holidays
- ☐ Abrasion ☐ Fall Out ☐ Other _____

Ambient Conditions

Time (Indicate AM or PM)	:	:	:	:
Dry Bulb Temp° (C/F)	°	°	°	°
Wet Bulb Temp° (C/F)	°	°	°	°
% Relative Humidity	%	%	%	%
Surface Temp° (C/F) Min/Max	/ °	/ °	/ °	/ °
Dew Point Temp° (C/F)	°	°	°	°
Wind Direction/Speed				
Weather Conditions:				

Surface Preparation

Start Time: Finish Time: Est Sq/ft:

- ☐ Solvent Clean ☐ Hand Tool ☐ Power Tool
- ☐ HP Wash PSI_____ ☐ Other _____
- ☐ Abrasive Blast ☐ Abrasive Type _____ ☐ Sample
- ☐ Blast Hose Size _____ ☐ Nozzle Size / PSI _____
- ☐ Air Supply CFM _____ ☐ Air Supply Cleanliness
- ☐ Water/Oil Trap Check ☐ Equipment Condition Check

Application

Start Time : Finish Time : Est. Sq/ft.

☐ Primer ☐ Intermediate ☐ Topcoat ☐ Touch-up

Generic Type:		Qty Mixed:	
Manuf.:		Mix Ratio:	
Prod Name:		Mix Method:	
Prod #:		Strain/Screen:	
Color:		Material Temp:	°F
Kit Sz/Cond.:		Sweat-in Time:	Min/Hrs
Shelf Life:		Pot Life:	Min/Hrs
Batch #'s		Reducer #:	
(A)		Qty Added:	Pt/Qt/Gal
(B)		% by Vol:	%
(C)		Specified WFT Avg:	Mils
Reducer:		Achieved WFT Avg:	Mils

☐ Airless/Conv. Spray ☐ Brush ☐ Roller ☐ Other _____

Pump Pot	Hose Dia.	Air Check
Ratio/Size	Hose Lng.	SEP/Trap
GPM/CFM	Spray Gun	Filter
PSI	Tip Sz.	Agitator

Surface Cleanliness & Profile Measurement

- ☐ Job Specification ☐ SSPC/NACE - SP- _____
- ☐ SSPC/NACE Spec / Visual Stds ☐ _____
- Profile Check: _____ ☐ Disc ☐ Tape ☐ Gauge
- ☐ Specified_____mils avg. / Achieved _____mils
- ☐ Surface effect on DFT Gauge/BMR_____mils

Dry Film Thickness

Gage Type / Model	Gage Serial #	Gage Calib. Verified	Spec Avg. DFT	Total Avg DFT	DFT Last Coat	DFT This Coat

Inspector's Signature Date

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 23 05 29

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for providing and installing the following:
   1. Metal pipe hangers and supports.
   2. Metal framing systems.
   3. Thermal-hanger shield inserts.
   4. Fastener systems.
   5. Equipment supports.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:
   1. Section 05 50 00 - "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

   1. ASCE/SEI 7

1.3 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 1.

B. Product Data: For each type of product indicated.

C. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:

   1. Metal framing systems.
   2. Equipment supports.

D. Welding certificates

1.4 PROJECT RECORD DOCUMENTS

A. General: Submit record documents as specified in Division 1.

1.5 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
   3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
   4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
   5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.

2.2 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

   1. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
   2. Standard: MFMA-4.
   3. Channels: Continuous slotted steel channel with inturned lips.
   4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
   5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.

   6. Metallic Coating: Hot-dipped galvanized.

2.3 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.
B. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.
C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.4 FASTENER SYSTEMS

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

2.5 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.6 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.
B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
    1. Properties: Nonstaining, noncorrosive, and nongaseous.
    2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

C. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

D. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

E. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

F. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

G. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

H. Install lateral bracing with pipe hangers and supports to prevent swaying.

I. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

J. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

K. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

L. Insulated Piping:

1. Attach clamps and spacers to piping.

a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
5. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
B. Grouting: Place grout under supports for equipment and make bearing surface smooth.
C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for equipment supports.
B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches .

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils .

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
E. Use carbon-steel pipe hangers and supports and attachments for general service applications.
F. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
G. Use padded hangers for piping that is subject to scratching.
H. Use thermal-hanger shield inserts for insulated piping and tubing.
I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
   2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
   3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
   4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.

5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
7. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
8. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
9. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 , from two rods if longitudinal movement caused by expansion and contraction might occur.
10. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
11. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
12. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
13. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.

3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.

5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

O. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

P. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

Q. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 23 05 48

VIBRATION ISOLATION - HVAC

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for furnishing and installation of vibration isolators for mechanical equipment, piping and ductwork and all other appurtenances for a complete installation.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 23 23 00 - Refrigeration Piping and Specialties
2. Section 23 31 00 - Ductwork

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. ASTM A 36/A36M - Specification for Structural Steel.
2. NFPA 90A - Installation of Air Conditioning and Ventilating Systems

1.3 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 1.

B. Shop Drawings: Submit shop drawings showing structural design and details of vibration isolators, inertia bases, steel beam bases and other custom-fabricated work not covered by the manufacturer's submitted data.

1. Furnish templates to fabricators of equipment bases, foundations and other support systems, as needed for coordination of vibration isolation units with the supported equipment.

2. Submit shop drawings indicating locations of units and flexible connections. Include support isolation points for piping and ductwork including risers, air housings and inertia bases.

3. Include a schedule of the units, showing size or manufacturer's part number, and weight supported and resulting deflection of each unit.

4. Submit catalog data for each type of vibration isolation including materials, dimensions, application and performance characteristics.

1.4 QUALITY ASSURANCE

A. Product Qualification: Provide each type of vibration isolation unit produced by specialized manufacturer and as follows:

1. Except otherwise indicated, obtain vibration isolation units from a single manufacturer.

2. Engage the manufacturer to provide technical support in selection and supervision of installation of vibration isolation units.

B. Performance: Comply with the minimum static deflections recommended by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, including definitions of critical and noncritical locations, for selection and application of vibration isolation materials and units as indicated.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted.

1. Vibration Isolators.

a. Consolidated Kinetics Corp.
b. Korfund Dynamics Corp.
c. Mason Industries, Inc.
d. Vibration Eliminator Co., Inc.
e. Vibration Mountings and Controls, Inc.

2. Flexible Duct Connectors.

a. Vent Products Co. Inc.
b. Ventfabrics Inc.
c. Holtz Rubber Co.

3. Flexible Pipe Connectors.

a. Flow Flex Engr. Co.
b. Flexonic Inc.

c. Metraflex Co. Inc.
d. Holtz Rubber Co.
e. Mercer Rubber Co.

2.2 PAD-TYPE ISOLATORS

A. General: Except as otherwise indicated, provide a manufacturer's standard pad-type isolation unit, one of the following types, color coded to indicate load capacity:

1. Fiberglass pads or shapes.
2. Neoprene pads.
3. Cork/neoprene pads.

B. Fiberglass Pads and Shapes: Use glass fiber of not more than 0.18 mil diameter, produced by multiple-flame attenuation process, molded with the manufacturer's standard fillers and binders through 10 compression cycles at 3 times the rated load bearing capacity, to achieve natural frequency of not more than 12 hertz, in thicknesses and shapes required for use in vibration isolation units.

C. Neoprene Pads: Use oil-resistant neoprene sheets, of the manufacturer's standard hardness and cross-ribbed pattern, designed for neoprene-in-shear-type vibration isolation, and of the thicknesses required.

D. Cork/Neoprene Pads: Use a close grained composition cork sheet, laminated between 2 sheets of ribbed, oil-resistant neoprene, in the thicknesses required.

2.3 SPRING ISOLATORS

A. Spring Isolators, Free-Standing: Except as otherwise indicated, provide vibration isolation springs between top and bottom loading plates, and with pad-type isolators bonded to the bottom of the bottom loading plate. Include studs or cups to provide for centering of the springs on the plates. Include leveling bolts with lock nuts and washers, centered in the top plate, arranged for leveling and anchoring the supported equipment. Include holes in the bottom plate for bolting the unit to the substrate.

B. Vibration Isolation Springs: Use wound-steel compression springs, of high-strength, heat-treated, spring alloy steel, with an outside diameter of not less than 0.8 times the operating height, with a lateral stiffness not less than vertical stiffness, and designed to reach solid height before exceeding the rated fatigue point of the steel.

2.4 RAILS

A. Equipment Rails: Where rails or beams are indicated for use with isolator units to support equipment, provide steel beams complying with ASTM A 36/A36M, with a minimum depth of 6 inches or 0.08 times the span of beam between isolators (whichever is greater). Provide welded brackets at the ends of each beam, and anchor each end to the spring isolator unit. Provide bolt holes in beams matching anchor bolt holes in equipment. Provide beams of the section modulus indicated, or, if not indicated, selected for normal-weight equipment loading to limit static load stress to 16,000 psi. Except as otherwise indicated, position equipment on equipment rails so that the load will be equally supported by the isolator units.

2.5 BASES AND FRAMES

A. Fabricated Equipment Bases: Where supplementary bases are required for use with isolator units to support equipment (base not integral with equipment), provide welded units, fabricated of structural steel shapes, plates and bars complying with ASTM A 36/A36M, as shown. Provide welded support brackets at points as required, and anchor the base to spring isolator units. Except as otherwise indicated, arrange brackets to result in the lowest possible mounting height for the equipment. Provide bolt holes in bases to match mounting anchor bolt holes in the equipment. Fabricate the bases with the depth of the structure not less than 0.10 times the longest span of the base, rigidly braced to support the equipment without deflections or distortions which would be detrimental to the equipment or equipment performance.

B. Inertia Base Frames: Where inertia bases are required for use with isolation units to support the equipment, provide welded or bolted framing units of structural steel shapes, plates and bars complying with ASTM A 36/A36M. Frame the units as shown, or, if not shown, with a minimum depth of 0.08 times the longest dimension of the base, but not less than 6 inches deep. Size frames as shown, or, if not shown, so that weight of the frame plus the concrete fill will be equal to the operating weight of equipment supported. Provide No. (4) steel reinforcing bars (8) inches on center both ways with both ends of each bar butt welded to the base framing.

1. Provide 16-gauge sheet steel bottom paneling, welded to the base framing, and with welded seams.

2. Provide anchor bolts, located as required for equipment anchorage and supported for casting of concrete. Locate bolts as indicated, or, if not indicated, locate bolts so that operating weight of equipment will be centered both ways on the inertia base.

3. Provide adjustable bolts in pipe sleeves for 3-inch pipe size.

4. Provide stud bolts, welded to framing or subframing in base frames, located by equipment manufacturer's template.

2.6 HANGERS AND RISERS

A. Isolation Hangers: Provide hanger units formed with brackets and including the manufacturer's standard compression isolators of the type indicated. Design brackets for 5 times the rated loading of units. Fabricate units to accept misalignment of suspension members, and for use with either rod or strap type members, including acoustical washers to prevent metal-to-metal contacts.

1. Provide a vibration isolation spring with a cap and pad-type isolators, securely retained in the unit.

2. Provide a neoprene pad, securely retained in the unit.

3. Provide a fiberglass pad or shape, securely retained in the unit, with a threaded metal top plate.

4. Install a removable spacer in each unit, to limit the deflection during installation to the rated-load deflection.

B. Riser Isolators: Provide the manufacturer's standard pad-type isolator bonded to steel plates, formed for welding to the pipe sleeve extension.

C. Riser Support Isolators: Provide the manufacturer's standard pad-type isolator laminated between 2 formed steel plate members, one for welding to the pipe sleeve extension and other for welding to the pipe riser.

2.7 DUCT AND PIPE CONNECTORS

A. Flexible Duct Connectors: Provide flexible connections made from prefabricated metal, and laminated flexible sheets of cotton duct and sheet elastomer (butyl, neoprene or vinyl), reinforced with steel wire mesh where required for strength to withstand the duct pressure indicated. Form connectors with full-faced flanges and accordion bellows to perform as a flexible isolation unit, and of the manufacturer's standard length for each size unless otherwise indicated. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and capable of absorbing vibration of connected equipment. Equip each unit with galvanized steel retaining rings for airtight connections with ductwork. Provide products approved by NFPA for vibration isolation connectors in duct systems as covered by NFPA Bulletin 90A.

B. Flexible Pipe Connectors: For ferrous piping, provide stainless steel hose covered with stainless steel wired braid with NPT steel nipples or 150 psi ANSI flanges, welded to the hose.

C. Rubber Flexible Pipe Connectors: Provide connectors of rubber and butyl construction with integral full-faced duck and butyl flanges, internally steel wire reinforced, and furnished complete with steel retaining rings. Provide connectors with the temperature and pressure ratings to suit the intended service.

PART 3 EXECUTION

3.1 APPLICATIONS

A. General: Apply types of vibration isolation materials and units indicated at locations shown or otherwise required. Selection is at the CONTRACTOR's option where more than one type is indicated.

B. Isolation Hangers: Install isolation hangers where the following suspended equipment is indicated:

1. Air handling, make-up air, fan coil, cabinet heater and utility fan equipment.

2. Unit Heaters.

3. Pipe over 1-inch pipe size, located in mechanical equipment rooms, and each run connected to vibration-isolation-mounted equipment for a distance of 100 diameters but not less than 50 feet.

4. Ductwork (except flexible ductwork), located in mechanical equipment rooms, and each run connected to vibration-isolation-mounted equipment for a distance of 50 feet.

5. Ductwork, where air velocity is 3000 fpm or greater.

C. Flexible Duct Connectors: Install flexible duct connectors at the following ductwork connections:

1. Connections with air handling equipment.
2. Connections with all fans.
3. Building expansion joints.

D. Flexible Pipe Connectors: Install flexible pipe connectors in piping systems at the following locations:

1. Condensers/condensing units - refrigerant pipes.

3.2 INSTALLATION

A. General: Except as otherwise indicated, comply with the manufacturer's instructions for installation and load application to vibration isolation materials and units. Make adjustment so that the units do not exceed the rated operating deflections or bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices (if any) intended for temporary protection against overloading during installation.

B. Other Requirements: Meet the following installation requirements.

1. Anchor and attach units to substrate and equipment as required for a secure operation and to prevent displacement by normal forces, and as indicated.

2. Adjust leveling devices as required to distribute this loading uniformly onto isolators. Shim units as required where leveling devices cannot be used to distribute loading properly.

3. Install inertia base frames on isolator units as indicated, so that a minimum of 2 inches clearance below the base will result when the frame is filled with concrete and the supported equipment has been installed and loaded for operation.

4. Locate isolation hangers as near overhead support structure as possible.

5. Weld riser isolator units in place as required to prevent displacement from loading and operations.

6. Bond flanges of flexible duct connectors to ducts and housings to provide airtight connections. Seal seams and penetrations to prevent air leakage.

7. Install flexible pipe connectors on the equipment side of shutoff valves, horizontally and parallel to equipment shafts wherever possible.

3.3 EXAMINATION OF RELATED WORK

A. Coordination: Examine the installation of equipment, piping, ducts and conduits related to vibration isolation, including items connected to vibration isolators, and after completion of other related work (but before equipment startup), furnish a written report listing any observed inadequacies for proper operation and

performance of the vibration isolators. Have the report cover, but not necessarily be limited to the following:

1. Equipment installations on vibration isolators.

2. Piping connections including flexible connections.

3. Ductwork connections including provisions for flexible connections.

4. Passage of piping and ductwork which is to be isolated through walls and floors.

B. Equipment Start-Up: Do not start-up equipment until inadequacies have been corrected in an acceptable manner.

END OF SECTION

SECTION 23 05 53

MECHANICAL IDENTIFICATION

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for furnishing and installing identification materials and devices for mechanical systems.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 23 23 00 – Refrigeration Piping and Specialties
2. Section 23 31 00 – Ductwork

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. ASME A13.1 - Scheme for the Identification of Piping Systems.

1.3 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 1.

B. Product Data: Submit the manufacturer's technical product data and installation instructions for each identification material and device required.

C. Schedules: Submit a schedule for each equipment, piping system, and ductwork system. Tabulate equipment tags, piping system, and ductwork system abbreviation (as shown on tag) .

D. Samples: Submit samples of each color, lettering style, and other graphic representation required for each identification material or system. Provide a mock-up type sample installation.

E. Maintenance Data: Include product data and schedules in the appropriate operation and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide the specified items from firms regularly engaged in the manufacture of identification devices of types and sizes required, whose products have been in satisfactory use in similar service for not less than (5) years and which issues complete catalog data on these products.

1.5 SPARE PARTS

A. Spares: Furnish a minimum of 5% extra stock of each mechanical identification material required, including additional numbered valve tags (not less than 3) for each piping system, additional piping system identification markers, and additional plastic laminate engraving blanks of assorted sizes.

1. Where stenciled markers are provided, clean and retain the stencils after completion of stenciling and include used stencils in the extra stock, along with the required stock of stenciling paints and applicators.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted.

1. Identification Materials

a. Brady (W.H.) Co.; Signmark Div.
b. Industrial Safety Supply Co., Inc.
c. Seton Name Plate Corp.

2.2 MATERIALS

A. Provide the manufacturer's standard products of categories and types required for each application as referenced in other Division 23 sections. Where more than a single type is specified for an application, selection is at the CONTRACTOR's option, but provide a single selection for each product category. Comply with ASME A13.1 for lettering size, length of color fields, colors and viewing angles of identification devices.

2.3 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: stainless steel, 0.025-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.

2. Letter Color: Black or White.

3. Background Color: Black or White.

4. Letter and Background color shall be different.

5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

7. Fasteners: Stainless-steel rivets.

8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.4 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.

2. Lettering Size: [Size letters according to ASME A13.1 for piping] [At least 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm) and proportionately larger lettering for greater viewing distances].

2.5 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch minimum thickness, and having predrilled holes for attachment hardware.

B. Letter Color: Black or White.

C. Background Color: Black or White.

D. Letter and Background color shall be different.

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

H. Fasteners: Stainless-steel rivets or self-tapping screws.

I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

J. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include duct size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

PART 3 EXECUTION

3.1 PREPARATION

A. Surface Preparation: Degrease and clean surfaces to receive adhesive for identification materials.

3.2 INSTALLATION

A. General: Install identification products in accordance with the manufacturer's recommendations and approved shop drawings and as specified in Division 1.

B. Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces, install the identification after completion of the covering and painting. Install the identification prior to installation of acoustical ceilings and similar removable concealment.

3.3 DUCTWORK IDENTIFICATION

A. General: Identify air supply, return, exhaust, intake and relief ductwork with duct markers, or provide stenciled signs and arrows, showing ductwork service and direction of flow, in black or white (whichever provides the most contrast with the ductwork color).

B. Location: In each space where ductwork is exposed, or concealed only by a removable ceiling system, locate signs near points where the ductwork originates or continues into concealed enclosures (shaft, underground or similar concealment), and at 50 foot spacings along exposed runs. Paint all exposed ductwork per color selection as approved.

C. Access Doors: Provide duct markers or stenciled signs on each access door in ductwork and housings, indicating purpose of access (to what equipment) and other maintenance and operating instructions, and appropriate safety and procedural information.

3.4 PIPING SYSTEM IDENTIFICATION

A. General: Install pipe markers of one of the following types on each system and include arrows to show normal direction of flow:

1. Plastic pipe markers, with application system as indicated under "Materials" in this section. Install on pipe insulation segment where required for hot noninsulated pipes.

B. Color Coding: Continuously paint and color code all exposed piping to allow for quick identification. Paint each piping system a different color as selected and approved.

C. Identifier Location: Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior nonconcealed locations.

1. Near each valve and control device.

2. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be a question of the flow pattern.

3. Near locations where pipes pass through walls or floors/ceilings, or enter nonaccessible enclosures.

4. At access doors, manholes and similar access points which permit view of the concealed piping.

5. Near major equipment items and other points of origin and termination.

6. Spaced intermediately at a maximum spacing of 50 feet along each piping run, except reduce spacing to 25 feet in congested areas of piping and equipment.

7. On piping above removable acoustical ceilings, except omit intermediately spaced markers.

3.5 MECHANICAL EQUIPMENT IDENTIFICATION

A. General: Install engraved plastic laminate signs on or near each major item of mechanical equipment and each operational device, as specified if not otherwise specified for each item or device. Provide signs for the following general categories of equipment and operational devices:

1. Packaged HVAC units

2. Condensing units

B. Lettering Size: Use a minimum 1/4 inch high lettering for name of unit where viewing distance is less than 2 feet 0 inches, 1/2-inch high for distances up to 6 feet 0 inches, and proportionately larger lettering for greater distances. Provide secondary lettering of 2/3 to 3/4 of the size of the principal lettering.

C. Text of Signs: In addition to the name of the identified unit, provide lettering to distinguish between multiple units, inform the operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

3.6 ADJUSTING AND CLEANING

A. Adjusting: Relocate any mechanical identification device which has become visually blocked by the Work of this division or other divisions.

B. Cleaning: Clean the face of identification devices, and glass frames of valve charts.

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 23 05 93

TESTING, ADJUSTING AND BALANCING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for providing and installing the following:

1. Testing, adjustment and balancing of air systems.
2. Measurement of final operating conditions of HVAC systems.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 23 09 00 - HVAC Controls
2. Section 23 23 00 - Refrigerant Piping and Specialties
3. Section 23 31 00 - Ductwork
4. Section 23 33 00 - Ductwork Accessories

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. AABC - National Standards for Field Measurement and Instrumentation, Total System Balance.

2. ASHRAE - Most Recent Systems Handbook: Chapter 57, Testing, Adjusting and Balancing.

3. NEBB - Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.

1.3 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 1.

B. Testing and Balancing Agency: Submit the name and qualifications of the testing, adjusting and balancing agency and their personnel for approval within (30) days after the award of the contract.

C. Test Reports: Submit a complete set of all approved tests prior to final acceptance.

D. System Testing and Balancing: Submit a detailed account of the proposed methods and sequence to carry out system testing and balancing.

E. Draft Reports: Prior to commencing the Work, submit draft reports indicating adjusting, balancing and equipment data required.

1. Submit three draft copies of the report for review prior to final acceptance. Provide three final copies for the OWNER and for inclusion in the operation and maintenance manuals.

F. Reports Quality: Provide reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include a set of reduced drawings with air outlets and inlets, and equipment identified to correspond with the data sheets, and indicating thermostat locations.

G. Testing and Balancing Equipment: Submit data sheets of specific instruments to be used, listing their most recent calibration dates prior to commencing system balance.

1.4 REPORT FORMS

A. General: Submit reports on AABC National Standards for Total System Balance or NEBB forms.

B. Format: Include the following information on the report forms:

1. Title Page

a. Company name
b. Company address
c. Company telephone number
d. Project name
e. Project location
f. Project ENGINEER
g. Project CONTRACTOR
h. Project altitude

2. Instrument List

a. Instrument
b. Manufacturer
c. Model
d. Serial number
e. Range

f. Calibration date

3. Air Handling Equipment

a. Identification/Location
b. Manufacturer
c. Model/Size
d. Air flow, design and actual
e. Return air flow, design and actual
f. Outside air flow, design and actual
g. Total static pressure (total external), design and actual
h. Inlet pressure
i. Discharge pressure
j. Fan RPM

4. Electric Motors

a. Manufacturer
b. HP/BHP
c. Phase, voltage, amperage; nameplate, actual, no load
d. RPM
e. Enclosure
f. Service factor
g. Starter size, rating, heater elements

5. V-Belt Drive

a. Identification/Location
b. Required driven RPM
c. Driven sheave, diameter and RPM
d. Belt, size and quantity
e. Motor sheave, diameter and RPM
f. Center to center distance, maximum, minimum and actual

6. Duct Traverse

a. System zone/branch
b. Duct size
c. Area
d. Design velocity
e. Design air flow
f. Actual velocity
g. Actual air flow
h. Duct static pressure
i. Air temperature

j. Air correction factor

7. Air Distribution Test Sheet

a. Air terminal number
b. Room number/location
c. Terminal type
d. Terminal size
e. Area factor
f. Design velocity
g. Design air flow
h. Actual velocity
i. Actual air flow
j. Percent of design air flow

8. Air Cooled Condenser

a. Identification/Location
b. Manufacturer
c. Model/Size
d. Entering DB air temperature, design and actual
e. Leaving DB air temperature, design and actual
f. Number of compressors

1.5 PROJECT RECORD DOCUMENTS

A. General: Submit record documents as specified in Division 1.

B. Location Record: Accurately record actual locations of flow measuring stations balancing valves and rough setting.

1.6 QUALITY ASSURANCE

A. Provide services from a company specializing in the testing, adjusting and balancing of systems specified in this Section with minimum (3) years experience certified by AABC or NEBB.

1. Perform Work under supervision of AABC Certified Test and Balance Engineer or NEBB Certified Testing, Balancing and Adjusting Supervisor or registered Professional Engineer.

2. Perform the total system balance in accordance with AABC National Standards for Field Measurement and Instrumentation, Total System Balance or NEBB Procedural Standards for Testing, Balancing and Adjusting of Environmental System.

1.7 SEQUENCING AND SCHEDULING

A. Sequence the Work to commence after completion of systems and schedule completion of Work before Substantial Completion.

PART 2 PRODUCTS

PART 3 EXECUTION

3.1 EXAMINATION

A. General: Before commencing Work, verify that the systems are complete and operable. Verify the following:

1. Equipment is operable and in a safe and normal condition

2. Temperature control systems are installed complete and operable

3. Proper thermal overload protection is in place for electrical equipment

4. Final filters are clean and in place. If required, install temporary media in addition to final filters

5. Duct systems are clean of debris

6. Fan rotations are correct

7. Fire and volume dampers are in place and open

8. Coil fins have been cleaned and combed

9. Access doors are closed and duct end caps are in place

10. Air outlets are installed and connected

11. Duct system leakage has been minimized

B. Defects and Deficiencies: Report any defects or deficiencies noted.

C. System Imbalance: Promptly report abnormal conditions in mechanical systems or conditions which prevent system balancing.

D. Acceptance of Existing Conditions: Beginning of testing means acceptance of existing conditions.

3.2 PREPARATION

A. Additional Balancing: Provide additional balancing devices as required.

B. Instruments: Provide instruments required for testing adjusting and balancing operations. Make these instruments available to facilitate spot checks during testing.

3.3 INSTALLATION TOLERANCES

A. Air Systems: Adjust the air handling systems to plus or minus 5 percent for supply systems and plus or minus 10 percent for return and exhaust systems from the design figures indicated.

3.4 ADJUSTING

A. General: Adjust Work as specified in Division 1.

B. Completion: Properly install, inspect and confirm proper operation of each individual component of the system before giving notice to proceed with testing, adjusting and balancing. Do not perform testing, adjusting and balancing until all mechanical equipment is properly installed and is 100 percent operational, all temperature controls are installed and calibrated and all systems are cleaned and clean filters installed.

C. Deficiency and Correction: Assist in the system testing, adjusting and balancing. Adjust the system and make corrections of any deficiencies found such as: motor starters and horsepower; improper sheave and belt sizes; missing, improperly installed or malfunctioning volume control dampers, air extractors, power wiring, controls and any other items that prevent the completion of the system testing, adjusting and balancing.

D. Recorded Data: Record data representing actually measured, or observed conditions.

E. Settings: Permanently mark settings of valves, dampers and other adjustment devices the allow the balanced settings to be restored. Set and lock memory stops.

F. Balance Verification: After adjustment, take measurements to verify that the balance has not been disrupted or that such disruption has been rectified.

G. Operating Systems: Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to the specified settings.

H. Final Inspection: At final inspection, recheck random selections of data recorded in the report. Recheck points or areas as selected and witnessed by the OWNER.

I. Checking: Check and adjust the systems approximately six months after final acceptance and submit report.

3.5 AIR SYSTEM TESTING AND BALANCING

A. Perform air system balancing as follows:

1. Check filters for cleanliness and minimum bypass leakage, dampers (both volume and fire) for correct position, and temperature controls for completeness of installation.

2. Prepare test report sheets for fans, and air inlets and outlets. Obtain the manufacturer's flow factors and follow the recommended procedure of testing.

3. Open all supply dampers, and place all fans in specified operation.

4. Check motor amperage and voltage for each motor, fan rotation, and automatic dampers for proper position.

5. Check air and water temperature controls and verify that they are operating to deliver design temperatures. Adjust the system with mixing dampers positioned under the minimum outdoor air condition.

6. Using pitot tube and calibrated manometer, traverse the main duct and all main branches and ascertain the total air being delivered. Adjust or replace pulleys and belts and install additional dampers if required to obtain the design airflow. Make adjustments so that all finally adjusted air quantities are at least equal to, but more than 10 percent above, the air quantities noted on the drawings.

7. Adjust branch dampers until the proper air volume is obtained in each branch duct.

8. Commence terminal outlet balancing beginning with the outlets nearest the fan. Use branch dampers for major adjusting and terminal dampers for minor adjustments only.

9. Make additional test and adjustment passes through entire systems as necessary to obtain the noted outlet values.

10. Read and record amperage readings for each motor lead, fan static and velocity pressures and the static pressure drop across each major component (i.e., intake, filters, coils, heat recovery device).

11. Reposition system dampers to supply maximum outdoor air and record the amperage and pressure readings in this position.

12. Adjust air terminal outlets for proper distribution pattern.

13. Inspect and test all electrical protective devices and circuits for proper motor protection, including properly sized starter overload heater elements, for all equipment furnished.

14. Provide a system schematic with the required and actual air quantities recorded at each outlet or inlet.

15. When modulating dampers are provided, take measurements and balance the system at extreme conditions.

16. Measure building static pressure and adjust the supply, return and exhaust air systems to provide the required relationship to maintain approximately 0.05 inches positive static pressure for each zone near building entries.

17. Check multizone units for motorized damper leakage. Adjust air quantities with mixing dampers first set for summer ventilation, then heating, then modulating.

18. Permanently mark the balance position of all manual volume dampers, and replace all access covers.

3.6 OPERATION DEMONSTRATION

A. General: When each system has been completed and proved functional, demonstrate its intended operation in each of its operating modes. Simulate in an

acceptable manner functions dependent upon parameters such as weather, process or emergency conditions which are unavailable at the time of test, or separately demonstrate when those parameters exist, to assure proper functioning under all operating conditions. Immediately after testing, properly reset control settings temporarily modified for such simulations.

B. Final Acceptance: Final acceptance of the Work will be contingent upon the operation of all equipment and systems meeting the specified requirements.

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 23 09 00

HVAC CONTROLS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for providing electronic/electric temperature control systems for heating, ventilating, and air conditioning systems as indicated. Provide systems complete in all respects, including thermostats, smoke detectors, thermometers, relays and switches, automatic dampers, damper operators, signal selectors, transmitters, miscellaneous accessories, temperature control panels (TCP), and alarm systems.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 23 05 93 - Testing, Adjusting and Balancing
2. Section 26 05 00 - Basic Electrical Material and Methods
3. Section 26 05 19 - Wire and Cable - 600 Volts and Below
4. Section 26 05 53 - Electrical Identification
5. Section 26 05 60 - Electrical Requirements for Shop Assembled Equipment

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. AMCA 500 - Test Methods for Louvers, Dampers and Shutters

2. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

3. ASTM B 32 - Solder Metal

4. NEMA 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum)

5. NFPA 90A - Installation of Air Conditioning and Ventilation Systems

6. ASTM B 280 - Seamless Copper Tube for Air Conditioning and Refrigeration Field Service

7. ASTM D 1693 - Environmental Stress - Cracking of Ethylene Plastics

8. ASME 40.1 - Gauge, Pressure and Vacuum, Dial Indicating (for Air, Steam, Oil, Water, Ammonia, Chloro-Fluorohydrocarbon Gases, and Compressed Gases)

9. FS-QQ-S-571 - Solder, Tin Alloy; Tin-Lead Alloy; and Lead Alloy

10. MIL-F-18280 - Fitting, Flareless Tube, Fluid Connection

11. NEMA DC 3 - Residential Controls - Electric Wall-Mounted Room Thermostats

1.3 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 1.

B. Product Data: Provide complete catalog data for all proposed control components including manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts and installation instructions.

C. Shop Drawings: Provide shop drawings for the following:

1. Complete data on all proposed control components

2. Dimensioned external, control panel layouts, with components identified

3. Bills of material for all control components

4. Control sequence description for each system

5. Control diagrams

6. Damper schedule including sizes, trim, operator sizes and pressure drop calculations

7. Air temperature sensor schedule including range, element type, element length accuracy, hysteresis, linearity, power requirements and mounting details

8. Detailed operating instructions

9. Complete plan wiring, riser and schematic diagrams, and terminal connection diagrams

10. Software listings for all control loops and each point in the system

11. Calculations and all other details required to demonstrate the system design has been coordinated and will properly function as a system. Submit all sensor range calculations.

D. Operation and Maintenance Manuals: Submit operation and maintenance manuals covering the function, operation and maintenance of all control components and systems, including the DDC control system as specified in Division 1.

1.4 QUALITY ASSURANCE

A. Manufacturer: Provide equipment from a company specializing in manufacturing the products specified in this Section with minimum of (3) documented experience and which issues complete catalog data on these products.

B. Installer: Provide company specializing in installing the Work of this Section with minimum (3) years documented experience.

1.5 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store, and handle all products and materials as specified in Division 1 and as follows.

B. Acceptance: Accept products on-site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect products for damage.

C. Storage and Protection: Store products in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.6 SPARE PARTS

A. Furnish the following spare parts.

1. TCP Panel lights and switches of each kind – 1 each.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted.

1. Temperature Control Equipment

a. Johnson Controls, Inc.
b. Landis & Gyr Powers, Inc.
c. Barber Colman Company
d. Honeywell Inc.

2. Control Dampers

a. Aluminum Dampers

(1) Ruskin - Model CD50
(2) Air Balance - Series 500

b. Galvanized Steel and Stainless Steel Dampers

(1) Ruskin - Model CD30VG2 (Galvanized Steel and Stainless Steel)
(2) American Warming - Model VC-1 and VC-2 (Galvanized Steel - Model VC-20 and 21 (Stainless Steel)

c. Fiberglass Reinforced Plastic (FRP) Damper

(1) Swartwout - Model 1108 Rectangular Dampers
(2) Swartwout - Model 912 (1-10 inches w.g.) Round Dampers
- Model 914 (10-30 inches w.g.) Round Dampers

3. Damper Operators

a. Electric/Electronic Damper Operators

(1) Johnson Controls - Series M-100
(2) Barber Colman - Series MP-400/MA-400

4. Time Delay Relays

a. Agastat - Cat. No. SSC12ABA
b. ISSC - Cat. No. 1017-B-1

5. Repeat Cycle Timers

a. Eagle Signal Controls - CA Series
b. Automatic Timing and Controls Co. - Series 342

6. Differential Pressure Switches

a. Dwyer Instruments Inc. - Series 1900

7. Thermostats

a. General Use Thermostats

(1) Johnson Controls
(2) Barber Colman
(3) Honeywell

b. Corrosion-Resistant Thermostats

(1) Indeeco - Cat. No. C211-040

8. Smoke Detectors

a. Duct-Mounted Smoke Detectors

(1) Pyrotronics - Series 3 with AD-3RP housing

9. Remote Smoke Detector Alarm Annunciator

a. Pyrotronics - Model RLP

10. Time Clocks

a. AMF Paragon
b. Tork

11. Airflow Traverse Probes

a. Air Monitor Corp. - Volu Probe/1

12. Alarm Annunciators

a. Panalarm - Series 70
b. Ronan - Series X12

2.2 HVAC CONTROLS, GENERAL

A. General: Provide temperature control systems as specified and complete in all respects. Provide control components subject to mechanical strain of metallic construction. Provide all electric and electronic control components to be UL listed.

B. Wiring: Provide electrical wiring and conduit for the following.

1. Control and interlock wiring from remote heating, ventilating and air conditioning control components to identified terminals on TCPs and to control panels supplied with the heating, ventilating and air conditioning equipment.

2. Power and alarm wiring from the control components initiating alarms to the TCPs.

3. Alarm wiring from TCPs to the remote smoke detector alarm annunciator.

4. Motor starters and power wiring wired to terminal connections in the TCP for HVAC motors less than 1/2 horsepower.

5. Wiring of safeties required for sequences of operation including, but not limited to, air flow switches, static pressure switches, low temperature thermostats, damper end switches, etc.

6. Power wiring to electric actuators from respective TCP.

7. Power and control wiring from motor starters to motors and local and remote control panels.

8. Power and control wiring to HVAC smoke detectors.

Provide electrical power feeders to the TCPs, and interlock wiring from terminal strips in the TCPs to motor control centers, multiplexers and like equipment under Division 26. Provide electrical power source to the TCPs under Division 26.

Provide all wiring and conduit to meet the requirements of applicable Division 26 sections.

2.3 SWITCHES AND RELAYS

A. General: Provide electric or pneumatic relays necessary to accomplish specified control functions installed in the appropriate temperature control panels. Provide electric switches and relays complying with applicable requirements specified in Division 26.

B. Construction: Provide electric relays of the plug-in solid-state type with compatible current and voltage ratings.

C. Time Delay Relays: Provide adjustable time delay relays with automatic reset, with ranges as specified and electrical rating of at least 10 amperes rms at 115 volts. (Agastat Cat. No. SSC12ABA, ISSC Cat. No. 1017-B-1.)

2.4 REPEAT CYCLE TIMERS

A. General: Provide multirange power-operated repeat cycle timers with separate programmable ON and OFF time periods. Design the timers to repeat cycles consisting of an ON period and an OFF period whenever 120-volt ac power is applied to the timer. Provide a pilot light on the front of the unit to indicate the ON time period. Provide timers which have a dial range of 60 minutes with a minimum setting of 6 minutes unless specified otherwise. (Eagle Signal Controls CA Series, Automatic Timing and Controls Co. Series 342.)

2.5 FLOW AND DIFFERENTIAL PRESSURE SWITCHES

A. General: Provide each flow switch or differential pressure switch with a solid-state "ON delay" time delay relay, either integral with the flow switch, or separately mounted in the related temperature control panel. In either case, wire the time delay relay from the temperature control panel and incorporate a delay of about 5 seconds (5 to 60 seconds adjustable) except where specified otherwise, to prevent false alarm until fluid flow is established during start-up. Mount separate time delay relays in the temperature control panel. Provide DDC software time delay acceptable with DDC controlled systems. Furnish the electrical rating for flow and differential pressure switches and time delay relays as at least 10 amperes rms at 115 volts, single phase.

B. Flow Switches: Provide flow switches for water and other liquid systems suitable for operating a maximum pressure of 150 psi and a maximum temperature of 250 degrees F. Design the switch to be operated by a segmented stainless steel or similar corrosion-resistant metal paddle. Furnish the bearing as hardened steel, and the switch complete with a sensitivity adjusting screw.

C. Differential Pressure Switches: Supply differential pressure switches for air systems. Select each differential pressure switch with a suitable operating range for the specific application. Provide differential pressure switches diaphragm operated, suitable for temperatures -30 degrees F to 180 degrees F, with 45-inch w.g. rated pressure and 10 psig maximum surge pressure and complete with adjustable differential pressure set point screw. (Dwyer Instruments Inc. Series 1900.)

D. Functions: Unless otherwise noted, provide each switch to accomplish the following functions:

1. De-energize the respective fan starter

2. Energize an audible alarm and an identified pilot light at the related temperature control panel

3. Close a pair of dry contacts wired to a terminal strip in the related temperature control panel to complete a remote alarm circuit

2.6 THERMOSTATS

A. Electric Thermostats: Provide electric thermostats as two-position type of fully modulating type as required. Furnish electric thermostats with bimetallic sensing elements and concealed adjustable set point. Supply electric thermostats with field adjustable sensitivity and with thermometers in covers of approved standard finish. Equip electric modulating type thermostats to operate on the balanced bridge principle. Provide thermostats sensing the temperature of rooms, when located outside of the room, of the remote bulb type with stainless steel bulb and capillary not exceeding 20 feet in length.

B. Corrosion-Resistant Thermostats: Provide all thermostats located in corrosive areas to be electric, corrosion-resistant type in a NEMA 4X enclosure with a nickel-plated or stainless steel bulb. (Indeeco Cat. No. C211-040.)

2.7 SMOKE DETECTORS

A. Duct-Mounted Smoke Detectors: Furnish duct-mounted smoke detectors of the self-contained 115-volt photoelectric type suitable for duct mounting, complete with sampling tube and box assembly. Equip the locking cover box with a power ON light, an alarm indicator light, a reset switch, and a detector, all prewired ready for wiring connections. Extend sampling tubes the full width of the ducts in which they are mounted. (Pyrotronics Series 3 w/AD-3RP housing.)

B. Remote Alarm Lamp Assembly: Where smoke detectors are concealed from view, provide a remote alarm lamp assembly at a suitable location near each concealed smoke detector, wired to provide a visual smoke alarm indication from each concealed smoke detector. (Pyrotronics Model RL4.)

C. Function: Design smoke detectors to accomplish the following functions when any one of the smoke detectors is activated.

1. Activate a visual alarm at the smoke detector and a visual and audible alarm at its respective temperature control panel and the DDC operators console.

2. Stop the associated supply fans and exhaust fans.

3. Close relay dry contacts wired to its associated temperature control panel terminal strip, to close a DDC and remote alarm.

4. Provide smoke detectors so that a trouble alarm from any one of the smoke detectors associated with a specific system activate a single identified visual alarm indication for that system at the temperature control panel alarm annunciator or remote smoke detector alarm annunciator and through the DDC system.

2.8 REMOTE SMOKE DETECTOR, ALARM ANNUNCIATOR

A. Provide the remote smoke detector alarm annunciator equipped with a separate lamp for smoke detection and a separate lamp for trouble alarm for each temperature control panel. Provide multiple remote lamp panels where the number of indicator lamps exceeds the number of lamps available on one standard panel. Provide a surface-mounted horn of the vibrating type with frames and grilles of die-cast aluminum and aluminum diaphragm integral with the remote lamp panel or separately mounted adjacent to the remote lamp panel, wired to provide an audible alarm when any visual smoke detector alarm is activated at the panel. Comply with applicable section of Division 26.

2.9 TIME CLOCKS

A. General: Provide time clocks as the 7-day type driven by a heavy-duty synchronous motor with spring-wound carry-over providing a minimum 10-hour reserve. Provide the electric motor suitable for 115-volt, single-phase electric supply.

B. Design: Design each time clock to permit different ON/OFF schedules on different days of the week accommodating a minimum 28 trippers for four ON/OFF operations per day (28 per week), and a minimum 90-minute ON or OFF time. Provide a signal lever for MANUAL, AUTOMATIC or OFF operation, and heavy-duty terminals for up to AWG No. 8 wire.

C. Enclosure: House time clocks in a NEMA 12 enclosure with hasp for padlock or seal where mounted outside of temperature control panels or equipment panels.

2.10 TEMPERATURE CONTROLS PANELS

A. General: Furnish temperature control panels with suitable brackets for wall mounting, each prewired to integral identified terminal strips. Provide interior panel wiring color coded and numbered conductors, neatly bundled and secured. Furnish panels as of the enclosed type, equipped with hinged doors and locks, and constructed of heavy-gauge sheet metal or aluminum with baked enamel finish. Provide a disconnect switch mounted inside the panel for each 120-volt circuit connected to the temperature control panel. Provide a power "ON" pilot light mounted on the face of the panel to be energized when the electric circuits feeding the panel are energized. Number each panel and provide a nameplate identifying the system or systems controlled. Conform panels to Section 26 05 60. Provide all

Process Control System Panels as part of Division 40, including PLC panels, complying with the requirements of UL-508A, NFPA 79, and NEC Article 409 - Industrial Control Panels.

B. Panel Components: Furnish the temperature control panels with magnetic starters, thermometers, switches, alarm annunciators and pilot lights mounted on the front of the panel. Mount controllers, control relays, timing relays, reset timers, remote control stations, terminal strips and other components inside the panel. Equip the panels with manual starters with thermal overload for associated HVAC and plumbing equipment motors 1/3 hp and smaller. Provide an identified RUN pilot light for each fan. Provide red RUN indication pilot light.

C. Magnetic Starters: Provide 240-volt, 1-phase, 60-hertz across-the-line combination motor circuit protector and magnetic starters having individual control power transformers.

1. Provide starter contacts of the replaceable, spring-loaded, wedge type with silver-cadmium odixe-plated contact surfaces. Provide replaceable coils of the epoxy sealed type.

2. Thermal Overload Elements: Provide each magnetic starter unit with a Class 20 thermal overload element and all required accessories. Provide size five and larger starters with current transformer operated overload relays.

a. Provide and adjust overload relays to match the associated motor nameplate running current rating. Size the overload relays after approval of the corresponding motor.

b. Provide a set of isolated normally-open and normally-closed contacts for each overload relay.

D. Motor Circuit Protectors: Provide a motor circuit protector for each combination starter using molded-case, air-break type designed for 600-volt, 60-hertz service with an interrupting capacity of 65,000 rms symmetrical amperes at 240 volts. Provide magnetic trip units capable of being adjusted from 700 to 1,300 percent of the motor full load amperes.

E. Alarm Annunciator: Provide the alarm annunciator as solid-state suitable for flush panel mounting or mounting adjacent to the temperature control panel. Provide the annunciator window engraved with black lettering and illuminated blue for ALARM. Provide a panel-mounted lamp test push button such that when pressed all alarm lights are illuminated. (Panalarm Series 70, Ronan Series X12.)

F. Alarm Module Function: Provide the alarm module such that when an alarm occurs, the alarm module causes a horn to sound and the corresponding alarm light

to flash. Provide a panel-mounted SILENCE push button to silence the horn and change the flashing light to a steady light when pressed. Provide the alarm module such that another alarm occurring in the system repeats the above sequence. When the alarm condition returns to normal, the alarm module automatically causes the corresponding steady alarm light to turn off. Provide each annunciator module with a lock/nonlock feature.

G. Auxiliary Contacts: Include in each alarm module auxiliary isolated dry contacts which repeat the field contact function. Provide alarm circuits as double pole, prewired to a terminal strip for remote signaling. Provide, in addition, the annunciator with an auxiliary contact which closes upon loss of power to the annunciator.

H. Alarm Horn: Furnish the annunciator with a variable volume alarm horn powered by 115-volt ac, 60 hertz, and suitable for panel mounting.

I. Identification: Identify devices mounted on the front of the panel by engraved bakelite or formica tags. Identify all equipment as scheduled and as shown on the control diagram. Permanently mount the control diagrams provided under suitable protective cover adjacent to the local control panel.

J. Electrical Diagrams: Consult the schematic diagrams shown for control relays, timing relays and other accessory equipment to be provided, and mounted and prewired to terminal strips in the temperature control panels. Provide control relays, timing relays, reset timers, manual motor starters and remote control stations meeting applicable requirements of Division 26.

PART 3 EXECUTION

3.1 EXAMINATION

A. General: Verify that systems are ready to receive control component Work. Beginning of installation means that the installer accepts the existing conditions.

3.2 INSTALLATION

A. General: Install required control components in accordance with the manufacturer's recommendations and approved shop drawings and as specified in Division 1. Adjust and test to meet the required control performance. Coordinate prior to control installation the proposed controls with electrical plans and interfacing equipment for compatibility. Install the systems by experienced

competent mechanics employed by a firm with an established controls service organization.

B. Electrical Requirements: Provide electrical material and installation in accordance with applicable requirements of Division 26.

C. Set Points: Provide adjustable set points for all set points listed in the specified or scheduled control sequences. All temperature set points in the control sequences are in degrees Fahrenheit.

D. Testing: Prove operation of all exhaust air fans by a differential pressure type flow switch and located across each and fan. If a fan has been commanded on and the flow switch indicates a no-flow status, initiate an individual identified audible and visual alarm and close remote alarm contacts at the temperature control panel annunciator for the fan in alarm. Provide an adjustable time delay function for each flow switch to lock out the alarm during fan start-up.

E. Selector Switches: Provide a HAND/OFF/AUTO selector switch for each exhaust air fan at the temperature control panel, or as specified otherwise:

1. Operate fans through their safety devices, as specified, when the selector switch is in the HAND or AUTO position.

2. Provide the selector switch which permits continuous operation of each fan when placed in the HAND position. When the selector switch is in the HAND position, provide dampers which function as specified for the AUTO position.

F. Test Button: Provide an OFF/LOCK-ENABLE switch with a momentary contact TEST push button at each fan. Provide and wire the TEST push button to test the fan motor with the selector switch in the AUTO position and to bypass the fan's safety devices.

G. Control Sensors: Check and verify locations of thermostats and other exposed control sensors with plans and room details before installation. Locate room thermostats 48 inches above floor.

H. Smoke Detectors: Provide a smoke detector installed downstream of the air filters and a smoke detector installed in the return and exhaust airstream prior to the air being exhausted from the building or diluted by outside air, for each supply, return and exhaust air system which handles more than 2,000 cfm of air, or as otherwise required.

I. Control Dampers: Provide mixing dampers of (opposed) (or) (parallel) blade construction arranged to mix streams. Provide pilot positioners on mixed air

damper motors. (Provide separate minimum outside air damper section adjacent to return air dampers with separate damper motor.) Test multizone dampers for temperature pickup due to leakage when hot deck is closed and cold deck is open. Adjust for maximum temperature rise of 2 degrees F when the temperature difference between the hot and cold decks is 20 degrees F.

J. Damper Operators: Provide pilot positioners on damper operators sequenced with other controls. Locate damper operators outside of the airstream wherever possible.

K. Temperature Control Panels: Mount control panels adjacent to associated equipment on vibration-free walls or freestanding angle iron supports. One cabinet may accommodate more than one system in same equipment room.

L. Starters: Provide Split System Air Conditioner starters at part of TCP.

M. Conduit and Wiring: Provide conduit and electrical wiring where required.

3.3 SEQUENCE OF OPERATIONS

A. Split System Air Conditioners W-ACU-1 & W-ACU-2 with duct mounted thermostats (TCP-1)

1. ACU fan to be interlocked with the VFD and shall run upon VFD run.

2. ACCUs to provide cooling based off individual adjustable thermostats attached to the return duct next to the unit.

3. When the duct mounted thermostat at the ACU return calls for cooling, the associated ACCU starts.

4. Build a 5 °F deadband into set point.

5. If W-ACU-1 or W-ACU-2 fail to run, an alarm shall be indicated on the TCP and a GENERAL HVAC ALARM shall sent to SCADA

B. Roof Exhaust Fans (W1 and W2)

1. A HAND-OFF-AUTO switch at the TCP shall be provided for W1 and W2. AUTO position shall be provided for Roof Exhaust Fans W1 and W2 and Dampers No. 1 and No. 2. Roof Exhaust Fans W1 and W2 shall be interlocked with Dampers No. 1 and No. 2. In the AUTO position, and when the space temperature exceeds the wall-mounted thermostat set point temperature of 85°F, Dampers No. 1 and No. 2 shall open and Roof Exhaust Fans W1 and W2 shall be started. HAND position shall be provided to open

Dampers No. 1 and No. 2 and to start interlocked Roof Exhaust Fans W1 and W2.

2. When the duct smoke detectors located at W1 and W2 are tripped an alarm shall be initiated at the smoke detector, W1 and W2 shall stop, and an alarm shall be indicated on the TCP and a GENERAL HVAC ALARM shall be sent to SCADA.

3. If W1 or 2 fail to run, an alarm shall be indicated on the TCP and a GENERAL HVAC ALARM shall sent to SCADA.

C. Roof Exhaust Fans (W3)

1. A HAND-OFF-AUTO switch at the TCP shall be provided for W3. AUTO position shall be provided for Roof Exhaust Fan W3 and Dampers No. 3 and No. 4. Roof Exhaust Fans W3 shall be interlocked with Dampers No. 3 and No. 4. In the AUTO position, and when the space temperature exceeds the wall-mounted thermostat set point temperature of 90°F, Dampers No. 3 and No. 4 shall open and Roof Exhaust Fan W3 shall be started. HAND position shall be provided to open Dampers No. 3 and No. 4 and to start interlocked Roof Exhaust Fan W3.

2. When the duct smoke detector located at W3 is tripped an alarm shall be initiated at the smoke detector, W3 shall stop, and an alarm shall be indicated on the TCP and a GENERAL HVAC ALARM shall be sent to SCADA.

3. If W3 fails to run, an alarm shall be indicated on the TCP and a GENERAL HVAC ALARM shall sent to SCADA.

D. Switches, Pilot Lights and Push Buttons (TCP-1)

1.	W-ACU-1	H-O-A
2.	W-ACU-2	H-O-A
3.	W1 & W2	H-O-A
4.	W3	H-O-A
5.	W-ACU-1	RUN (RED)
6.	W-ACU-2	RUN (RED)
7.	W1	RUN (RED)
8.	W2	RUN (RED)
9.	W3	RUN (RED)
10.	TCP-1	POWER ON (WHITE)

E. Alarm Annunciation (Visual, TCP-1)

1.	W-ACU-1	UNIT FAILURE (AMBER)

2.	W-ACU-2	UNIT FAILURE (AMBER)
3.	W1	UNIT FAILURE (AMBER)
4.	W2	UNIT FAILURE (AMBER)
5.	W3	UNIT FAILURE (AMBER)
6.	W1	SMOKE (AMBER)
7.	W2	SMOKE (AMBER)
8.	W3	SMOKE (AMBER)

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Services: Furnish the services of a qualified representative of the manufacturer to provide instruction on proper installation of the equipment, and to instruct the operating personnel in the operation and maintenance of the temperature control system as specified in Division 1.

1. Provide a minimum of 8 hours of service. Provide basic operator training for data display, alarm and status descriptors, requesting data, execution of commands and request of logs. Provide 4 hours of instruction time.

2. Provide operator instruction at an agreed upon time, during normal working hours by competent representatives familiar with the computer's software, hardware and accessories.

B. Tests: After installation of the equipment, control equipment and all appurtenances, subject each unit to a field running test as specified in Division 1, under actual operating conditions.

1. Perform prefinal inspection/test as follows:

a. Carry out test with controls operating as near as possible to service conditions.

b. Correct all defects in the controls.

2. Final inspection/test:

a. Prior to the acceptance test, completely adjust and operate properly all controls.

b. Notify the OWNER when the installation is ready for acceptance tests. At least two weeks prior to scheduled acceptance tests, deliver copies of record internal panel layouts and detailed schematic and wiring diagrams to the OWNER. At the acceptance test, demonstrate the complete functions and proper operation of each control system to the Owner. Simulate

conditions of off-season temperature and alarms as required for a complete demonstration.

END OF SECTION

SECTION 23 11 23

FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 SUMMARY

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

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Manual gas shutoff valves.
5. Pressure regulators.
6. Dielectric fittings.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 26 32 13 – Packaged Engine Generator System

1.2 REFERENCES

A. Codes and Standard referred to in this Section are:

1. NFPA 54 - National Fuel Gas Code

2. AGA - American Gas Association

3. NFPA-70 - National Electrical Code

4. ASTM D 2385 - Test Method for Hydrogen Sulfide and Mercaptan Sulfur in Natural Gas

5. ASTM D 2420 - Test Method for Hydrogen Sulfide in Liquified Petroleum Gases

6. ASTM D 2513 - Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings

7. ASTM D 2517 - Specification for Reinforced Epoxy Resin Gas Pressure Pipe and Fittings

8. MSS SP 78 - Gray Iron Plug Valves, Flanged and Threaded Ends

9. ASTM D 1248 - Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable

10. ASTM D 3350 - Specification for Polyethylene Plastics Pipe and Fittings Materials

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.4 SUBMITTALS

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

1. Piping specialties.
2. Corrugated, stainless-steel tubing with associated components.
3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
4. Pressure regulators. Indicate pressure ratings and capacities.
5. Dielectric fittings.

B. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1. Shop Drawing Scale: 1/4 inch per foot.
2. Detail mounting, supports, and valve arrangements for pressure regulator assembly.

C. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.

D. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.

E. Qualification Data: For qualified professional engineer.

F. Welding certificates.

G. Field quality-control reports.

H. Operation and Maintenance Data: For pressure regulators to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

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

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. NFPA 54 - National Fuel Gas Code, for gas piping materials and components, gas piping installations and inspection, testing, and purging of gas piping systems.

E. AGA - American Gas Association.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

D. Protect stored PE pipes and valves from direct sunlight.

1.7 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:

1. Notify Construction Manager or Owner no fewer than two days in advance of proposed interruption of natural-gas service.
2. Do not proceed with interruption of natural-gas service without Construction Manager's or Owner's written permission.

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.

2. Service Regulators: 65 psig (450 kPa) minimum unless otherwise indicated.

2.2 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

    a. Material Group: 1.1.
    b. End Connections: Threaded or butt welding to match pipe.
    c. Lapped Face: Not permitted underground.
    d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
    e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.

5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

    a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

6. Mechanical Couplings:

    a. Stainless-steel flanges and tube with epoxy finish.
    b. Buna-nitrile seals.
    c. Stainless-steel bolts, washers, and nuts.
    d. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
    e. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

2.3 PIPING SPECIALTIES

A. Quick-Disconnect Devices: Comply with ANSI Z21.41.

1. Copper-alloy convenience outlet and matching plug connector.
2. Nitrile seals.
3. Hand operated with automatic shutoff when disconnected.
4. For indoor or outdoor applications.
5. Adjustable, retractable restraining cable.

B. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.

2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

C. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.4 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.5 MANUAL GAS SHUTOFF VALVES

A. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.

1. CWP Rating: 125 psig.
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
4. Tamperproof Feature: Locking feature.
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

B. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.

1. CWP Rating: 125 psig.
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
3. Tamperproof Feature: Locking feature.
4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

C. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

1. Body: Bronze, complying with ASTM B 584.
2. Ball: Chrome-plated bronze.
3. Stem: Bronze; blowout proof.
4. Seats: Reinforced TFE; blowout proof.
5. Packing: Threaded-body packnut design with adjustable-stem packing.
6. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. CWP Rating: 600 psig.
8. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

D. Bronze Plug Valves: MSS SP-78.

1. Body: Bronze, complying with ASTM B 584.
2. Plug: Bronze.
3. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
4. Operator: Square head or lug type with tamperproof feature where indicated.
5. Pressure Class: 125 psig.
6. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
7. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.

1. Body: Cast iron, complying with ASTM A 126, Class B.
2. Plug: Bronze or nickel-plated cast iron.
3. Seat: Coated with thermoplastic.
4. Stem Seal: Compatible with natural gas.
5. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
6. Operator: Square head or lug type with tamperproof feature where indicated.
7. Pressure Class: 125 psig.
8. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

F. Cast-Iron, Lubricated Plug Valves: MSS SP-78.

1. Body: Cast iron, complying with ASTM A 126, Class B.
2. Plug: Bronze or nickel-plated cast iron.
3. Seat: Coated with thermoplastic.
4. Stem Seal: Compatible with natural gas.
5. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
6. Operator: Square head or lug type with tamperproof feature where indicated.
7. Pressure Class: 125 psig.
8. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

G. Valve Boxes:

1. Cast-iron, two-section box.
2. Top section with cover with "GAS" lettering.
3. Bottom section with base to fit over valve and barrel a minimum of 5 inches in diameter.
4. Adjustable cast-iron extensions of length required for depth of bury.
5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

2.6 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Line Pressure Regulators: Comply with ANSI Z21.80.

1. Body and Diaphragm Case: Cast iron or die-cast aluminum.
2. Springs: Zinc-plated steel; interchangeable.
3. Diaphragm Plate: Zinc-plated steel.
4. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
5. Orifice: Aluminum; interchangeable.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
8. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
9. Overpressure Protection Device: Factory mounted on pressure regulator.
10. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
11. Maximum Inlet Pressure: 2 psig.

2.7 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Description:

a. Standard: ASSE 1079.
b. Pressure Rating: 125 psig minimum at 180 deg F.
c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Description:

a. Standard: ASSE 1079.
b. Factory-fabricated, bolted, companion-flange assembly.
c. Pressure Rating: 125 psig minimum at 180 deg F.
d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Description:

a. Nonconducting materials for field assembly of companion flanges.
b. Pressure Rating: 150 psig.
c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
e. Washers: Phenolic with steel backing washers.

2.8 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

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

3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to NFPA 54 and the International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with NFPA 54 and the International Fuel Gas Code requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

A. Comply with NFPA 54 and the International Fuel Gas Code for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 36 inches below finished grade.

1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.

C. Install underground, PE, natural-gas piping according to ASTM D 2774.

D. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
3. Replace pipe having damaged PE coating with new pipe.

E. Install fittings for changes in direction and branch connections.

3.4 INDOOR PIPING INSTALLATION

A. Comply with NFPA 54 and the International Fuel Gas Code for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

P. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.

1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.

    a. Exception: Tubing passing through partitions or walls does not require striker barriers.

5. Prohibited Locations:

    a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
    b. Do not install natural-gas piping in solid walls or partitions.

Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

R. Connect branch piping from top or side of horizontal piping.

S. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

T. Do not use natural-gas piping as grounding electrode.

U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

V. Install pressure gage upstream and downstream from each line regulator.

W. Install sleeves for piping penetrations of walls, ceilings, and floors.

X. Install sleeve seals for piping penetrations of concrete walls and slabs.

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.5 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install anode for metallic valves in underground PE piping.

3.6 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

G. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

3.7 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

3.8 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.9 PAINTING

A. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Alkyd System: MPI EXT 5.1D.

a. Prime Coat: Alkyd anticorrosive metal primer.
b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
c. Topcoat: Exterior alkyd enamel.
d. Color: as approved by Owner.

B. Paint exposed, interior metal piping, valves, regulators and piping specialties, except components, with factory-applied paint or protective coating.

1. Latex Over Alkyd Primer System: MPI INT 5.1Q.

a. Prime Coat: Alkyd anticorrosive metal primer.
b. Intermediate Coat: Interior latex matching topcoat.
c. Topcoat: Interior latex.
d. Color: as approved by Owner.

2. Alkyd System: MPI INT 5.1E.

    a. Prime Coat: Alkyd anticorrosive metal primer.
    b. Intermediate Coat: Interior alkyd matching topcoat.
    c. Topcoat: Interior alkyd.
    d. Color: as approved by Owner.

C. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Test, inspect, and purge natural gas according to the International Fuel Gas Code and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.11 OUTDOOR PIPING SCHEDULE

A. Aboveground natural-gas piping shall be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

3.12 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 5 PSIG

A. Aboveground piping NPS 2 and smaller shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground piping NPS 2-1/2 and larger shall be the following:

1. Steel pipe with wrought-steel fittings and welded joints.

3.13 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 and smaller shall be the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

B. Valves for pipe sizes NPS 2-1/2 and larger shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Cast-iron, nonlubricated plug valve.

END OF SECTION

SECTION 23 23 00

REFRIGERATION PIPING AND SPECIALTIES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Refrigeration piping and piping specialties used for air conditioning applications.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 23 09 00 - HVAC Controls
2. Section 40 05 03 - Mechanical Identification
3. Section 23 27 00 - Mechanical Insulation

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. ASHRAE 15 - Safety Standard for Refrigeration Systems

2. ASME Boiler and Pressure Vessel Code, SEC IX - Welding and Brazing Qualifications

3. ASME B31.5 - Refrigeration Piping and Heat Transfer Components

4. ASME B31.9 - Building Services Piping

5. AWS A5.8 - Brazing Filler Metal

6. AWS BRH - Brazing Handbook

7. AHRI 760 - Performance Rating of Solenoid Valves for Use with Volatile Refrigerants

1.3 ELECTRICAL REQUIREMENTS

A. Design the solenoid and regulating valves for use on a nominal 120 or 24 volts, 1 phase, 60 hertz electrical service.

1.4 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 1.

B. Product Data: Provide the manufacturer product data for each type of valve and for each type refrigerant piping specialty specified.

C. Shop Drawings: Submit shop drawings showing the layout of refrigerant piping, specialties, and fittings including, but not necessarily limited to, pipe and tube sizes, valve arrangements and locations, slopes of horizontal runs, wall and floor penetrations, and equipment connection details. Show the interface and spatial relationships between piping and proximate to equipment.

D. Brazer's Certification: Submit signed qualification certificates certifying that brazers comply with the requirements specified under "Quality Assurance".

E. Maintenance Data: Submit maintenance data for refrigerant valves and piping specialties, for inclusion in the Operating and Maintenance Manual specified in Division 1.

1.5 QUALITY ASSURANCE

A. Welding Materials and Procedures: Qualify brazing processes and brazing operators in accordance with ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications".

B. Regulatory Requirements: Conform work to ANSI/ASME B31.9 as applicable.

1.6 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, and store piping and specialties in shipping containers with labeling in place.

B. Protection: Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.

1.7 SEQUENCING AND SCHEDULING

A. General: Coordinate the installation of roof piping supports, and roof penetrations.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. General: List includes acceptable manufacturers. Other manufacturers of equivalent products may be submitted for approval.

1. Copper pipe and Fittings

a. Mueller Industries, Inc., Wichita, KS
b. Nibco, Elkhart, IN

2. Refrigerant Valves and Specialties:

a. Alco Controls, Div. of Emerson Electric
b. Danfoss
c. EATON Corporation, Controls Div.
d. Henry Technologies
e. Parker-Hannifin Corp., Refrigeration and Air Conditioning Div.
f. Sporlan Valve Co.

2.2 MATERIALS

A. Pipe and Tubing Materials: Provide Type K hard drawn copper tubing that meets ASTM B 88 requirements.

a. Fittings: Provide ASME B16.18, cast copper alloy or ASME B16.22 wrought copper and copper alloy fittings.

b. Joints: Brazed joints, AWS A5.8 BCUP silver/phosphorus/copper alloy with melting range 1190-1480 degrees F.

B. Valves: Provide complete valve assemblies, UL-listed, and designed to conform to ARI 760.

1. Globe: 450 psig maximum operating pressure, 275 degrees F maximum operating temperature; cast bronze body, with cast bronze or forged brass wing cap and bolted bonnet; replaceable resilient seat disc; plated steel stem. Provide valves capable of being repacked under pressure. Provide straight through or angle pattern valves, with solder-end connections.

2. Check Valves - Smaller Than 7/8 inch: 500 psig maximum operating pressure, 300 degrees F maximum operating temperature; cast brass body, with removable piston, Teflon seat, and stainless steel spring; straight

through globe design. Provide straight through pattern valves, with solder-end connections.

3. Check Valves - 7/8 inch and Larger: 450 psig maximum operating pressure, 300 degrees F maximum operating temperature; cast bronze body, with cast bronze or forged brass bolted bonnet; floating piston with mechanically retained Teflon seat disc. Provide straight through or angle pattern valves, with solder-end connections.

4. Solenoid Valves: 240 degrees F temperature rating, 500 psig working pressure; packless construction, forged brass, with Teflon valve seat and stainless steel core, two-way straight through pattern, and solder end connections. Provide manual operator to open valve. Furnish complete with NEMA 1 solenoid enclosure with 1/2-inch conduit adapter, and normally closed moisture resisting holding coil.

5. Evaporator Pressure Regulating Valves: Pilot-operated, forged brass or cast bronze; complete with pilot operator, stainless steel bottom spring, pressure gauge tappings, standard coil; and wrought copper fittings for solder end connections.

6. Thermal Expansion Valves: Straight through or angle design, with solder-end connections, thermostatic adjustable, modulating type; size as required for specific evaporator requirements, and factory set for proper evaporator superheat requirements. Provide packless type valves with a forged brass body and corrosion resistant brass and stainless steel trim, complete with sensing bulb, a distributor having a side connection for hot gas bypass line, external superheat adjustments, and an external equalizer line.

7. Hot Gas Bypass Valve: Adjustable type, sized to provide capacity reduction beyond the last step of compressor unloading; and wrought copper fittings for solder end connections.

C. Refrigeration Piping Specialties: Provide complete refrigeration piping specialty assemblies designed to conform to ARI 760, and UL-listed.

1. Strainers: 500 psig maximum working pressure; forged brass body with monel 80-mesh screen, and screwed cleanout plug; Y-pattern, with solder end connections.

2. Moisture/liquid Indicators: 500 psig maximum operation pressure, 200 degrees F maximum operating temperature; forged brass body, with replaceable polished optical viewing window, moisture sensing element which changes color when an unsafe moisture level exists in the system, and solder-end connections.

3. Filter-driers: 500 psig maximum operation pressure; steel shell, flange ring, and spring, gasketed ductile iron cover plate with steel capscrews, and wrought copper fittings for solder end connections. Furnish complete with replaceable filter-drier core kit, including gaskets, as follows:

   a. High capacity desiccant sieves to provide micronic filtration and extra drying capacity.

4. Suction Line Filter-Drier: 350 psig maximum operation pressure, 225 degrees F maximum operating temperature; steel shell, and wrought copper fittings for solder end connections. Permanent filter element with a molded felt core surrounded by a desiccant, for removal of acids and moisture for refrigerant vapor.

5. Suction Line Filters: 500 psig maximum operation pressure; "T" type corrosion resistant plated steel shell, flange ring, and spring, gasketed ductile iron cover plate with steel capscrews, and wrought copper fittings for solder end connections. Furnish complete with replaceable filter core kit, including gaskets, as follows:

   a. High capacity filter kit to provide micronic filtration.

6. Flanged Unions: 400 psig maximum working pressure, 330 degrees F maximum operating temperature; two brass tailpiece adapters for solder end connections to copper tubing; flanges for 7/8 inch through 1-5/8 inch unions of forged steel, and for 2-1/8 inch through 3-1/8 inch of ductile iron; four plated steel bolts, with silicon bronze nuts and fiber gasket. Have a factory-applied rust-resistant coating provided for flanges and bolts.

7. Flexible Connectors: 500 psig maximum operating pressure; seamless tin bronze or stainless steel core, high tensile bronze braid covering, solder connections, and synthetic covering; dehydrated, pressure tested, minimum 7 inch in length.

2.3 IDENTIFICATION

A. General: Provide piping, equipment and valve identification complying with Section 23 05 53.

PART 3 EXECUTION

3.1 EXAMINATION

A. General: Examine rough-in for refrigeration piping systems to verify actual locations of piping connections prior to installation.

3.2 INSTALLATION

A. Piping: Install refrigeration piping in accordance with ASHRAE Standard 15.

1. Install piping in as short and direct arrangement as possible to minimize pressure drop.

2. Install piping for minimum number of joints using as few elbows and other fitting as possible.

3. Arrange piping to allow normal inspection and servicing of compressor and other equipment.

4. Provide adequate clearance between pipe and adjacent walls and hanger, or between pipes for insulation installation. Use sleeves through floors, walls, or ceilings, sized to permit the installation of full thickness insulation.

5. Insulate suction lines. Liquid lines are not required to be insulated, except where they are installed adjacent and clamped to suction lines. Under these conditions insulate both liquid and suction lines as a unit. Do not install insulation until system testing has been completed and all leaks have been eliminated.

6. Install branch tie-in lines to parallel compressors with an equal length, and pipe identically and symmetrically.

7. Install copper tubing in rigid or flexible conduit in locations where copper tubing will be exposed to mechanical injury.

8. Slope refrigeration piping as follows:

a. Install horizontal hot gas discharge piping with 1/2-inch per 10 feet downward slope away from the compressor.

b. Install horizontal suction lines with 1/2 inch per 10 feet downward slope to the compressor, with no long traps or dead ends which may cause oil to separate from the suction gas and return to the compressor in damaging slugs.

c. Install traps and double risers where indicated, and where required to entrain oil in vertical runs.

d. Liquid lines may be installed level.

9. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

10. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1 inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

11. Make reductions in pipe sizes using eccentric reducer fittings installed with the level side down.

B. Valves and Specialties: Install valves and specialties in accessible locations to allow for servicing and inspection, and in accordance with the manufacturer's instructions.

1. Install globe valves on each side of strainers and driers, in liquid and suction lines at evaporators, and elsewhere as indicated.

2. Install a full sized, 3-valve bypass around each drier.

3. Install solenoid valves ahead of each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at the top.

   a. Electrical wiring for solenoid valves is specified in Section 26 05 19. Coordinate electrical requirements and connections.

4. Thermostatic expansion valves may be mounted in any position, as close as possible to the evaporator.

   a. Where refrigerant distributors are used, mount the distributor directly on the expansion valve outlet.

   b. Install the valve in such a location so that the diaphragm case is warmer than the bulb.

   c. Secure the bulb to a clean, straight, horizontal section of the suction line using two bulb straps. Do not mount the bulb in a trap or at the bottom of the line.

   d. Where external equalizer lines are required make the connection where it will clearly reflect the pressure existing in the suction line at the bulb location.

5. Install pressure regulating and relieving valves as required by ASHRAE Standard 15.

6. Install strainers immediately ahead of each expansion valve, solenoid valve, hot gas bypass valve, compressor suction valve, and as required to protect refrigerant piping system components.

7. Install moisture/liquid indicators in liquid lines between filter/driers and upstream of thermostatic expansion valves and in liquid line to receiver.

   a. Install moisture/liquid indicators in lines larger than 2-1/8 inch OD, using a bypass line.

8. Install filter/driers upstream of solenoid and expansion valves.

9. Install unions to allow for removal of solenoid valves, pressure regulating valves, expansion valves, and at connections to compressors and evaporators.

10. Install flexible connectors at the inlet and discharge connection of compressors and condensers.

C. Hangers and Supports: Hangers, supports, and anchors are specified in Section 23 05 29.

D. Pipe Joint Construction: Provide brazed joints complying with the procedures contained in the AWS "Brazing Manual."

1. WARNING: Some filler metals contain compounds which produce highly toxic fumes when heated. Avoid breathing fumes and provide adequate ventilation.

2. CAUTION: When solenoid valves are being installed, remove the coil to prevent damage. When sight glasses are being installed, remove the glass. Remove stems, seats, and packing of valves, and accessible internal parts of refrigerant specialties before brazing. Do no apply heat near the bulb of the expansion valve.

3. Fill the pipe and fittings during brazing, with an inert gas (ie., nitrogen or carbon dioxide) to prevent formation of scale.

4. Heat joints using oxy-acetylene torch. Heat to the proper and uniform brazing temperature.

E. Equipment Connections: The Drawings indicate the general arrangement of piping, fittings, and specialties. Install piping adjacent to machines to allow servicing and maintenance.

F. System Charging: Charge the system using the following procedure:

1. Install core in filter dryer after leak test but before evacuation.

2. Evacuate refrigerant system with vacuum pump, until a temperature of 35 degrees F is indicated on the vacuum dehydration indicator.

3. During evacuation, apply heat to pockets, elbows, and low spots in the piping.

4. Maintain a vacuum on the system for minimum of 5 hours after closing the valve between the vacuum pump and the system.

5. Break the vacuum with refrigerant gas, and allow the pressure to build up to 2 psi.

6. Complete charging of system, using a new filter dryer core in the charging line. Provide full operating charge.

3.3 FIELD QUALITY CONTROL

A. Inspection: Inspect, test, and perform corrective action of refrigerant piping in accordance with ASME Code B31.5, Chapter VI.

B. Repairs: Repair leaking joints using new materials, and retest for leaks.

C. Manufacturer's Field Service: Train the Owner's maintenance personnel on procedures and schedules related to start-up and shut-down, troubleshooting, servicing, and preventative maintenance of refrigeration piping valves and refrigeration piping specialties, as specified in Division 1.

3.4 ADJUSTING AND CLEANING

A. General: Verify actual evaporator applications and operating conditions, and adjust the thermostatic expansion valve to obtain proper evaporator superheat requirements.

B. Adjust Controls and Safeties: Replace damaged or malfunctioning controls and equipment with new materials and products.

C. Procedures: Before installation of copper tubing, clean the tubing and fittings using the following cleaning procedure:

1. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through the tubing by means of a wire or an electrician's tape.

2. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until the cloth is not discolored by dirt.

3. Draw a clean, lintless cloth, first saturated with compressor oil and then squeezed dry, through the tube or pipe to remove any remaining lint. Inspect the tube or pipe visually for remaining dirt and lint.

4. Finally, draw a clean, dry, lintless cloth through the tube or pipe.

END OF SECTION

SECTION 23 27 00

MECHANICAL INSULATION - HVAC

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Mechanical insulation for piping and ductwork.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 23 23 00 - Refrigeration Piping and Specialties
2. Section 23 31 00 - Ductwork
3. Section 23 05 53 - Mechanical Identification

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. ASTM C 195- - Mineral Fiber Thermal Insulation Cement
2. ASTM C 533 - Calcium Silicate Block and Pipe Thermal Insulation
3. ASTM C 552 - Cellular Glass Block and Pipe Thermal Insulation
4. ASTM C 553 - Mineral Fiber Blanket and Felt Insulation
5. ASTM C 547 - Mineral Fiber Pipe Insulation
6. ASTM C 612 - Mineral Fiber Block and Board Thermal Insulation
7. ASTM C 921 - Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
8. ASTM E 84 - Test Method for Surface Burning Characteristics of Building Materials
9. NFPA 255 - Surface Burning Characteristics of Building Materials
10. UL 723 - Surface Burning Characteristics of Building Materials

1.3 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 1.

B. Product Data: Submit the manufacturer's technical product data, insulation materials, fire ratings, material safety data sheets and installation instructions for each type of mechanical insulation. Submit a schedule showing the manufacturer's product number, k-value, thickness, density, and furnished accessories for each mechanical system requiring insulation.

C. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product data in the maintenance manual.

1.4 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide insulation from firms regularly engaged in manufacture of mechanical insulation products, of the types and sizes required, whose products have been in satisfactory use in similar services for not less than (3) years.

B. Installer's Qualifications: Use firm with at least (5) years successful installation experience on projects with mechanical insulations similar to that required for this project.

C. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.

1. Exception - Outdoor Mechanical Insulation: Flame spread index of 75 and a smoke developed index of 150.

1.5 DELIVERY, STORAGE, AND HANDLING

A. General: Deliver, store and handle all products and materials as specified in Division 1 and as follows.

B. Labeling: Deliver the insulation, coverings, cements, adhesives, and coatings to the site in containers with the manufacturer's stamp or label, affixed showing the fire hazard indexes of products.

C. Protection: Protect the insulation against dirt, water, and chemical and mechanical damage. Do not install damaged or wet insulation and remove damaged materials from the project site.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. General: Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted.

1. Armstrong World Industries, Inc.
2. Babcock and Wilcox; Insulating Products Div.
3. Certainteed Corp.
4. Knauf Fiber Glass GmbH.
5. Manville Products Corp.
6. Owens-Corning Fiberglas Corp.
7. Pittsburgh Corning Corp.
8. Rubatex Corp.
9. Raychem Corp. (Electric Heat Tracing)
10. Thermon Manufacturing Co. (Electric Heat Tracing)
11. Pipe Shields Inc. - "Thermal-Hanger Shields"
12. IMCOA (Refrigerant Piping)

2.2 MATERIALS

A. Refrigerant Pipe Insulation: Provide refrigerant pipe insulation of the waterproof closed cell type with a zero water vapor transmission rate, temperature range of -10 degree F to +200 degree F and which do not contain corrosive constituents associated with stress corrosion failure of copper tube. Provide insulation which has excellent resistance to chemicals, ozone and solvents. Provide seam joining to be moisture proof using non-toxic sealant.

1. Accessories: Provide the following accessories:

a. Provide staples, bands, wires and cement as recommended by the insulation manufacturer for the applications indicated.

b. Provide adhesives, sealers, and protective finishes as recommended by the insulation manufacturer for the applications indicated.

B. Ductwork Insulation: Provide rigid fiberglass ductwork insulation meeting ASTM C 612, Class 1, with "K" value of (0.24) at 75 degrees F, and (3) lb/cu.ft. minimum density.

C. Thermal Hanger Shields: Provide insulated pipe protectors consisting of a 360-degree high density, 100 psi, waterproofed calcium silicate inserts encased in 360-degree sheet metal shields. On cold water pipes provide protectors with insulation extended 1-inch beyond the sheet metal shield.

1. Provide the thickness of the insulation insert to be the same as the adjoining pipe insulation, and sheet metal gauge in accordance with the manufacturer's recommendations.

PART 3 EXECUTION

3.1 INSPECTION

A. General: Examine areas and conditions under which mechanical insulation is to be installed. Do not proceed with Work until unsatisfactory conditions have been corrected in manner acceptable for insulation installation.

3.2 HVAC PIPING SYSTEM INSULATION

A. Sub-Freezing Piping (0 to 39 degrees F) Application Requirements: Insulate the following sub-freezing HVAC piping systems:

1. Refrigerant liquid and suction lines between evaporators and compressors.

2. Insulate each piping system specified above with the following type and thicknesses of insulation:

a. Closed Cell: 1-inch thick for pipe sizes up to and including 1-inch, 1-1/2 inch thick for pipe sizes over 1-inch.

B. Cold Piping (40 degrees F to ambient) Application Requirements: Insulate the following cold HVAC piping systems:

1. Air conditioner condensate drain piping.

2. Insulate each piping system specified above with the following type and thicknesses of insulation:

a. Fiberglass: 1-inch thick for pipe sizes up to and including 4 inches, 1-1/2-inch thick for pipe sizes over 4 inches.

C. Hot Low Pressure Piping (to 250 degrees F) Application Requirements: Insulate the following hot low pressure HVAC piping systems up to 250 degrees F.

1. Hot gas refrigerant piping.

2. Insulate each piping system specified above with the following type and thicknesses of insulation:

a. Fiberglass: 1-inch thick for pipe sizes up to and including 1-inch, 1-1/2-inch thick for pipe sizes 1-1/4-inch through 2 inches, 2-inch thick for pipe over 2-1/2 inches, 2-1/2-inch thick for steam pipes 4 inches and larger.

D. Insulation of Piping Exposed to Weather: Protect outdoor insulation from weather by installing an aluminum or stainless steel jacket. Place jacket to shed water from the insulation.

E. Thermal Hanger Shields: Provide insulated pipe protectors at all support points.

3.3 DUCTWORK SYSTEM INSULATION

A. Cold Ductwork (Below Ambient Temperature) Application Requirements: Insulate the following ductwork:

1. HVAC supply ductwork between fan discharge, or HVAC unit discharge, and room terminal outlet.

2. HVAC return ductwork between room terminal inlet and return fan inlet, or HVAC unit inlet, except omit insulation on return ductwork located in conditioned spaces.

3. HVAC plenums and unit housings not pre-insulated at the factory or lined.

4. Insulate each ductwork system specified above with one of the following types and thicknesses of insulation:

a. Rigid Fiberglass: 1-1/2-inch thick, increase thickness to 2 inches in machine, fan and equipment rooms.

B. Jackets for Ductwork Insulation: Jacket ductwork insulation.

3.4 INSTALLATION

A. General: Install piping and ductwork thermal insulation products in accordance with the manufacturer's recommendations and approved shop drawings, and as specified in Division 1. Install all products in accordance with the recognized industry practices so that insulation serves its intended purpose.

B. Piping Insulation

1. Order of Installation: Install insulation on pipe systems subsequent to testing, and acceptance tests.

2. Insulation Surfaces: Install the insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete the run. Do not use cut pieces or scraps abutting each other.

3. Cleaning and Drying: Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to form a complete and tight fit over the surfaces to be covered.

4. Integrity: Maintain integrity of the vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.

5. Insulating Fittings: Cover valves, fittings and similar items in each piping system with an equivalent thickness and composition of insulation as applied to the adjoining pipe run. Install factory molded, precut or job fabricated units except where a specific form or type is indicated.

6. Penetrations: Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.

7. Pipe Hangers: Butt pipe insulation against pipe hanger insulation inserts. For hot pipes, apply a 3 inch wide vapor barrier tape or band over the butt joints. For cold piping apply a wet coat of the vapor barrier lap cement on butt joints and seal the joints with a 3 inch wide vapor barrier tape or band.

8. Pipe exposed to weather: Provide water tight aluminum (stainless steel) jackets to protect piping located outside.

C. Ductwork Insulation

1. Insulation Surfaces: Install the insulation materials with smooth and even surfaces.

2. Cleaning and Drying: Clean and dry ductwork prior to insulating. Butt insulation joints firmly together to form a complete and tight fit over the surfaces to be covered.

3. Integrity: Maintain the integrity of the vapor-barrier on ductwork insulation, and protect it to prevent puncture and other damage.

4. Penetrations: Extend ductwork insulation without interruption through walls, floors and similar ductwork penetrations, except where otherwise indicated.

5. Corner Angles: Except for oven and hood exhaust duct insulation, install corner angles on external corners of insulation on ductwork in exposed finished spaces before covering with the jacketing.

3.5 PROTECTION AND REPLACEMENT

A. Replacement: Replace damaged insulation which cannot be satisfactorily repaired, including units with vapor barrier damage and moisture saturated units.

B. Protection: Follow methods which are required for protection of the insulation Work during the remainder of construction period, to avoid damage and deterioration.

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 23 31 00

DUCTWORK

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Ductwork materials, construction, hangers and supports, duct lining, and cleaning.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 23 05 93 - Testing, Adjusting and Balancing
2. Section 23 33 00 - Ductwork Accessories
3. Section 23 05 48 - Vibration Isolation
4. Section 23 05 03 - Mechanical Identification
5. Section 23 27 00 - Mechanical Insulation

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1.	ASHRAE	-	ASHRAE Handbook - Fundamentals; Duct Design
2.	ASHRAE	-	ASHRAE Handbook - HVAC Systems and Equipment; Duct Construction
3.	ASTM A 36/A36M-		Specification for Structural Work
4.	ASTM A 90/A90M-		Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles
5.	ASTM A 167	-	Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
6.	ASTM A 653	-	Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

7.	ASTM A 700	-	Practices for Packaging, Marking and Loading Methods for Steel Products for Domestic Shipment
8.	ASTM B 209	-	Aluminum and Aluminum Alloy Sheet and Plate
9.	ASTM C 411	-	Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation
10.	ASTM C 581	-	Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass Fiber-Reinforced Structures, Intended for Liquid Service
11.	ASTM C 916	-	Specification for Adhesives for Duct Thermal Insulation
12.	ASTM C 920	-	Specification for Elastomeric Joint Sealants
13.	ASTM C 1071	-	Specification for Thermal and Acoustical Insulation
14.	ASTM D 638	-	Test Method for Tensile Properties of Plastics
15.	ASTM D 790	-	Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
16.	ASTM D 2563	-	Recommended Practice for Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts
17.	ASTM D 2996	-	Specification for Filament-Wound Fiberglass
18.	ASTM D 4024	-	Specification for Reinforced Thermosetting Resin Flanges
19.	ASTM E 84	-	Test Method for Surface Burning Characteristics of Building Materials
20.	AWS D1.1	-	Structural Welding Code - Steel
21.	AWS D9.1	-	Sheet Metal Welding Code
22.	BOCA Section M-309-		Hazardous Exhaust Systems

23.	NFPA 90A	-	Installation of Air Conditioning and Ventilating Systems
24.	NFPA 90B	-	Installation of Warm Air Heating and Air Conditioning Systems
25.	NFPA 255/ ASTM E 84	-	Test Method for Surface Burning Characteristics of Building Materials
26.	SMACNA	-	HVAC Duct Construction Standards
27.	SMACNA	-	Fibrous Glass Duct Construction Standards
28.	SMACNA	-	Fire Damper Guide
29.	UL 181-Factory	-	Made Air Ducts and Connectors

1.3 DEFINITIONS

A. Sealing Requirements Definitions: The following definitions apply for duct system sealing requirements:

1. Seams: Joining of two longitudinally (in the direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on the duct perimeter are deemed to be joints.

2. Joints: Joints include girth joints; branch and subbranch intersections; so-called duct collar tap-ins; fitting subsections; louver and air terminal connections to ducts; access door and access panel frames and jambs; duct, plenum, and casing abutments to building structures.

1.4 SYSTEM DESCRIPTION

A. Design Requirements: The duct system design, as indicated, has been used to select and size air moving and distribution equipment and other components of the air system. Changes or alterations to the layout or configuration of the duct system must be specifically approved in writing. Accompany requests for layout modifications with calculations showing that the proposed layout will provide the original design results without increasing the system total pressure.

1.5 SUBMITTALS

A. General: Provide all submittals, including the following as specified in Division 1.

B. Shop Drawings: Submit scaled shop drawings indicating duct systems routing, sizes, fitting details, reinforcing, support, required clearances, and installed accessories and devices.

C. Installation Data: Submit manufacturer's installation instructions for glass fiber ducts. Submit manufacturer's certificate that installation of glass fiber ducts meets or exceeds recommended fabrication and installation requirements.

1.6 QUALITY ASSURANCE

A. General: Provide materials from a company specializing in the design and manufacture of ductwork and duct fittings having a minimum of (5) years (documented) experience, which issues complete catalog data on these products.

B. Codes: Qualify welding processes and welding operators in accordance with AWS D1.1 for hangers and supports and AWS D9.1 Certify that each welder qualification is current.

1.7 DELIVERY, STORAGE, AND HANDLING

A. General: Deliver, store, and handle all products and materials as specified in Division 1 and as follows:

B. Delivery: Deliver sealant and fire-stopping materials to site in original unopened containers or bundles with labels informing about manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multicomponent materials. Deliver stainless steel sheets with mill-applied adhesive protective paper, maintained through fabrication and installation.

C. Storage and Protection: Store and handle sealant fire-stopping materials in compliance with manufacturers' recommendations to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes. Protect the PVC ductwork from abrasion by separating surfaces with a soft protective separator, such as insulation, cardboard or similar material. Store ductwork and duct fittings in a clean dry place and protect from physical damage.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted.

1. Gasket for flanged connections for sheet metal ductwork

a. Ductmate Industries 440 Butyl Gasket

2.2 DUCTWORK

A. General: Provide ductwork and plenums conforming to the more stringent recommendations of the current editions of the ASHRAE Handbook and of the SMACNA "HVAC Duct Construction Standards".

B. Steel Ductwork: Provide galvanized steel ductwork as follows:

1. Galvanized sheet steel of lock-forming quality, ASTM A 653, coating designation G 90 with mill-phosphatized finish for exposed surfaces of ducts exposed to view.

C. Construction Material: Unless otherwise specified, provide duct reinforcing and duct accessories constructed of the same materials as the duct, if commercially available. Otherwise, provide such reinforcing and duct specialties fabricated of Type 316L stainless steel. Provide extruded aluminum grilles, registers, and diffusers on corrosion-resistant duct systems as specified with Type 316L stainless steel ductwork. Where dissimilar metals join, isolate metals electrolytically to prevent corrosion.

D. Reinforcing: Reinforce ductwork to prevent sagging, flexing and drumming, and build ductwork to be airtight at the fan static pressures scheduled.

E. Dimensions: The dimensions of the ducts shown are not to be considered absolute; however, any changes from dimensions indicated are subject to approval. Where it is necessary to change dimensions of ducts, do not exceed equivalent friction loss.

1. Duct sizes noted are the clear dimensions inside the duct liner for lined ducts, or the actual inside dimensions for unlined ducts.

F. Pressure Loss: Provide duct curves, bends, offsets, transitions and transformation pieces to be gradual, to minimize air turbulence. In general, design duct transformations changing air velocity for minimum loss in total pressure.

1. Refer to equipment schedules for duct system pressure and seal classifications.

2.3 SHEET METAL DUCTWORK

A. Construction: Construct sheet metal ducts in accordance with requirements recommended by SMACNA and ASHRAE.

1. Provide materials that are free from visual imperfections, such as pitting, seam marks, roller marks, stains, and discolorations.

2. Crossbreak or bead duct sides that are 19 inches and larger and are 20 gauge or less, with more than 10 square feet of unbraced panel area unless they are lined or are externally insulated. In addition, crossbreak on both diagonals duct section surfaces exceeding 4 square feet unless the duct perimeter is beaded at 18-inch or closer spacing.

3. Fabricate and brace ducts to be quiet in operation.

B. Curved Rectangular Elbows: Fabricate curved rectangular elbows with the centerline radius of at least 1-1/2 times the duct dimension parallel to the radius. Where space limitations require elbows with a smaller radius ratio, fabricate the elbows with sufficient full radius turning vanes to result in a pressure loss not greater than that for the elbow specified above.

C. Mitered Rectangular Elbows: Equip mitered rectangular elbows with turning vanes.

D. Round Elbows: Fabricate round elbows with the centerline radius of at least 1-1/2 times the duct dimension parallel to the radius. Where space limitations require elbows with a smaller radius ratio, fabricate the elbows with sufficient full radius turning vanes to result in a pressure loss not greater than that for the elbow specified above. Fabricate round cross-section elbows of minimum 5-piece construction.

E. Joints and Seams: Fabricate sheet metal rectangular joints and seams meeting the following requirements:

1. Submit certified test results, material safety data sheets, and applicable spec sheets for proprietary transverse duct connectors with shop drawings.

2. Conform certified test results to the entire sheet and joint deflection criteria defined by SMACNA, in Section VII, of the SMACNA HVAC Air Duct Leakage Test Manual.

3. The nonproprietary TDC/TDF connectors may be used, constructed as the nonproprietary SMACNA T-24 Flange, whose duct construction limits are defined on page 1-25 of the SMACNA HVAC Air Duct Leakage Test Manual. No other duct construction methods concerning TDC/TDF will be accepted.

4. Fabricate longitudinal seams with the Pittsburgh lock seam on all ductwork.

F. Sealing Materials: Provide sealing materials as follows:

1. Joint and Seam Sealants, General: The term sealant used here is not limited to materials of adhesive or mastic nature, but also includes tapes and combinations of open weave fabric strips and mastics.

2. Joint and Seam Sealant: Provide one-part, nonsag, solvent-release-curing, polymerized butyl sealant complying with FS TT-S-001657, Type I; formulated with a minimum of 75 percent solids.

3. Flanged Joint Mastics: Provide one-part, acid-curing, silicone elastomeric joint sealants, complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

4. Flanged Connections: Provide approved gasket between all SMACNA T-24, TDC/TDF flanged connections on metal ducts.

G. Hangers and Supports: Provide duct hangers and supports meeting the following requirements.

1. Building Attachments: Fasten duct hangers and supports to concrete surfaces with steel threaded expansion type concrete anchors when cast-in-place concrete inserts are not installed. Do not cut reinforcing steel. Do not use powder actuated concrete fasteners.

2. Hangers: Securely support horizontal ducts from the building structure by means of hanger rods or angle supports not more than 8 feet apart. Provide the hanger rods sized for the weight carried, threaded at both ends, and equipped with nuts and washers. Provide angles as duct bottom supports. When angle hangers are used, extend the hangers from flanged duct connections, extended stiffeners, or fabricated trapezes.

3. Duct Attachments: Provide sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

4. Trapeze and Riser Supports: Provide steel shapes conforming to ASTM A 36/A36M as follows:

a. Where galvanized steel ducts are installed, provide hot-dipped galvanized steel shapes and plates.

2.4 IDENTIFICATION

A. General: Provide identification for ductwork systems as specified in Section 23 05 03.

PART 3 EXECUTION

3.1 APPLICATION

A. General: Except as otherwise indicated construct all ductwork as specified of galvanized steel in accordance with SMACNA standards.

3.2 DUCT INSTALLATION, GENERAL

A. Duct System Pressure Class: Construct and install each duct system for the specific duct pressure classification as required.

B. Joints: Install ducts with the fewest possible joints.

C. Fittings: Use fabricated fittings for all changes in directions, changes in size and shape, and connections.

D. Duct Openings: Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

E. Duct Location: Locate ducts, except as otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building. Install duct systems in shortest route that does not obstruct useable space or block access for servicing building and its equipment.

F. Construction Penetrations: Determine the exact location and size of floor opening required for ductwork. Core drill all penetrations through existing floors, walls or ceilings. Chipping is not allowed in lieu of core drilling. Obtain written approval prior to making any new penetrations through existing floors, walls or ceilings. Drill pilot holes before core drilling to locate any interference with existing conduits, equipment, etc. Neatly patch and seal opening after installation of new equipment to match existing walls, floors, ceilings, etc.

G. Clearances: Where insulated or uninsulated ducts pass through walls, floors, or partitions, provide the opening in the construction not exceeding 1-inch clearance

on all sides. Where ducts pass through walls, floors, or partitions required to have a fire-resistance rating and fire dampers are not required, provide the opening in the construction not exceeding 1-inch clearance on all sides, filled solidly with an approved material capable of preventing the passage of flame and hot gases sufficient to ignite cotton waste when subject to the same NFPA 251 time-temperature fire conditions required for fire barrier penetration. Where fire dampers are installed, maintain proper clearance for expansions.

H. Flexible Connections: Support at free end within 12 inches of flexible connection all ducts at flexible connections with air-handling equipment and fans.

I. Shafts and Enclosures: Conceal ducts from view in finished and occupied spaces by locating in mechanical shafts, hollow wall construction, or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as specifically shown.

J. Layout: Coordinate layout with suspended ceiling and lighting layouts and similar finished Work.

K. Electrical Equipment Spaces: Route ductwork to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

L. Nonfire-Rated Partition Penetrations: Where ducts pass interior partitions and exterior walls, and are exposed to view, conceal the space between construction opening and duct or duct insulation with sheet metal flanges of same gauge as duct. Overlap openings on four sides by at least 1-1/2 inches.

M. Seal: Seal externally insulated ducts prior to insulation installation.

N. Concrete Insert: Install concrete inserts prior to placing concrete.

O. Plenum Access Doors: Set plenum access doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.

P. Blank Off Panels: Blanked off unused portions of louvers with insulated panels provided under Section 08 91 00.

Q. Flexible Duct: Provide flexible duct connectors at final connection to air handling troffers, T-bar diffusers and where shown.

R. Temporary Closures: During construction, provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

S. Hanging and Supporting: Support ductwork as follows:

1. Make provisions for supporting all ductwork, dampers, and other ductwork accessories, where necessary.

2. Construct, reinforce, support and brace ductwork to prevent buckling, warping, sagging, flexing and vibrating and be quiet in operation under all operating conditions and airtight at the fan static pressures scheduled.

3. Securely support horizontal ducts from the building structure by means of hanger rods or angle supports not more than 8 feet apart. Size hanger rods for the weight carried, thread at both ends, and equip with nuts and washers.

4. Support horizontal ducts within 2 feet of each elbow and within 4 feet of each branch intersection.

5. Support and fasten horizontal ducts on the roof of the building to roof equipment mounting supports.

6. Support vertical ducts at a maximum interval of 16 feet and at each floor.

3.3 CLEANING

A. General: Perform cleaning Work in accordance with the following:

1. Keep each duct system internally clean by installing only clean materials and by providing temporary closures during the installation.

2. Remove all loose materials and obstructions from interior of ducts.

3. Clean duct system and force air at high velocity through duct to remove accumulated dust. To obtain sufficient air, clean half the system at a time. Protect equipment which may be harmed by excessive dirt with temporary filters, or bypass during cleaning.

4. Clean large duct systems with high power vacuum machines. Protect equipment which may be harmed by excessive dirt with filters, or bypass during cleaning. Provide adequate access into ductwork for cleaning purposes.

END OF SECTION

SECTION 23 33 00

DUCTWORK ACCESSORIES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Ductwork accessories such as turning vanes, volume dampers, splitter dampers, air extractors, duct hardware, access doors, instrument test holes, gravity backdraft dampers, fire dampers and airflow measuring stations.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 23 05 93 - Testing, Adjusting and Balancing
2. Section 23 31 00 - Ductwork
3. Section 23 27 00 - Mechanical Insulation

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. SMACNA - HVAC Duct Construction Standards, Metal and Flexible.
2. ASHRAE - Handbook - Systems and Equipment; Recommendations pertaining to construction of ductwork accessories.
3. UL 555 - Fire Dampers and Ceiling Dampers.
4. UL 33 - Heat Responsive Links for Fire Protection Services.
5. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.

1.3 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 1.

B. Product Data: Submit catalog product data indicating dimensions, assembly, materials and finishes, and operation and performance data.

C. Shop Drawings: Submit shop drawings for shop fabricated assemblies. Provide product data for the hardware used.

D. Operation and Maintenance Data: Submit the manufacturer's installation, maintenance, and repair data as specified in Division 1 including a parts lists for each type of duct accessory. Include this data, product data, and shop drawings in the operation and maintenance manual.

1.4 QUALITY ASSURANCE

A. Provide equipment from manufacturers regularly engaged in the design and manufacture of ductwork accessories, of the types and sizes required, which have a minimum of (3) years experience and which issue complete catalog data on these products.

1.5 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store and handle all products and materials as specified in Division 1 and as follows:

B. Storage and Protection: Store products in a clean, dry place and protect from physical damage in their original shipping packings, with labeling in place until the time of installation.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted.

1. Turning Vanes.

   a. Aero Dyne Co.
   b. Tuttle and Bailey

2. Volume Dampers

   a. Ruskin
   b. Young Regulator Co.

3. Duct Hardware

   a. Ventfabrics Inc.
   b. Young Regulator Co.

4. Access Doors

   a. Air Balance Inc.
   b. Ruskin Mfg. Co.
   c. Ventfabrics Inc.

5. Instrument Test Holes

   a. Ventfabrics Inc.
   b. Young Regulator Co.

2.2 MATERIALS

A. General: Provide ductwork accessories of the same materials as the duct, if commercially available. Otherwise fabricate such ductwork accessories of Type 316L stainless steel, protected inside and outside with a factory applied 4-6 mil heresite, or equal, air dried phenolic coating. Construct duct accessories in accordance with SMACNA "HVAC Duct Construction Standards."

B. Turning Vanes: Provide turning vanes as follows:

   1. Manufactured Turning Vanes: Factory fabricate turning vanes of a streamlined design, with single thickness vanes not more than 1-1/2 inch apart for ducts 24 inches and smaller and with double thickness vanes spaced 3-1/4 inches apart for ducts larger than 24 inches.

C. Volume Dampers: Provide volume dampers complete with brass bushings, steel rods, brackets, locking quadrant controls, and of closed end type designed for use on high pressure ducts. Provide multiple opposed blade type volume dampers if the duct dimension perpendicular to the damper shaft exceeds 10 inches.

D. Duct Hardware: Provide duct hardware, manufactured by one manufacturer for all items on project, for the following:

   1. Quadrant Locks: Provide for each damper, a quadrant lock device on one end of the shaft; and an end bearing plate on the other end for damper lengths over 12 inches. Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.

E. Access Doors: Provide duct and plenum access doors of the size indicated, where indicated and where necessary to service or replace equipment. Construct doors of the same or greater gauge as the ductwork or plenums served. Provide insulated doors for insulated ductwork and plenums. Provide insulated doors as double wall type insulated with 1-inch 6-pound density glass fiber, with suitable reinforced

edges, closing into structurally framed openings with 1/2-inch neoprene-lined channels. Provide door panels with double diagonally cross breaks, hinged with two or more butt hinges and secured with two or more compression latches. Provide plenum doors with latch handles on both the inside and outside. Provide flush frames for uninsulated ductwork, and extended frames for externally insulated duct. Provide one side hinged and the other side with one handle-type latch for doors 12 inches high and smaller or 2 handle-type latches for larger doors.

F. Test Holes: Provide instrument test holes in the ducts and plenums at appropriate locations for insertion of 3/4-inch pitot tubes and similar air measuring instruments. Equip the openings with removable, tight fitting caps or covers.

PART 3 EXECUTION

3.1 EXAMINATION

A. General: Examine areas and conditions under which ductwork accessories will be installed. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General: Install ductwork accessories in accordance with the manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA standards, and in accordance with recognized industry practices to ensure that products serve intended function. Make all necessary adjustments to provide a complete and satisfactory operation upon completion of the installation.

B. Turning Vanes: Install turning vanes in square or rectangular 90 degree elbows in supply, return and exhaust air systems, and elsewhere as indicated.

C. Volume Dampers: Install volume dampers in main ducts and branch ducts and at all return and exhaust air branch duct take off connections and all other locations where shown.

D. Duct Hardware: Install locking quadrant controls for each volume damper. Provide remote flexible drives for dampers located above plastered ceilings or where manual damper operators are inaccessible.

E. Access Doors: Install access doors to open against system air pressure, with latches operable from either side, except outside only where the duct is to small for a person to enter. Provide access doors, amply sized to suit their function, in ducts and plenums, for inspection and cleaning, before and after filters, coils, fans,

automatic dampers, fire dampers, and where indicated and necessary to service or required to replace equipment.

F. Instrument Test Holes: Provide instrument test holes in ducts and plenums where required for testing and balancing purposes.

G. Coordination: Coordinate as necessary to interface installation of ductwork accessories properly.

3.3 FIELD QUALITY CONTROL

A. Tests: Operate installed ductwork accessories to demonstrate their compliance with the specified requirements. Test for air leakage while the system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leakproof performance.

3.4 ADJUSTING AND CLEANING

A. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.

1. Label access doors in accordance with Section 23 05 03.

2. Final positioning of manual dampers is specified in Section 23 05 93.

B. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with the manufacturer's touch-up paint.

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 23 81 26

SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Split-system air conditioning units.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment
2. Section 23 05 48 -Vibration Isolation - HVAC
3. Section 23 05 93 - Testing Adjusting and Balancing
4. Section 23 09 00 - HVAC Controls
5. Section 23 21 00 - Hydronic Piping Valves and Specialties
6. Section 23 23 00 -Refrigeration Piping and Specialties
7. Section 23 31 00 - Ductwork
8. Section 23 82 16 - Air Coils
9. Section 26 05 60 -Electrical Requirements for Shop-Assembled Equipment
10. Section 26 05 80 - Electric Motors
11. Section 40 05 17 - Steel Pipe and Fittings
12. Section 40 05 20 - Valves

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. ASHRAE 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

2. ASHRAE 62.1 - Ventilation and Acceptable Indoor Air Quality

3. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems

1.3 SUBMITTALS:

A. General: Provide all submittals, including the following, as specified in Division 1.

B. Product Data: Submit the manufacturer's technical product data, including rated capacities of the selected model clearly indicated, weights of units, furnished specialties and accessories, and installation and start-up instructions.

C. Shop Drawings: Submit the manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

D. Service Connections: Indicate water, drain, electrical, and refrigeration rough-in connections on shop drawings and product data.

E. Wiring Diagrams: Submit the manufacturer's electrical requirements for power supply wiring to packaged air conditioning units, and air purifier units. Submit the manufacturer's ladder-type wiring diagrams for interlock and control wiring required for final installation of packaged air conditioning units and controls. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

F. Maintenance Data: Submit maintenance data and a parts list for each packaged air conditioning unit, air purifier unit, control, and accessory; including "trouble-shooting" maintenance guide. Include this data and product data in an operation and maintenance manual as specified in Division 1.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements: Conform to ANSI/NFPA 90A for the installation of packaged air conditioning units.

B. Manufacturer: Provide equipment from a Company specializing in the manufacture of the products specified in this section with a minimum of 3 years documented) experience.

1.5 DELIVERY, STORAGE, AND HANDLING

A. General: Deliver, store and handle all products and materials as specified in Division 1 and as follows:

B. Handling: Handle packaged air conditioning units, air purifier units and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged packaged air conditioning units, air purifier units or components. Replace damaged units with new units.

C. Storage and Protection: Store packaged air conditioning units, air purifier units and components in a clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

D. Unloading: Comply with the manufacturer's rigging and installation instructions for unloading packaged air conditioning units, air purifier units, and moving units to final location for installation.

1.6 SPARE PARTS

A. Furnish the following spare parts.

1. One complete set of filters for each indoor air conditioning unit

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted.

1. Split-System Air Conditioning Units

a. Trane
b. Carrier
c. Daikin
d. Or Equal

2.2 INDOOR UNITS

A. Concealed Evaporator-Fan Components:
1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
2. Insulation: Faced, glass-fiber duct liner.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
4. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
5. Fan Motors:
a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 26 05 80 "Electric Motors."
b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
c. Three-phase, permanently lubricated, ball-bearing motors with built-in thermal-overload protection.
d. Wiring Terminations: Connect motor to chassis wiring with plug connection.

6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
7. Filters: 1 inch thick, in fiberboard frames.
8. Condensate Drain Pans:
    a. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
        (1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
        (2) Depth: A minimum of 2 inches.
    b. Single-wall, galvanized-steel sheet.
    c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
        (1) Minimum Connection Size: NPS 1.
    d. Pan-Top Surface Coating: Asphaltic waterproofing compound.
    e. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

2.3 OUTDOOR UNITS

A. Air-Cooled, Compressor-Condenser Components:
1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
    a. Compressor Type: Scroll.
    b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
    c. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.
3. Fan: Aluminum-propeller type, directly connected to motor.
4. Motor: Permanently lubricated, with integral thermal-overload protection.
5. Mounting Base: Polyethylene.

2.4 ACCESSORIES

A. Control equipment and sequence of operation are specified in Section 23 09 00 "HVAC Controls."
B. Thermostat: Low voltage with subbase to control compressor and evaporator fan.
C. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:
1. Compressor time delay.
2. 24-hour time control of system stop and start.

3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
4. Fan-speed selection including auto setting.

D. Automatic-reset timer to prevent rapid cycling of compressor.

E. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

F. Drain Hose: For condensate.

G. Monitoring:
1. Monitor constant and variable motor loads.
2. Monitor cooling load.
3. Monitor air distribution static pressure and ventilation air volumes.4

2.5 CAPACITIES AND CHARACTERISTICS

A. Refer to schedules.

PART 3 EXECUTION

3.1 INSPECTION

A. General: Examine areas and conditions under which packaged air conditioning units and air purifier units are to be installed. Do not proceed with installation work until unsatisfactory conditions have been corrected in an acceptable manner.

B. Field Verification: Verify that the roof, structural support and the ceiling system is ready to receive Work and opening dimensions are as indicated on shop drawings.

C. Service Connections: Examine rough-in for hydronic, refrigeration, and condensate drainage piping, and electrical conduits, to verify the proper locations of connections prior to installation.

3.2 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install roof-mounted, compressor-condenser components on equipment supports per manufacturer’s requirements and instructions. Anchor units to supports with removable, cadmium-plated fasteners.

D. Equipment Mounting:
1. Comply with requirements for vibration isolation and seismic control devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC."

E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.
C. Duct Connections: Duct installation requirements are specified in Section 23 31 00 "Ductwork." Drawings indicate the general arrangement of ducts. Connect supply and return ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Section 23 33 00 "Air Duct Accessories."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
B. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
C. Tests and Inspections:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
D. Remove and replace malfunctioning units and retest as specified above.
E. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.

3.6 DEMONSTRATION

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

END OF SECTION

SECTION 26 05 00

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: General requirements for providing basic electrical materials and methods.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Certain equipment, control devices, conduit and wiring are shown on electrical drawings, but are specified in other sections pertaining to plumbing, heating, ventilating, air conditioning, temperature control systems, process equipment, process control systems and instrumentation. Install and connect these items to the electrical system as indicated or required in accordance with the Contract Documents.

C. Overall Application of Specifications: This Section applies to all Division 26 sections and to other sections that include requirements for electrical equipment. Irrespective of where the electrical requirements are specified, provide and install all materials necessary for a complete operational system.

D. Temporary Requirements: This Section applies to any temporary circuits, overcurrent devices, conduit, wiring, and other equipment required during changeover from the existing electrical system to a new electrical system. This Section also applies to temporary rewiring of lighting circuits, power circuits, instruments and devices.

1.2 DEFINITIONS

A. Hazardous Areas: Hazardous areas as defined by the NEC as Class I, Division 1, Group D, or Class I, Division 2, Group D. The following areas are designated hazardous:

1. N/A

1.3 SYSTEM DESCRIPTION

A. Design Requirements: Design requirements are specified in the applicable sections.

B. Performance Requirements: Performance requirements are specified in the applicable sections.

1.4 SUBMITTALS

A. General: Furnish all submittals, including the following, as specified in Division 01.

B. Product Data and Information: Furnish a complete list of electrical equipment and materials to be furnished that shows the manufacturer, catalog number, size, type, capacity, voltage rating and other pertinent information related to each item on the list.

1. Furnish catalog data for the manufacturer's standard equipment and materials. Clearly identify the equipment and devices specifically being proposed on manufacturers' catalog data sheets.

2. Identification: Furnish a complete schedule or listing of system and equipment identification labels with legends.

C. CONTRACTOR's Shop Drawings: Furnish shop drawings on items manufactured for the Contract.

1. Furnish connection and schematic diagrams for each piece of electrical equipment where applicable. A manufacturer's standard connection or schematic diagram showing more than one method of wiring is not acceptable unless, the intended method is clearly marked.

2. Furnish diagrams that show connections to field equipment. Clearly differentiate between manufacturer's and field wiring.

3. Furnish raceway layout drawings that show conduits, boxes, and panels which contain the conductors to be provided. Include schedules listing conduit sizes, conductor content and identification.

4. Where additions and modifications are made to existing equipment, furnish drawings which clearly identify remaining existing equipment and the new Work.

D. Coordination Drawings: Furnish coordination drawings that have a scale of 1/4"=1'-0" or larger; that show major elements, components, and systems of electrical equipment as they relate to other systems, installations, and building components. Indicate locations where access space is limited and where sequencing and coordination of installations are required for the efficient flow of the Work, including (but not limited to) the following:

1. Indicate the proposed locations of major raceway systems, equipment and materials. Include the following:

    a. Clearances for servicing equipment, including space for equipment disassembly as required for periodic maintenance.

    b. Exterior wall and foundation penetrations.

    c. Fire-rated wall and floor penetrations.

    d. Equipment connections and support details.

    e. Sizes and location of required concrete pads and bases.

2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.

3. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.

4. Prepare reflected ceiling plans to coordinate the installation of air outlets and inlets, light fixtures, communications systems components, fire alarm devices, sprinklers, and other ceiling-mounted devices.

E. Record Documents: Furnish record documents, and in addition to the requirements specified in Division 1, indicate installed conditions for:

1. Interior and exterior major raceway systems' sizes and locations; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker sizes and arrangements.

2. Exposed and concealed equipment locations dimensioned from prominent building lines.

3. Approved substitutions, and actual equipment and materials installed.

F. Maintenance Manuals: Furnish maintenance manuals, and in addition to the requirements specified in Division 1, include the following information for equipment items:

1. Functional description, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and catalog numbers of replacement parts. Where a Bill of Materials is

provided, include a manufacturers' data sheet for each component and device listed therein.

2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.

3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

4. Servicing instructions and lubrication charts and schedules.

1.5 QUALITY ASSURANCE

A. Codes: Provide all electrical Work in accordance with applicable local codes, regulations and ordinances. If there is a conflict between the requirements specified in the Contract Documents and the codes, follow the more stringent requirements as determined and approved.

B. Testing: As a minimum, provide standard factory and field tests for each type of equipment. Other tests may be specified in the applicable equipment section.

C. Labeling: Provide electrical equipment and materials that are listed and approved by Underwriters Laboratories or other OSHA recognized testing laboratories with the testing agency's label attached.

D. Standard Products: Unless otherwise indicated, provide electrical materials and equipment which are the standard products of manufacturers regularly engaged in the production of such materials and equipment. Provide the manufacturer's latest standard design that conforms to these Specifications. Provide the products of the same manufacturer when two or more units of the same class of material and equipment are required.

1.6 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store and handle all products and materials as specified in Division 01 (and as follows:)

B. Shipping and Packing: Provide materials and equipment suitably boxed, crated or otherwise completely enclosed and protected during shipment, handling, and storage. Clearly label such boxes, crates or enclosures with manufacturer's name, and name of material or equipment enclosed.

C. Acceptance at Site: Conform to acceptance requirements as required in Division 1.

1. Repair or replace all materials and equipment damaged by handling and storage as directed at no additional Contract cost.

D. Storage and Protection: Protect materials and equipment from exposure to the elements and keep them dry at all times. Handle and store to prevent damage and deterioration in accordance with manufacturer's recommendations. Provide temporary power to space heaters where provided with equipment to prevent condensation from developing.

1.7 PROJECT CONDITIONS

A. General: The Drawings indicate the extent and general arrangement of the principal electrical elements, outlets, devices and circuit layouts. Install and connect all electrical elements and devices to form a complete workable system as required by the Contract Documents, regardless of whether all system components are specifically stated in the Specifications or shown. Provide necessary materials and installation wherever required to conform to the specific requirements of the furnished equipment and for proper installation of the Work.

B. Physical Layouts: In general, the routing of feeders show general arrangement and are not intended to show exact routing and locations of raceways. Verify actual and final arrangement, equipment locations, and prepare circuit and raceway layouts before ordering materials and equipment. Equipment locations are approximate and are subject to modifications as determined by approved equipment dimensions.

C. Coordination of Work: Coordinate the Work so that the electrical equipment may be installed without altering building components, other equipment or installations.

D. Departure from Design: If departures from the design are deemed necessary due to structural conditions, obstructions or other problems, provide details of such departures and the reasons for requesting approval. Submit variations as soon as practical but no later than the submittal of the required raceway layout drawings. Do not depart from the design without written approval.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 ROUGH-IN

A. Final Location: Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

3.2 ELECTRICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:

1. Coordinate electrical systems, equipment, and materials installation with other building components.

2. Verify all dimensions by taking field measurements.

3. Arrange for chases, slots, and openings in other building components as construction progresses to provide for electrical installations.

4. Coordinate the installation of required supporting devices and sleeves to be set in cast-in-place concrete and other structural components, as they are constructed.

5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.

6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum possible headroom.

7. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide all required connections for each service.

8. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the ENGINEER for resolution.

9. Where installed exposed in finished spaces, install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components.

10. Provide electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

11. Provide access panels or doors where units are concealed behind finished surfaces.

12. Install systems, materials, and equipment providing right-of-way priority to systems required to be installed at a specified slope.

13. All wiring specified, scheduled, noted or shown is to be installed in conduit unless identified otherwise.

3.3 CUTTING AND PATCHING

A. General: Perform cutting and patching as specified in Division 1. In addition to the requirements specified in Division 1, the following requirements apply:

1. Perform cutting, fitting, and patching of electrical equipment and materials required to:

   a. Uncover Work to provide for installation of ill-timed Work.

   b. Remove and replace defective Work.

   c. Remove and replace Work not conforming to requirements of the Contract Documents.

   d. Remove samples of installed Work as specified for testing.

   e. Install equipment and materials in existing structures.

   f. Locate existing structural reinforcing with a pachometer where core drilled penetrations are required so as not to cut the steel reinforcing.

2. Cut, remove, and properly dispose of selected electrical equipment, components, and materials as indicated. Included are the removal of electrical items indicated to be removed and items made obsolete by the new Work. Deliver all removed serviceable apparatus to the OWNER as directed.

3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

4. Provide and maintain adequate temporary partitions or dust barriers that prevent the spread of dust and dirt to adjacent areas.

5. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

6. Patch finished surfaces and building components using new materials that are compatible with the original installation and applied by experienced installers.

END OF SECTION

SECTION 26 05 10

ELECTRICAL UTILITY COORDINATION AND REQUIREMENTS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for arranging and coordinating with the Utility Company for permanent electrical power service.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 03 31 00 - Cast-In-Place Concrete
2. Section 26 29 23 - Adjustable Frequency Drives
3. Section 26 05 73 - Short Circuit and Coordination Study
4. Section 26 24 13 - 480 Volt Switchboards

1.2 SYSTEM DESCRIPTION

A. Utility Company: AEP/PSO

B. Utility Company Contact: Chris Williams
Office Telephone: 918.476.2715

C. System Characteristics:

1. 480 Volts

2. 3 Phase

3. 4 Wire

4. Solidly Grounded Neutral

D. New electric power extension to new pole adjacent to property, from new pole new underground routing to utility junction box. From junction box to new pad-mounted utility transformer and meter. From meter to new service entrance into the building.

1.3 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 01.

B. Correspondence: Furnish copies of all correspondence with the Utility Company including available short circuit currents and X/R ratings for each feeder.

C. Utility Company Drawings: Furnish Utility Company prepared drawings.

D. Layout Drawings: Furnish the following drawings:

1. Equipment pad details
2. Equipment mounting details.

1.4 QUALITY ASSURANCE

A. General: Perform Work in accordance with Utility Company's written requirements and standards.

1.5 PROJECT CONDITIONS

A. Field Measurements: Verify that field measurements are as indicated on Utility Company drawings.

B. Field Inspection: Field inspection by utility required according to PSO standards. Including but not limited to inspection of transformer pad prior to concrete pour.

PART 2 PRODUCTS

2.1 UTILITY METERING

A. Revenue Meters: Meters will be furnished by Utility Company.

B. Meter Base: Provide meter base in accordance with the requirements of the Utility Company.

C. Metering Transformer Cabinet: Metering transformer cabinet to be coupled with Utility Transformer.

PART 3 EXECUTION

3.1 EXAMINATION

A. General: Verify that service equipment is ready to be connected and energized.

3.2 PREPARATION

A. Utility Company Arrangements: Make arrangements with Utility Company to obtain permanent electric service to the Project.

B. Utility Engineering and Facility Charges: Pay all charges and fees associated with securing both temporary and permanent electrical service for the project.

C. Utility Company Access: Coordinate location of Utility Company's facilities to provide proper access.

D. Coordination: Coordinate schedule of Utility Company's facilities with all other work.

E. Utility Company System Information: Obtain all information required to perform the Harmonic Analysis as specified in Section 26 29 23 – Adjustable Frequency Drives and the Short Circuit and Coordination Study specified in Section 26 05 73.

3.3 INSTALLATION

A. General: Install Electrical Power Service routing in accordance with the Utility Company's recommendations and approved shop drawings and as specified in Division 01.

B. Meter Base: Install meter base in accordance with the Utility Company requirements and as shown.

C. Concrete Pads: Provide cast-in-place concrete pads for Utility Company transformers and other equipment.

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 26 05 19

WIRES AND CABLES 600 VOLTS AND BELOW

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for providing all wires and cables rated at 600 volts and below for complete electrical systems as shown.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 26 05 00 - Basic Electrical Materials and Methods
2. Section 26 05 53 - Electrical Identification
3. Section 26 80 00 - Electrical Testing Requirements

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. ASTM B3 - Standard Specifications for Soft or Annealed Copper Wire

2. ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

3. UL 44 - Thermoset-Insulated Wires and Cables

4. UL 83 - Thermoplastic-insulated Wires and Cables

5. NEMA WC-70 / ICEA S-95-658 - Power Cable s Rated 2000 Volts Or Less For The Distribution Of Electrical Energy

6. NFPA 70 - National Electrical Code (NEC)

1.3 SUBMITTALS

A. General: Furnish all submittals, including the following, as specified in Division 01 and Section 26 05 00.

B. Product Data and Information: Furnish manufacturer's catalog data for each type of wire and cable furnished.

1.4 QUALITY ASSURANCE

A. General: Furnish wire and cable in accordance with applicable IEEE and NEMA standards and meeting the applicable requirements of the NEC and UL.

B. Tests: Furnish factory tested cables prior to shipment in accordance with ICEA standards for the insulation specified.

1.5 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store and handle wire and cable in accordance with the manufacturer's instructions and as specified in Division 01.

B. Storage: Store cable reels on concrete, 2x4 wood lagging, or other hard surface. Do not store reels flat.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted for review.

1. Wire and Cable

a. Southwire Company
b. The Okonite Company
c. General Cable Corporation

2. Instrumentation Cable

a. Belden
b. Dekoron Wire and Cable
c. The Okonite Company

3. Multiconductor Cable

a. The Okonite Company
b. Southwire Company

4. Wire Connectors

a. Thomas & Betts/ABB Group
b. 3 M/Electrical Products Division
c. Ideal Industries

5. Color Coding Marker

a. W. H. Brady Company
b. Thomas & Betts/ABB Group

2.2 MATERIALS

A. Conductors: Provide soft drawn or annealed copper stranded conductors with 98 percent minimum conductivity, meeting requirements of ASTM B 8. Solid No. 12 and No. 10 AWG meeting requirements of ASTM B 3 may be used in lighting fixture and convenience outlet wiring.

B. Insulation: Provide wires and cables with insulation as follows:

Power, control and lighting wiring

a. Single Conductor: Provide insulation as follows:

NEC Type Letter	Insulation Material
XHHW/XHHW-2	Cross-linked Polyethylene (XLPE)

b. Multiconductor Cables: Insulate individual conductors with 15 mils of polyethylene or PVC and 4-mil nylon jacket. Wrap the conductors with type binder and an outer jacket not less than 45 mils of PVC. Use ICEA Method 1 for color coding wires.

2. Instrumentation Wiring: The manufacturers' name and catalog number shown below are for the purpose of establishing quality and general configuration.

a. Two conductor or single pair: Stranded No. 16 AWG wire, 600 volt polyethylene insulation, twisted conductors, tinned copper drain wire, overlapped metalized tape overall shield providing 100 percent shield coverage and outer jacket of PVC. Dekoron Cat. No. 2X52-69610.

b. Three Conductor: Stranded No. 16 wire, 600 volt polyethylene insulation, twisted conductors, tinned copper drain wire, overlapped metalized tape overall shield providing 100 percent shield coverage and outer jacket of PVC. Okonite Cat. No. 267-38-3401.

c. Multiple Pairs or Triads: Provide individually shielded pairs or triad of stranded No. 16 AWG wire with overall shield. Insulate each wire for 600 volts with 15 mils of PVC and a 4-mil nylon jacket. Assemble pairs or triads with tinned copper drain wire and metalized tape shield providing 100 percent shield coverage. Cable pairs or triads together with tinned copper drain wire and overall metalized tape shield.

C. Printed Data on Covering: Provide the following information printed on the surface of all wires and cables at regular intervals throughout the entire length.

1. Manufacturer or trade name.
2. Size of conductor.
3. Type of insulation.
4. Voltage classification.

2.3 WIRE CONNECTIONS AND CONNECTING DEVICES

A. Connectors for No. 10 AWG and Smaller: Provide insulated compression type butt connectors.

B. Connectors for No. 8 AWG and Larger: Provide UL, Inc. listed compression type tube connectors for parallel or butt splices. Provide companion preformed plastic insulating covers or tape to provide insulation equal to conductor insulation.

C. Miscellaneous Connectors: Provide pre-insulated spring connectors for lighting and receptacle splices and pigtails.

D. Solderless Lugs: Provide solderless terminal lugs for stranded and multiple solid conductors at connection to terminals or use UL listed crimp tool compression style lugs.

E. Control Wire Terminations: Provide spade lug or pressure type control conductor connection terminations for control wiring terminations. Provide lug bolting at devices or bus bars with a flat washer, a Belleville washer and a locknut.

2.4 COLOR CODING

A. General: Use a vinyl impregnated tape resistant to oil, dirt and heat for conductor color coding.

PART 3 EXECUTION

3.1 INSTALLATION

A. General: Swab new and existing conduits to be used to clear debris and remove moisture before conductor installation. Install conductors in raceways with no splices in conduits and between boxes.

B. Pulling Equipment: Pull conductors using proper equipment without exceeding manufacturer's recommendation for maximum pulling tension. Protect conductor insulation jacket at all times from twists, kinks, scrapes, punctures and other damage. Replace damaged conductors. Pull wires and cables into ducts and conduit without the use of lubricants, except where such use is necessary and approved. Use UL listed lubricating compound compatible with the conductor insulated jacket and raceway.

Use lines of nylon or polypropylene, propelled by carbon dioxide, or compressed air, to snake or pull wire and cable into conduits. Do not use flat steel tapes or steel cables.

C. Conductor Support: Support conductors in vertical risers with woven grips to prevent loading on conductor connectors.

D. Seals: Provide a seal between the conductor and conduit for conduits entering buildings or from areas where the temperature change may cause condensation or moisture. Provide a non-hardening, removable, seal compatible with conductor insulation. Seal the conduits after the conductors are in place.

E. Identification: Identify all cables as specified in Section 26 05 53.

F. Color Coded Tape: Apply color coding tape at all terminations and splices with overlapping turns for a minimum length of two inches, starting two inches back from the termination point. Provide color code tape in all boxes and manholes.

G. Provide color coding throughout the entire network for service, feeder, branch, control and low energy signal circuit conductors. Use the following color code for conductors.

COLOR CODING	
SYSTEM	COLORS
208/120 Three phase	Phase A - Black Phase B - Red Phase C - Blue Neutral - White Ground - Green
240/120 Single Phase	Hot - Black Neutral - White Ground - Green
480/277 Three Phase	Phase A - Brown Phase B - Orange Phase C - Yellow Neutral - White Ground - Green
Control and low-energy signal	Hot - Red Neutral - White Ground - Green
Instru-mentation	Gray

H. Terminations: Leave a minimum of six inches of free conductor at each connected outlet and a minimum of nine inches at unconnected outlets.

I. NEC Requirements: Install wiring in accordance with applicable provisions of National Electrical Code, local codes having jurisdiction, and as indicated.

J. Conductor Sizing: Size conductors in accordance with the NEC, local codes having jurisdiction and the following:

1. Size for branch lighting circuits so that the greatest voltage drop between lighting panel and center of load does not exceed two percent at rated load.

2. Size conductors to limit the maximum conductor temperature to less than 75 degrees C, except where specifically stated otherwise.

3. Use minimum conductor sizes as follows:

a. Power and lighting branch circuits, No. 12 AWG.

b. 120-volt control circuits, No. 14 AWG.

c. Instrumentation and signal wiring, 2 or 3 conductors No. 16 AWG stranded shielded.

4. Conductor Ampacity Adjustment Factors:
   a. For installations in ambient temperatures other than 30 degrees C, adjust the conductor ampacity based on NEC Table 310.15(B)(2)(a).
   b. For installations of raceways or cables exposed to sunlight on or above rooftops, utilize ambient temperature adjustment per NEC Table 310.15(B)(3)(c).

5. Size conductors as shown or as required by the actual load to be served, whichever is larger.

K. Splicing: Install continuous cables without splices in all duct systems.

L. Instrumentation wiring:

Install instrumentation wiring as follows:

1. Wherever possible provide continuous instrumentation wiring without splices from field device to instrument. Where connections are required, make all connections in terminal boxes.

2. Terminate instrumentation wiring at terminal blocks only.

3. Where instrumentation wire is required to be connected in a terminal box, provide an isolated terminal for each shield.

4. Ground instrumentation shields and drain wires only at the panel end of loop only.

5. Install clear, heat-shrink, seamless tubing over exposed shields and drain wires in all terminal boxes, junction boxes, panels and field devices.

M. Hazardous Areas: Seal all conduits at boundaries of hazardous areas in accordance with the National Electrical Code, local codes having jurisdiction, and as indicated.

N. Accuracy of Information: The number and sizes of wires and conduits indicated are for guidance only and are not necessarily the correct number and sizes necessary for actual equipment installed. Install as many wires and conduits of the required size as necessary for a complete electrical system, and provide adequately for the equipment actually installed.

3.2 CONDUCTOR IDENTIFICATION

A. Labeling: Label each wire at both termination points and at each splice point in junction boxes. Carry individual conductor or circuit identification throughout, with circuit numbers or other identification clearly stamped on terminal boards and printed on directory cards in distribution cabinets and panelboards.

B. Identification: Identify each wire in junction boxes and cabinets by means of plastic slip-on wire marker.

C. Plastic Tags: In manholes, identify each wire by laminated plastic tag located so it can be easily seen in accordance with Section 26 05 53.

D. Color Coordination: Connect circuit conductors of the same color to the same phase throughout the installation.

3.3 WIRE AND CABLE CONNECTIONS TO EQUIPMENT

A. General: Provide electrical connections to all equipment in strict accordance with the manufacturer's approved wiring diagrams, the Plans, or as approved. Repair or replace any damaged equipment resulting from erroneous connections.

3.4 CONNECTOR AND TERMINAL LUG INSTALLATION

A. UL Requirements: Install all connectors and terminal lugs in accordance with UL requirements and manufacturer's recommendations.

3.5 FIELD QUALITY CONTROL

A. Insulation Tests: Test all feeders after installation but before final connections are made.

B. Continuity Tests: Test all power conductors and 20% of all control conductors to demonstrate proper cable connection.

C. Perform tests in accordance with the requirements of Section 26 08 00.

D. Test Results: Perform all tests and submit certified test results. Replace and retest any conductors that fail the tests.

END OF SECTION

SECTION 26 05 26

GROUNDING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for providing a complete grounding system as specified and shown. Grounding includes but is not limited to: electric equipment enclosures, raceway systems, transformers, unit substations, motor control centers, panelboards, ground grid systems, grounding rods, grounding conductors, bonding jumpers, water pipe connections, and structure metal frames as required.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 26 05 00 - Basic Electrical Materials and Methods
2. Section 26 05 33 - Electrical Raceway Systems
3. Section 26 05 19 - Wires and Cables - 600 Volts and Below
4. Section 26 08 00 - Electrical Testing Requirements

1.2 REFERENCES

A. Codes and Standards: The following codes and standards are referred to in this Section:

1. NFPA 70 - National Electrical Code (NEC)

1.3 SUBMITTALS

A. General: Furnish all submittals, including the following, as specified in Division 01.

B. Product Data and Information: Furnish manufacturer's catalog data for the following:

1. Grounding and grounded conductors
2. Grounding connectors, clamps and bushings
3. Grounding rods
4. Bonding jumpers

C. Shop Drawings: Furnish shop drawings showing the locations and length of grounding rods. Denote the size and material used for grounding rods. Furnish details pertaining to the installation of grounding electrode conductors, grounding

and grounded conductors, grounding connections, grounding enhancement materials and the ground grid for buildings, structures, lighting units, manholes and handholes.

D. Quality Control: Furnish a field report stating the results of the system ground impedance test.

1.4 QUALITY ASSURANCE

A. Codes and Standards: Construct a complete grounding system in accordance with applicable ANSI, IEEE Standards, the NEC and local codes.

1.5 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store and handle all products and materials as specified in Division 01.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted for review.

1. Grounding and Grounded Conductors

    a. Okonite Company
    b. Southwire Company

2. Ground Plates

    a. Burndy/ Hubbell IncorporatedO-Z Gedney/Emerson Industrial Automation
    b. Eritech Grounding Products
    c. Thomas & Betts/ABB Group

3. Grounding Rods

    a. Harger Lightning Protection, Inc.
    b. Thompson Lightning Protection, Inc.
    c. Carolina Galvanizing Utility Products Division
    d. Eritech Grounding Products
    e. Superior Grounding Systems

4. Ground Rod Access and Test Well Box

a. Hubbell Power Systems – Quazite
b. Oldcast Precast, Inc.
c. Thompson Lightning Protection
d. Eritech Grounding Products

2.2 MATERIALS

A. General: Provide conductor sizes as shown or required.

B. Materials: Provide conductors in accordance with the requirements specified in Section 26 05 19.

C. Bare conductors: Provide bare copper conductor where buried in earth, embedded in concrete or exposed.

D. Insulated Conductors: Provide copper conductor with green color insulation rated at 600 volts where installed in conduits or other enclosed raceways.

2.3 CONNECTORS

A. Grounding Clamps and Bolted Connectors: Provide grounding clamps and bolted connectors suitable for devices or cables being connected.

B. Ground Plates: Provide two-hole, cast, copper alloy, ground plates suitable for installation in concrete. Fabricate the ground plates with two ½-inch diameter threaded holes and a 4/0 stud for connection to the grounding system.

C. Welding: Provide the exothermic welding process for buried, concealed and accessible connections to structural members, ground rods, and case grounds. Clean and paint welds embedded in the ground or encased in concrete with asphalt base paint.

D. Bolted Connectors: Provide bolted connectors for grounding to ground buses and equipment.

E. Pipe Grounding: Provide copper, brass, or bronze grounding clamps for grounding pipes. Do not provide strap type clamps.

F. Grounding Bushings: Provide grounding bushings for conduits where conduits are not effectively grounded by firm contact to the grounded enclosure.

2.4 GROUNDING RODS

A. Length and Size: Provide grounding rods 3/4-inch in diameter and 10 feet long.

B. Grounding Rod Material: Stainless steel.

2.5 GROUND ROD ACCESS AND TEST WELL BOXES

A. Interior Locations: Cast iron box with open bottom set-in concrete floor measuring a minimum of 12 inches in diameter by 18 inches deep with engraved/stamped cover reading “GROUND ELECTRODE”.

B. Exterior Locations: Precast concrete or polymer concrete junction box with open bottom, UL listed, Tier 22 in accordance with ANSI/SCTE 77, with engraved/stamped cover reading “GROUND ELECTRODE”.

PART 3 EXECUTION

3.1 INSTALLATION

A. General:

1. Install conductors to preclude exposure to physical damage.

2. Install connections firm and tight.

3. Arrange conductors and connectors without placing strain on the connections.

4. Bury equipment grounding conductors as shown, or at a minimum of 12 inches below grade.

5. Bring loops or taps up for connection to equipment or other items to be grounded.

6. Install an insulated grounding conductor in all conduits.

7. When raceways are used to contain and protect grounding conductors, install in accordance with Section 26 05 33 and NEC.

8. Where conductors are installed in nonmetallic raceway, provide the grounding conductor in addition to the neutral wire, sized in accordance with NEC or as scheduled.

9. Perform exothermic welding with properly sized molds.

B. Grounding Rod Installation:

1. Install grounding rods as shown with the top of the rod a minimum of 12 inches below grade.

2. Drive grounding rods into permanently moist soil.

3. Provide additional ground rod sections as required to reach permanently moist soil.

4. Provide junction box without bottom for access to grounding rod and conductor where shown.

C. Equipment Grounding: Ground each piece of electrical equipment using a conductor in the raceway feeding the equipment in accordance with NEC.

1. Unless specified otherwise, connect transformer enclosures and neutrals to the grounding system. Connect the neutral ground connection at the transformer terminal. Make the connection from the ground grid to the ground bus and enclosures of switchboards, switchgears and motor control centers, lighting and distribution panelboards, and control, relay and instrumentation panels.

2. Provide two separate, independent, diagonally opposite connections for power transformers so removal of one connection will not impair continuity of the ground system. Provide ground plates that are imbedded in the concrete pad so that transformers can be removed without damaging grounding system. Install a copper ground connect between ground plates and the transformers.

D. Grounding Conductors: Connect the grounding conductor between the equipment and the grounding system. Where a ground bar is furnished with the panelboard, connect the grounding conductor to the bar.

E. Miscellaneous Grounding: Provide grounding for the following:

1. Ground receptacles and switches and their metal plates through positive ground connection to the yoke/strap, outlet box and grounding system grounding wire installed in the conduit.

2. Ground racks, supports, frames, covers and metal parts in manholes or handholes, controllers, motor frames, surge capacitors, arrestors, lighting fixtures, metal structures, exposed noncurrent carrying metal, mechanical equipment, hoist beams, cranes and similar items.

3. Provide ground connections to equipment using ground plates imbedded in the concrete pad so that the equipment can be removed without damaging grounding system. Provide a copper ground connection between ground plates and the equipment.

4. Ground motor shaft protection for motors operating on adjustable frequency drives where provided.

3.2 FIELD QUALITY CONTROL

A. Tests: Conduct a witnessed test to determine the ground impedance for the entire system using a ground loop impedance tester. Provide a maximum impedance of 2 ohms at any point of the test. Add additional grounding rods if necessary to meet this requirement.

END OF SECTION

SECTION 26 05 33

ELECTRICAL RACEWAY SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for providing electrical raceway systems as indicated, in accordance with the Contract Documents.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 09 96 00 – High Performance Coatings
2. Section 26 05 00 - Basic Electrical Materials and Methods
3. Section 26 05 43 - Underground Electrical Distribution System

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1.	ANSI C80.1	-	Rigid Steel Conduit
2.	NEMA RN1	-	Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
3.	NEMA TC2	-	Electrical Polyvinyl Chloride (PVC) Conduit
4.	UL 6	-	Standard for Rigid Metal Conduit-Steel
5.	UL 651	-	Standard for Schedule 40 and 80 Rigid PVC Conduit
6.	NFPA 70	-	National Electrical Code (NEC)
7.	Intertek ETL SEMKO PVC-001	-	High Temperature H2O PVC Coating Adhesion Test Procedure

1.3 SUBMITTALS

A. General: Furnish all submittals, including the following, as specified in Division 01 and Section 26 05 00.

1.4 QUALITY ASSURANCE

A. Codes: Provide all materials and workmanship in accordance with the requirements of the National Electrical Code and local codes having jurisdiction.

B. Regulatory Requirements: Provide UL listed components.

1.5 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store and handle all products and materials as specified in Division 01.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted for review.

1. Rigid steel conduits:

   a. Allied Tube and Conduit
   b. Wheatland Tube Company/JMC Steel Group
   c. Republic Conduit Manufacturing

2. PVC coated steel conduits fitting and boxes:

   a. Plasti-Bond/Perma-Cote/KorKap-Robroy Industries
   b. Ocal – Thomas & Betts Corp.
   c. Perma-Cote Industries

3. Rigid nonmetallic conduits:

   a. Carlon– Thomas & Betts /ABB Group
   b. Cantex Inc.
   c. National Pipe & Plastics, Inc.

4. Liquidtight and flexible steel conduit:

   a. Electri-Flex Company
   b. The International Metal Hose Co.
   c. Southwire
   d. Anamet Electrical, Inc.
   e. Thomas & Betts /ABB Group

5. Conduit Fitting and Connectors

    a. Appleton /Emerson Industrial Automation
    b. Thomas & Betts/ABB Group
    c. Eaton's Cooper Crouse-Hinds
    d. O-Z Gedney/Emerson Industrial Automation
    e. Hubbell - Killark
    f. AdaletPLM/Scott Fetzer Company

6. Boxes and Enclosures:

    a. Appleton /Emerson Industrial Automation
    b. Raco/A Hubbell Company
    c. Eaton's Cooper Crouse-Hinds
    d. Thomas & Betts/ABB Group
    e. Hoffman
    f. Hope Electrical Products Company
    e. O-Z Gedney/Emerson Industrial Automation

7. Strut Channel and Fittings

    a. Allied Tube and Conduit
    b. Eaton's Cooper B-Line Systems, Inc.
    c. Thomas & Betts /ABB Group-SuperstrutEnduro Composites Inc.
    d. Strut Tech Systems
    e. Unistrut

8. Terminal Blocks

    a. Phoenix Contact
    b. ABB - Entrelec
    c. Weidmuller

2.2 RACEWAYS

A. General: Provide minimum 3/4-inch raceways.

B. Raceway Requirements: Provide raceways meeting the following requirements:

1. Provide rigid steel, heavy wall, hot-dip galvanized in accordance with the requirements of UL-6 and ANSI C80.1.

2. Provide PVC coated rigid steel in accordance with the requirements for rigid steel raceway herein and with 40 mils bonded PVC exterior coating meeting requirements of UL-6 and NEMA RN1. Provide PVC coated rigid steel

conduit that is listed and performance verified to ETL PVC-001 for 200 hours. Provide a nominal 2 mil urethane interior coating and a clear urethane coating over the galvanized threads.

3. Provide rigid nonmetallic Schedule 40 PVC in accordance with requirements of NEMA TC2 and UL 651 with solvent cement joints.

4. Provide liquidtight flexible single strip steel, hot-dip galvanized conduit with PVC jacket in accordance with requirements of UL 1. Provide a continuous copper bonding conductor wound spirally between convolutions on the inside of the conduit meeting requirements of UL 360 for conduit sizes 1-1/4-inch and smaller.

5. Provide flexible steel conduit constructed of continuous interlocked, zinc coated steel strip in accordance with the requirements of UL 1. Provide in a minimum 1/2 inch electrical trade size.

2.3 FITTINGS

A. General: Provide fittings of similar material as raceways.

B. Fittings Requirements: Provide fittings meeting the following requirements:

1. Set screw or indenter type fittings are not acceptable. Provide threaded connectors for all rigid metal conduits.

2. Provide solvent cement connections for all rigid nonmetallic conduits.

3. Provide insulated connectors for liquidtight flexible conduit.

4. Expansion/Deflection Fittings:

a. Provide a deflection and expansion coupling for rigid and intermediate metal conduits that have a ¾ inch movement in all directions from normal and a 30 degree angular deflection. Provide coupling that includes internal bonding jumper.

b. Provide a nonmetallic expansion coupling for nonmetallic conduits that have a 4-inch maximum expansion.

5. Bushings

a. Provide insulated nonmetallic bushing rated 105 degrees C for all installations where bonding is not required.

b. Provide insulated metallic grounding and bonding bushing rated 150 degrees C where bonding is required.

2.4 WALL AND FLOOR PENETRATIONS

A. Watertight:

1. For conduit penetrations in existing walls or floors, provide watertight sealing bushing consisting of a neoprene sealing ring between two PVC coated steel pressure discs. Provide stainless steel captive screws for sealing ring compression.

B. Fire-proofing Through Fire Rated Construction:

1. Provide a permanent fire stop system for all penetrations through fire-rated walls, partitions and floors.

2. Design fire stop system to maintain the integrity of the wall or floor assembly for its rated time period.

3. Arrange fire stop system to allow normal pipe movement without being displaced.

4. Do not utilize asbestos in fire stop systems.

5. Provide an intumescent fire stop system when exposed to flame or heat.

2.5 BOXES AND CABINETS

A. Outlet Box Requirements:

1. Provide galvanized cast iron boxes for galvanized rigid steel and intermediate metal conduit systems.

2. Provide nonmetallic boxes and covers in PVC conduit systems.

3. Provide PVC coated boxes and covers in PVC coated conduit systems.

4. Provide corrosion-resistant fiberglass reinforced polyester boxes with stainless steel hardware in corrosive areas as defined in Section 26 05 00 or as shown.

5. Provide watertight gasketed covers held with nonferrous screws for all cast metal boxes.

B. Junction and Pull Box Requirements:

1. Provide cast aluminum boxes with mounting lugs, threaded hubs and gasket covers for surface mounted boxes

2. Provide fabricated sheet metal boxes when cast metal box weight exceeds 50 pounds. Construct box from 1/8-inch thick galvanized sheet steel or aluminum with sides return channel flanged around cover opening. Provide angle or channel supporting frame. Provide continuously welded and ground smooth seams. Provide mounting lugs and threaded conduit hubs.

3. Provide cast steel or fabricated 10-gauge Type 316 stainless steel for boxes either partially or fully encased in concrete. For partially encased boxes provide sides return channel flanged around cover opening. For fully encased boxes provide flush covers. Provide continuously welded and ground smooth seams. Provide mounting lugs and threaded conduit hubs.

4. Provide watertight gasketed covers held with stainless-steel captive screw slot bolts.

5. Provide two padlocking hasps for boxes containing medium voltage cables.

6. Provide steel barriers in all boxes that isolates instrumentation wiring from all other wiring systems

7. Provide fabricated boxes located indoors in non-corrosive areas and conditioned spaces -meeting NEMA 12 requirements.

8. Provide all boxes located outdoors, in corrosive areas or where otherwise indidated meeting NEMA 4X, 316 stainless steel requirements.

C. Terminal Box Requirements:

1. Provide minimum 12 gauge stainless steel fabricated box with mounting lugs, floor stand, and hinged doors.

2. Provide the door with continuous piano hinge and 3 point lockable latch. Provide print pocket on inside of door.

3. Provide back plate fabricated from 12 gauge minimum steel with white enamel finish for mounting terminals and wire troughs.

4. Provide wire troughs consisting of plastic ducts with snap slot design and removable covers. Run all wiring within wire troughs.

5. Furnish a schedule of terminals with the following information

a. Source
b. Type of Signal
c. Function

6. Provide removable jumpers to allow operation of the equipment.

7. Separate analog terminals from all other terminals.

8. Provide number of terminals shown. Where the number of terminals are not shown, provide sufficient terminals for each wire entering the terminal box plus 20 percent but not less than 10 spare terminals.

9. Terminals:

   a. All catalog numbers refer to Phoenix Contact Type for the purpose of establishing the standard of quality and general configuration desired.

   b. Provide symmetrical type steel mounting rails, NS-35.

   c. Analog Signals: Provide terminals in enclosed housing suitable for wires from 22 to 12 AWG rated 600 volts with gray body, knife disconnect and test connection socket on both sides of disconnect, Phoenix Contact Type UK 5-MTK-P/P.

   d. Control and Alarm Signals: Provide terminals suitable for wires from 24 to 10 AWG rated 18 amperes at 600 volts, blue body, Phoenix Contact Type UK5N BU.

   e. 120-Volt Power Wiring: Provide terminals suitable for wires from 18 to 10 AWG rated 30 amperes at 600 volts, hot (black body), neutral (white body), ground (green body) , Phoenix Contact Type UK5N BK, UK5N WH & UK5N GN, respectively.

10. Enclosures: Provide enclosures meeting the same NEMA criteria for the various areas as specified under Junction and Pullboxes.

2.6 SUPPORTING DEVICES

A. Raceway Supports: Provide raceway supports meeting the following requirements:

1. Do not use perforated straps or plumbers tape for conduit supports.

2. Provide expansion bolts or inserts for fasteners in concrete, toggle bolts for hollow masonry or frame construction, and preset inserts for prestressed concrete.

3. Conduit Straps and Backs:

   a. For metallic conduits, provide steel or malleable iron.

   b. For nonmetallic and PVC coated conduits, provide PVC coated malleable iron with stainless steel anchors and bolts.

4. Conduit Hangers

   a. For metallic conduits, provide steel adjustable conduit hangers or clevis hangers.

   b. For nonmetallic and PVC coated conduits, provide PVC coated adjustable conduit hangers with stainless steel hardware.

5. Beam Clamps:

   a. For metallic conduits, provide malleable iron with steel bolt.

   b. For nonmetallic and PVC coated conduit, provide PVC coated malleable iron with stainless steel bolt.

6. Trapeze Hangers:

   a. For metallic conduits provide 12 gauge 1-1/2-inch square steel channels with steel channel straps to secure conduits.

   b. For nonmetallic or PVC coated conduit, provide either PVC coated 12 gauge 1-1/2-inch square steel channels or 1-5/8-inch square fiberglass channels. Provide PVC coated straps with stainless steel bolts for securing conduits.

   c. Provide addition channels welded together to limit the deflection to 1/240th of span.

7. Threaded Rod

   a. Provide threaded rod with the minimum size as follows:

      (1) Conduit Hangers

         (a) 3/4-inch to 1-1/2-inch conduit: 1/4-inch thread rod

         (b) 2-inch to 3-1/2-inch conduit: 3/8-inch thread rod

         (c) 4-inch and larger: 1/2-inch thread rod

(2) Trapeze Hangers: Provide thread rod of sufficient size to support the load. Provide a minimum of 3/8-inch thread rod.

b. For Metallic Conduit Systems: Provide continuous threaded galvanized steel rod.

c. For Nonmetallic or PVC Coated Conduit Systems: Provide continuous threaded stainless steel rod.

PART 3 EXECUTION

3.1 PREPARATION

A. General: Install electrical equipment and material of the size, type and general routing as shown or required.

B. Coordination with Reinforcing: Install raceway, fittings, boxes and cabinets free from direct contact with reinforcing steel.

C. Alignment: Provide fasteners, anchor bolts, anchorage items and supports as required to insure proper and rigid alignment. Attach equipment with fasteners sized according to size and weight of the equipment and the thickness of the supporting surface.

D. Aluminum Coating: Where aluminum is placed in contact with dissimilar metal or concrete, separate contact surfaces with gasket, nonabsorptive tape or coating as specified in Section 09 96 00 to prevent corrosion.

E. Grounding: Make metallic raceways electrically and mechanically continuous and ground as required. Install conduits continuous between outlets, boxes, cabinets and panels.

3.2 INSTALLATION

A. General: Unless otherwise indicated, install conduits exposed, parallel or perpendicular to building floors, ceilings and walls, to avoid interference with other work. In architecturally finished areas, conceal conduits within finished walls, ceilings and floors. Cut conduits square and deburr the cuts to the same degree as the conduit manufacturer. Fasten conduit securely to outlets, junction, pull and terminal boxes. Provide caps and seals to prevent the entrance of foreign material and moisture during installation and before pulling wire.

1. Where conduit size is not shown, provide conduits one size larger than indicated in Table 4, Chapter 9 of the NEC.

2. Saw cut aluminum conduit to prevent reduction in internal area.

3. Support raceways concealed above suspended ceilings from the slab above suspended ceiling in same manner as exposed raceways. Do not support raceways from suspended ceiling supports.

4. Keep conduit at least six inches away from high temperature piping, ducts, flues and surfaces. For mounting on concrete and masonry surfaces provide a minimum of 1/4 inch air space between conduit and mounting surface. Support and fasten conduit to building structural members spaced in accordance with electrical codes. Support conduit at least every eight feet or less in accordance with NEC requirements.

5. When two or more exposed conduits are in the same general routing, provide parallel installation with symmetrical bends and for three or more provide trapeze hangers. Size trapeze hangers with space for 25 percent additional conduits.

6. Make changes in direction with bends or fittings. Use factory-made bends or elbows wherever possible. Make field bends and offsets with a hand bender or conduit-bending machine. Provide a bending radius not less than 36-inches for conduits containing medium voltage cables.

7. Run conduit in buildings with no more than the equivalent of three 90 degree bends between pull points. Provide no more than 125 feet of conduit runs between pull points. Provide pull boxes where shown, specified or wherever required to install conductors and to meet the above requirement.

8. Install pull and junction boxes in accessible locations with working space in front of and around the installation. Obtain approval to locate boxes in finished areas.

9. Install an expansion fitting when a conduit crosses a structural expansion joint.

10. Unless otherwise approved, install conduits to cross at right angles to building structural expansion joints.

11. Where approved for encased installation, install conduits in slabs as close to the middle of concrete slabs as practicable without disturbing reinforcement. Do not use conduit with an outside diameter exceeding one-third of the slab thickness. Do not place conduits closer than three diameters on centers, except at cabinet locations where the slab thickness is increased.

12. Pitch conduits to outlet boxes to avoid trapping moisture. Where dips are unavoidable in exposed conduit runs, install drain fitting at low point.

B. Conduit Material Types: Provide conduit as follows:

1. Provide rigid steel conduit in all exposed indoor and outdoor installations, except as described below.

2. Provide rigid steel conduits in all installations concealed in structures, concrete encased within structures or under structures.

3. Provide rigid steel conduits for all instrumentation, and electronic equipment signal wiring in all exposed or concealed noncorrosive installations.

4. Provide rigid nonmetallic Schedule 40 conduits underground, concrete encased or direct buried, unless specifically detailed otherwise.

C. Connections to Equipment

1. Provide double locknuts and bushing for all boxes, enclosures and cabinets located in dry areas.

2. Provide watertight hub fittings for all boxes, enclosures and cabinets located below grade or in wet, damp or corrosive areas.

3. Provide rigid conduit connection where equipment is fixed and not subject to adjustment, mechanical movement or vibration. Provide union fittings to permit removal of equipment without cutting or breaking conduit.

4. Provide liquidtight flexible conduit connection where equipment is subject to adjustment, mechanical movement or vibration.

5. Coat all threads in steel conduit runs with zinc dust in oil or other corrosion-preventive compound before making connections.

D. Underground Conduits: Provide underground conduits meeting the requirements of Section 26 05 43.

E. Penetrations: Make concealed penetrations for single conduits not more than 1/4-inch larger than the diameter of the conduit. Make penetrations through walls, ceilings and floors other than concrete for exposed conduits not more than 1/4-inch larger than the diameter of the conduit. Fill the voids around conduit with caulking compound and finish the surface the same as the wall, ceiling or floor.

1. Where a conduit enters through a concrete roof or membrane waterproofed wall, floor or ceiling, provide a watertight sealing sleeve that can be tightened

from one or both sides. If the sealing sleeve is not placed with the concrete, core drill the proper size hole to provide a mechanically watertight installation.

2. Where a conduit enters through a concrete non-waterproofed wall, floor or ceiling, provide a Schedule 40 sleeve and fill the space between the conduit and sleeve with a plastic expandable compound. If the sleeve is not placed with the concrete, drill the hole not less than 1/2-inch and not more than one inch larger than the sleeve, center the sleeve and grout the sleeve for the total depth of penetrated concrete with non-shrink grout, polyurethane or silicone sealant.

F. Spare Conduit: Provide spare conduits for future use as shown or required. Provide a minimum 200 pound strength nylon pull line in each spare conduit and identify the origin and termination of the conduit at each end. Terminate spare conduits in equipment, boxes or by couplings plugged flush with the inside of building surfaces.

G. Boxes: Provide boxes of the proper dimensions for the size and quantity of conductors enclosed.

1. For boxes mounted on steel, concrete and masonry surface, provide a minimum 1/4-inch non-metallic spacer to hold the box away from the surface.

2. Provide pressed metal boxes in all partition constructed walls.

3. Provide separate support for boxes and bolt units to buildings with expansion anchors, toggle bolts or appropriate screws. For lighting fixture outlet boxes, provide supports adequate to support the weight of the fixture to be mounted on the box.

4. Remove debris including dust, dirt, wire clippings and insulation from the interior of boxes. Replace boxes with open conduit holes. Repair or replace damaged boxes as directed.

5. Unless otherwise indicated, mount outlet boxes flush with the finished wall or ceiling with the long axis vertical. Unless otherwise shown or specified, provide mounting heights measured from the finished floor to centerline of the outlet box as follows:

3.3 CLEANING AND PAINTING

A. Field Painting: Paint conduits meeting the requirements of Section 09 96 00.

B. Touch Ups: Touch up all PVC coatings on conduit, fittings and boxes where scratched, marred or otherwise compromised during handling and installation per the manufacturer’s instructions.

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 26 05 43

UNDERGROUND ELECTRICAL DISTRIBUTION SYSTEM

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for providing underground electrical raceway system consisting of concrete encased conduits, direct buried conduits, cables, manholes, handholes, and outdoor electrical equipment pads as shown.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 03 10 00 - Concrete Formwork
2. Section 03 20 00 - Concrete Reinforcement
3. Section 03 30 00 - Cast-In-Place Concrete
4. Section 26 05 00 - Basic Electrical Materials and Methods
5. Section 26 05 33 - Electrical Raceway Systems
6. Section 26 05 19 - Wire and Cable - 600 Volts and Below
7. Section 26 05 26 - Grounding
8. Section 26 05 53 - Electrical Identification
9. Section 31 23 16 - Excavation - Earth and Rock
10. Section 31 23 23 - Backfilling
11. Section 32 90 00 - Landscaping Work

1.2 SYSTEM DESCRIPTION

A. Design Requirements: Provide precast manholes and handholes capable of withstanding earth and hydrostatic pressures and vehicular loads of 20,800 lbs total equaling H20 AASHTO truck loading, rear wheel load of 16,000 lbs plus a 30 percent impact load of 4,800 lbs.

B. Performance Requirements: Arrange and route conduits as shown to allow pulling-in of conductors without exceeding the conductor's tension limits.

1.3 SUBMITTALS

A. General: Furnish all submittals, including the following, as specified in Division 1.

B. Product Data and Information: Furnish manufacturer's data for conduits, manholes, handholes and all accessories.

C. CONTRACTORS' Shop Drawings: Furnish working drawings for underground electrical raceway system showing conduits, concrete encasement, manholes, handholes, electrical equipment pads and reinforcing. Indicate the designation, type, size, location, elevations and slopes of the system. Provide scaled profile drawings as needed to resolve conflicts among the various disciplines and existing infrastructure. Profile drawings are to be scaled 1"=20'-0" horizontal and 1"=5'-0" vertical.

D. Quality Control: Furnish a signed and sealed certification from a professional engineer registered in Oklahoma stating that the design calculations and drawings for the precast concrete manholes and handholes were prepared by that professional engineer or under his direct supervision.

1.4 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store and handle all products and materials as specified in Division 01.

1.5 PROJECT CONDITIONS

A. Existing Conditions: Examine record drawings to determine the location of all obstructions along the conduit or cable route and at the sites of manholes, handholes and outdoor electrical equipment pads. Contact the local underground utility locator service and confirm the location of all existing utilities prior to excavating for new work.

B. Field Measurements: Field survey, and in critical areas, excavate test pits to verify locations of probable obstacles along the conduit or cable route and at the sites of manholes, handholes and outdoor electrical equipment pads.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted for review.

1. Conduit Spacers

a. Carlon -Thomas & Betts/ABB Group
b. Underground Devices, Inc.

2. Precast Manholes and Handholes

a. Penn-Cast Products, Inc.
b. Hartford Concrete Products, Inc.
c. Jensen Precast
d. Rockway Precast
e. Oldcast Precast

3. Manhole and Handhole Frames and Covers

a. Neenah Foundry Co.

4. Buried warning tape

a. Ezcode - Thomas & Betts/ABB Group
b. W. H. Brady Company

5. Manhole Accessories (pulling irons, cable rack and supports, insulators)

a. Underground Devices Inc.
b. A.B. Chance/Hubbell Power Systems

2.2 MATERIALS

A. Conduit: Provide conduits meeting the requirements of Section 26 05 33.

B. Cable: Provide cables meeting the requirements of Section 26 05 19.

C. Spacers: Provide rigid plastic, conduit spacers to maintain conduit separation as indicated.

D. Reinforcing Steel: Provide reinforcing steel meeting the requirements of Section 03 20 00.

E. Concrete: Provide concrete meeting the requirements of Section 03 31 00. Dye “red” the top layer of concrete for duct bank encasements.

F. Manhole and Handhole Frames and Covers: Provide waterproof cast iron manhole and handhole frame and solid bolted cover suitable for H-20 truck load. Cast the word "ELECTRIC" in the cover. Provide frame with a clear opening of 36 inches, unless otherwise shown.

G. Precast Manholes and Handholes: Provide precast manholes and handholes meeting the following criteria:

1. Submit shop drawings showing reinforcing in accordance with ACI-SP-66.

2. Submit detailed plans and sections showing all specified features and components.

3. Submittals shall bear the seal of the registered professional structural engineer who oversaw the design of the manholes and handholes.

4. Units shall comply with ASTM C478 and C478M.

5. Construct units using precast monolithic or assembled sections. Base and first riser shall be monolithic.

6. Provide tongue and groove joints for interlocking adjoining components. Seal all joints watertight using preformed plastic or rubber materials conforming to ASTM C990 or GSA SS-S-210A.

7. Provide lifting devices cast into units.

8. Identify all structures with the manufacturers' name embedded or otherwise permanently attached to an interior wall surface.

9. Provide window openings in walls to accept duct banks as shown on the plans. Terminate and make watertight all duct bank terminations.

10. Provide a sump pit in the floor at one corner for drainage.

11. Provide a circular centered opening in the roof suitable for accepting precast collars with frame and cover specified. Provide water stops at framed cold joints.

12. Provide a floor sleeve at a corner of the manhole for the onsite driving of a ground rod. Seal to make watertight after installing ground rod.

13. Provide a 1/4 X 2 inch continuous copper ground bus installed 12 inches above the floor and mounted on suitable standoffs along the interior perimeter of thel manhole for grounding of all metal parts within. Terminate all ground connections with exothermic welds. Where manholes consist of multiple compartments, provide a bonding conductor jumper between the ground buses in each adjacent compartment.

H. Grounding: Provide grounding meeting the requirements of Section 26 05 26 and Section 26 05 53.

I. Underground Warning Tape: Provide 6-inch wide detectable type plastic tape in red (electric), yellow (utility) and orange (communications) colors with suitable warning describing the type of buried electrical lines.

2.3 MANHOLE ACCESSORIES

A. Pulling-in Irons: Provide pulling-in irons constructed of hot-forged, hot-dip galvanized steel.

B. Cable Racks and Supports: Provide racks and supports of heavy-duty, hot-dip galvanized steel construction.

C. Insulators: Provide insulators made of high grade, dry process porcelain with smooth glazed surfaces.

PART 3 EXECUTION

3.1 CONDUIT INSTALLATION

A. General: Install underground, concrete encased and direct buried conduits as indicated.

B. Conduit Route: Establish and mark exactly conduit or cable routing. Resolve routing near existing obstacles and coordinate with other sitework. Maintain a 12-inch minimum longitudinal clearance from the conduit bank encasement or direct buried conduit to adjacent utility lines. Maintain a 6-inch minimum vertical clearance from the conduit bank encasement or direct buried conduit to utility lines at crossovers. Adhere to lines, grades, elevations and dimensions as shown.

C. Trench Excavation: Perform excavation work in accordance with the requirements of Section 31 23 16.

D. Workmat: Install concrete mat on trench bottom to provide an even base for concrete encased conduit bank in accordance with the requirements of Section 03 31 00.

E. Bedding: Provide a sand cover on trench bottoms to create a firm and smooth surface for direct buried conduits.

F. Spacers: Locate spacers at intervals of approximately four feet and stagger locations at each conduit tier to provide not less than 12-inches of longitudinal separation.

G. Conduit: Place conduit in straight lines and with a minimum slope of 0.25 percent (3 inches per 100 feet). Slope conduit down to manholes, handholes and structures. Install expansion fittings in straight runs exceeding 100-feet. Secure conduits in

place to prevent floating and movement. Provide innerducts with pull strings installed in all conduits scheduled for the routing of instrumentation wiring (Cat 5E, fiberoptic, twisted shielded, etc.) Provide spare innerducts to the maximum allowable capacity of the conduit size being used. Spare innerducts are to be of the same size used for the scheduled wiring.

H. Bends: Install 12-foot minimum radius bends in horizontal turns and vertical deflections. For bends used at ends of conduit runs install elbows with 4-foot minimum radius for 6-inch and 5-inch conduits, and elbows with 3-foot minimum radius for 4-inch and smaller conduits.

I. Inside Cleaning: Pull a standard flexible mandrel not less than 12-inches long, having a diameter approximately 1/4-inch less than the inside diameter of the conduit, through each conduit, then pull a brush with stiff bristles through each conduit. Replace conduit runs that do not allow the passage of the mandrel at no increase in Contract Price. Use the pneumatic method to draw into conduit the nylon or polypropylene pull line. Plug and seal all conduits after cleaning.

J. Concrete Reinforcing: Install concrete reinforcing meeting the requirements of Section 03 20 00. Provide ductbanks with No. 5 reinforcing, spaced 12 inches on centers, top and bottom, with No. 3 ties at 18 inches, unless otherwise shown.

K. Concrete Formwork: Install concrete formwork meeting the requirements of Section 03 10 00.

L. Outside Cleaning: Remove dirt, sand and debris around conduits and from workmat, prior to concrete placement.

M. Concrete Placement: Place concrete meeting the requirements of Section 03 31 00. Color the top layer for all duct bank encasements with a “red” sprinkled on dye, raked and vibrated in evenly.

N. Connections to Structures: Install as shown.

-

O. Backfilling: Backfill meeting the requirements of Section 31 23 23. Provide a cover layer of sand that is 6 inches deep above direct buried conduits or cables.

P. Underground Warning Tape: Provide one underground warning tape for each trench up to 18 inches wide. For trenches wider than 18 inches provide two underground warning tapesinstalled at each edge of the trench. Place the tape or tapes 12 inches below the finished grade.

Q. Markers: Provide 4-inch round, 6-inch thick, concrete markers identified with the letter "E" and directional arrows. Place these markers approximately every 200 feet along straight portions of conduit and cable runs, at each change in direction and at

the conduit run end. Install markers to protrude 1-inch above adjacent ground. Allow markers to protrude 1/2-inch in finished lawns. Do not place conduit markers at structures and at conduit risers.

R. Surface Finish: Restore existing pavements and curbs with materials and construction to match existing. Restore landscaped areas meeting the requirements of Section 32 90 00.

3.2 MANHOLES AND HANDHOLES

A. General: Provide precast reinforced concrete manholes and handholes as shown.

B. Location: Establish and mark manhole and handhole locations exactly. Resolve locations near existing obstacles and coordinate with other sitework. Adhere to orientation, elevations and dimensions as indicated.

C. Hole Excavation: Install hole excavations meeting the requirements of Section 31 23 16.

D. Cast-In-Place Manhole and Handhole Construction: Install cast-in-place manhole construction meeting the requirements of Sections 03 10 00, 03 20 00 and 03 31 00.

E. Precast Manhole and Handhole Installation: Place a 6-inch thick compacted crushed stone base on the bottom of the hole under the entire floor slab.

F. Manhole Entrance: Install concrete rings and frame with cover. Adjust position of frame and cover to protrude 1-inch above adjacent unpaved ground or to be flush with the finished surface of pavement.

G. Backfilling: Backfill meeting the requirements of Section 31 23 23.

H. Accessories: Install pulling-in-irons, cable racks with supports and insulators, grounding system and other items as indicated or otherwise required.

3.3 OUTDOOR ELECTRICAL EQUIPMENT PADS

A. General: Provide reinforced concrete pad for supporting Outdoor Utility Transformer according to latest AEP Meter and Service Guide.

B. Location: Establish and mark pad locations exactly. Resolve locations near existing obstacles and coordinate with other sitework under this Contract. Adhere to orientation, elevations and dimensions as shown.

C. Site Excavation: Provide site excavation meeting the requirements of Section 31 23 16.

D. Pad Construction: Install pad construction meeting the requirements of Sections 03 10 00, 03 20 00 and 03 31 00 and latest AEP Meter and Service Guide.

E. Conduit Entrances: Install conduit risers and laterals under pads prior to placement of pads. Separate conduits from pads as shown in latest AEP Meter and Service Guide.

F. Grounding: Install grounding conductors through pads meeting the requirements of Section 26 05 26 and latest AEP Meter and Service Guide.

END OF SECTION

SECTION 26 05 53

ELECTRICAL IDENTIFICATION

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for providing materials for the identification of electrical equipment, components, conduits, cables and wiring, and furnishing and installing safety signs.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 09 96 00 – High Performance Coatings
2. Section 26 05 00 - Basic Electrical Materials and Methods

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1.	ANSI C2	-	National Electrical Safety Code (NESC)
2.	ANSI Z535.1	-	Safety Color Code
3.	ANSI Z535.2	-	Environmental and Facility Safety Signs
4.	ANSI Z535.3	-	Criteria for Safety Symbols
5.	OSHA	-	Occupational Safety and Health Act

1.3 SUBMITTALS

A. General: Furnish all submittals, including the following, as specified in Division 01.

B. Product Data and Information: Furnish manufacturers' catalog data for safety signs, nameplates, labels and markers.

1. Furnish manufacturers' instructions indicating applicable conditions and limitations of use, storage, handling, protection, examination and installation of product.

C. CONTRACTOR's Record Drawings: Furnish CONTRACTOR's record drawings accurately showing the actual location and elevation of underground ducts, handholes and manholes at the completion of the Project.

1.4 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store and handle all products and materials as specified in Division 01.

1.5 SPARE PARTS

A. General: Furnish the following spare parts.

1. Ten safety signs of each size and wording.

B. Packaging: Package spare parts in containers bearing labels clearly identifiying the contents. Provide all spare parts with information needed for reordering. Deliver spare parts in original factory packaging.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted for review.

1. W. H. Brady Company
2. Seton
3. Thomas & Betts/ABB Group

2.2 MATERIALS AND COMPONENTS

A. General: Provide identification materials listed and classified by UL or tested by an acceptable Electrical Testing Company certifying the equivalence of the materials to UL listing requirements and OSHA approved.

B. Laminated Plastic Nameplates: Provide engraved three layer laminated plastic nameplates with black letters on white background and fastened with corrosion-resistant screws. Do not use mounting cement for fastening nameplates.

1. Provide nameplates with 1-inch high lettering for switchgears, switchboards, motor control centers, control panels, relay panels, contactor panels, panelboards, and similarly grouped equipment, transformers and disconnect switches.

2. Provide nameplates with 1/2-inch high lettering for individual components of a group such as main breakers, switchgear units, switchboard units, motor control center units and similar devices.

3. Provide nameplates with 1/4-inch high lettering for remote motor controllers, control stations, relays and similar equipment.

4. Provide nameplates for each motor identifying service or function and lettering of an appropriate size to suit each motor.

5. Provide approved laminated directories of circuits with typewritten designations of each branch circuit in each panelboard.

6. Provide smaller lettering for a neat, legible nameplate where the amount of lettering causes excessively large nameplates.

C. Wire Markers: Identify wire bundles and each individual wire.

1. Wire bundles: Provide a brass or rigid fiber identifying tag attached with nylon self locking "Ty-Raps".

2. Wire identification markers: Provide a printed white, heat-shrink, seamless tubing type with black bold lettering for wires size No. 10 AWG and smaller. Provide a printed self-laminating white, vinyl type with black bold lettering for wires No. 8 AWG and larger.

D. Conduit Marking Paint: Provide conduit marking paint meeting the requirements of Section 09 90 00.

E. Safety Signs: Provide safety signs in accordance with OSHA standard meeting the requirements of ANSI C2, ANSI Z535.1, ANSI Z535.2 and ANSI Z535.3.

1. Provide safety signs manufactured from vinyl having a minimum thickness of 60 mils with red and black letters and graphics on a white background.
2. Size: 10 inches by 14 inches except signs 7-inch by 10-inch may be provided where the larger size cannot be applied.

3. Mount safety signs using corrosion-resistant screws. Do not use mounting cement.

F. Working Space Floor Markers

1. Provide paint or tape to mark the working space on the floor at electrical equipment.

a. Tape: 2-inch wide, 5-mil pressure-sensitive vinyl tape, black and white stripes with clear vinyl overlay. Manufacturer: 3M Safety Stripe Tape 5700.

b. Paint: Black and white to be applied in 2-inch wide stripes or checkers. Refer to Specification Section 09 96 00 – High Performance Coatings.

G. Working Space Labels

1. Provide labels indicating required working clearance at electrical equipment that is likely to require examination, adjustment, servicing, or maintenance while energized.

a. Material: Self-adhesive polyester with pressure-sensitive adhesive back. Outdoor labels shall be suitable for a high-UV environment.

b. Dimensions: Approximately 6-3/4 x 2 inches.

c. The top line on the label is to read "NOTICE" in a 48 point white italic font letters on a safety blue background.

d. Provide message wording in a 24 point black or safety blue font letters on a white background.

(1) Message wording for 208Y/120-volt equipment: "KEEP AREA IN FRONT OF THIS ELECTRICAL EQUIPMENT CLEAR FOR 3 FEET. OSHA-NEC REGULATIONS."

(2) Message wording for 480-volt and 480Y/277-volt equipment: "KEEP AREA IN FRONT OF THIS ELECTRICAL EQUIPMENT CLEAR FOR 3-1/2 FEET. OSHA-NEC REGULATIONS."

e. Manufacturer: Brady, Brother, Seton.

H. Underground Warning Tape

1. Provide underground warning tape for underground cables, conduits and duct banks.

2. Use 6 inch wide, 0.004 inch thick, polyethylene underground warning tape with black lettering and background colors as follows:

a. Electric: Red.

b. Telephone/Data: Orange.

3. Provide lettering that indicates the type of buried service.

a. Electric: "CAUTION ELECTRIC LINE BURIED BELOW"

b. Telephone/data: "CAUTION TELEPHONE LINE BURIED BELOW"

4. Manufacturer: Utility Safeguard, LLC.

PART 3 EXECUTION

3.1 PREPARATION

A. Surface Preparation: Degrease and clean surfaces to receive nameplates, labels and marking paint.

3.2 INSTALLATION

A. General: Install nameplates on the front of equipment, parallel to the equipment lines and secured with corrosion resistant screws. Caulk all screw holes with clear silicone caulk prior to attaching nameplates on NEMA 4X enclosures.

1. Install laminated nameplates identifying:

a. Each electrical equipment enclosure
b. Individual equipment and devices

B. Wire Markers: Identify wire bundles and each individual wire with identification tags as follows:

1. Wire Bundles: Install an identifying tag engraved with the conduit number where conduits enter motor control centers, switchgear, switchboards, control panels, terminal boxes and the like.

2. Wire identification markers: Provide wire identification markers on each wire at all termination points.

a. On power and lighting circuits: The branch circuit or feeder number as indicated on drawings

b. On control circuits terminated in motor control centers, switchgears, control panels and alike: The field device and terminal number of the opposite end connection.

c. On control circuits at each field device: The panel or compartment number and terminal number of the opposite end connection.

3. Oversize wire markers so that after heat shrinking the wire marker can be rotated on the wire. Rotate wire markers so that wire identification number is

4. 480-Volt System
5. 240/120-Volt System
6. 24/48/125-Volt dc System

C. Safety Signs: Provide safety signs as follows or as shown including existing locations and equipment not signed per current industry standards and being modified or reused under this Contract:

1. Type DS-1

a. Wording: “DANGER - BATTERY CHARGING AREA, NO SMOKING”

b. Location: Within 3 feet of all station battery racks.

2. Type DS-2

a. Wording: “DANGER - ELECTRICAL EQUIPMENT, AUTHORIZED PERSONNEL ONLY”

b. Location: At each entrance to electrical rooms, and enclosed outdoor electrical equipment.

3. Type DS-3

a. Wording: “DANGER - HIGH VOLTAGE, KEEP OUT”

b. Location: At each entrance to electrical rooms, and enclosed outdoor electrical equipment operating at over 600 Volts. Also, on the sides of fences or walls which enclose outdoor equipment operating at over 600 Volts.

4. Type DS-4

a. Wording: “DANGER - HIGH VOLTAGE”

b. Location: Outside all equipment operating at over 600 Volts.

5. Type DS-5

a. Wording: “DANGER - POWERED FROM MORE THAN ONE SOURCE”

b. Location: Outside all equipment that operates from more than one power source.

6. Type DS-6

a. Wording: “NOTICE - KEEP DOOR CLOSED”

b. Location: On all doors with another safety sign installed.

7. Type DS-7

a. Wording: “CAUTION - CONTROLS & INTERLOCKS POWERED FROM MULTIPLE SOURCES”

b. Location: On all control panel doors.

D. Working Space Floor Markers

1. Install floor marking tape or paint on the floor at the locations listed below to indicate working space required by the NEC.

a. Front and rear of each free-standing low-voltage switchgear or switchboard section.

b. Front of each low-voltage transformer, switchboard, panelboard, industrial control panel, motor control center, enclosed circuit breaker, safety switch, and motor controller enclosure including those furnished with mechanical equipment.

c. Any other equipment likely to require examination, adjustment, servicing, or maintenance while energized.

2. Dimensions of working space area are to be as follows:

a. Width: the greater of the width of the equipment or 30 inches.

b. Depth:

(1) Systems 600V and Below: In accordance with NEC Table 110.26(A)(1)

(2) Systems Over 600V: In accordance with NEC Table 110.31

3. Thoroughly prepare floor surface to receive tape or paint.

4. Where marking tape is used, outline working space with tape then infill with diagonal tape stripes placed 6 inches on center.

5. Where paint is used, cover working space area with alternating 3 to 6 inch wide black and white diagonal stripes.

E. Working Space Labels

1. Provide working space labels at the following locations positioned at the optimal height for reading when standing facing the equipment:

a. Front and rear of each medium-voltage switchgear.

b. Front of each medium-voltage transformer.

c. Front and rear of each freestanding low-voltage switchgear or switchboard section.

d. Front of each low-voltage transformer, panelboard, industrial control panel, motor control center, enclosed circuit breaker, safety switch, and motor controller enclosure, including those furnished with mechanical equipment.

e. Any other equipment likely to require examination, adjustment, servicing, or maintenance while energized.

F. Underground Warning Tape

1. Install underground warning tape in the trench above underground conduit(s), 1 foot below the finished grade.

END OF SECTION

SECTION 26 05 73

SHORT CIRCUIT AND COORDINATION STUDY

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Short circuit and coordination study for the entire power distribution system.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 26 24 13 - 480 Volt Switchboards
2. Section 26 12 00 - Pad-Mounted Transformers
3. Section 26 08 00 - Electrical Testing Requirements

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. IEEE 242, "IEEE Recommended Practices for Protection and Coordination of Industrial and Commercial Power Systems"

2. IEEE 399, "IEEE Recommended Practices for Industrial and Commercial Power Systems Analysis"

3. NFPA 70 - National Electrical Code (NEC)

1.3 SYSTEM DESCRIPTION

A. Utility Data: Contact the electric utility to obtain the available fault current ratings. Refer to Section 26 05 10 – Electric Utility Coordination and Requirements for contact information.

B. Requirements: Furnish a short circuit and coordination study for the entire distribution system. Include the following in the short circuit study:

1. One-line diagram of the entire distribution system identifying all components considered and ratings of all power devices. Use ANSI device numbers to identify all protective devices.

2. Calculation of momentary and interrupting fault duties for each bus.

3. Calculation of bus-to-bus impedance values reduced to a common MVA base.

4. Individually consider all motors 100 horsepower and greater. Group motors less than 100 horsepower into one equivalent motor at the motor control center bus or switchboard distribution section.

5. A table listing the rating of each interrupting device related to the calculated duty and suggest changes when appropriate.

6. A table listing settings for all adjustable devices. Furnish these settings as a practical compromise between protection of equipment and coordination of downstream devices.

7. Time-current coordination curves to illustrate the protection and coordination achieved. Furnish curves that include:

   a. Appropriate NEC protection points

   b. Appropriate ANSI protection points

   c. Transformer magnetizing inrush and through-fault protective curve

   d. Motor starting characteristics

   e. Cable damage limit levels

   f. One-line diagram of system plotted

   g. Short circuit current levels

8. Analysis and recommended settings for all adjustable overvoltage, undervoltage and voltage unbalance protective devices. Include voltage and time delay settings.

9. In all areas that study results indicate a lack of coordination, recommend changes to achieve coordination where circuit breakers and protective relays with adjustable settings are applied. Where coordination cannot be achieved due to the application of non-adjustable devices, identify all such devices in the study for replacement consideration by the Engineer.

C. Provide a Flash Hazard Study for the electrical distribution system as defined above. The intent of the Flash Hazard Study is to determine hazards that exist at each piece of electrical equipment. This includes switchgear, panelboards, motor control centers, unit substations, automatic transfer switches, variable frequency drives,

transformers, disconnect switches and lighting panels. Include the following in the study for each pumping station:

1. Develop scenarios for the flash hazard study that consider operation during normal conditions and alternate operations such as emergency power conditions and any other operations which could result in an arc flash hazard.

2. Perform an flash hazard study after the short circuit and protective device coordination study has been updated to reflect installed equipment characteristics and wiring configurations.

3. Incorporate pertinent data, rationale employed, and assumptions in developing the calculations in the introductory remarks of the study.

4. Perform the study in accordance with applicable NFPA 70E, OSHA 29-CFR, Part 1910 Sub part S and IEEE 1584. Base the results of the flash hazard study on the IEEE 1584 method.

5. Determine the following for each bus

   a. Flash Hazard Protection Boundary

   b. Limited Approach Boundary

   c. Restricted Boundary

   d. Prohibited Boundary

   e. Incident Energy Level

   f. Required Personal Protective Equipment PPE Class

   g. Type of Fire Rated Clothing

6. In all areas that the study results indicate an arc flash hazard of Category 4 or greater, investigate and recommend changes that could be made to the electrical system that would lower the Category to below Category 3.

1.4 SUBMITTALS

A. Short Circuit and Coordination Study: Furnish all submittals, including the following, as specified in Division 01.

1. An executive summary of the study results and data

2. A tabulation of all protective device ratings compared with calculated fault duties

3. A tabulation of settings for all adjustable protective devices

4. A tabulation of all distribution equipment comparing the equipment ratings to the available fault current ratings.

5. Copies of all time-current coordination curves

6. Analysis of the data that led to the conclusions and recommendations included in the executive summary

7. The one-line diagram of the studied system including all ratings and identifications

8. Copies of all computed results referenced to the one-line diagram and the impedance listing

9. Furnish six bound copies of the final report

10. Preliminary and final reports are to be wet sealed and signed by a registered professional electrical engineer licensed in the State of Oklahoma overseeing the preparation of the study.

11. Furnish four CD-ROM containing the following:

    a. Complete copy of the report in PDF format

    b. Acrobat Reader

    c. Distribution system one-line diagrams in AutoDesk AutoCAD latest version drawing format.

    d. Short circuit and coordination study data is to include a project file containing all related input and component data, one line diagrams and library files compiled using SKM Power Tools or equivalent software. Equivalent software must be totally compatible with SKM Power Tools to allow for future updates to the study using the preferred named software.

    e. All voltage data.

12. Furnish the Short Circuit and Coordination Study in two stages. Submit a preliminary study containing the data necessary for confirming the interrupting and withstand ratings needed for electrical distribution equipment

being provided. The preliminary study is to be submitted and conditionally approved prior to submitting on the electrical distribution equipment. The final report is to contain all preliminary and final data required per this specification section.

B. Arc Flash Hazard Study: Furnish all submittals including the following as specified in Division 01.

1. Provide Arc Flash Hazard labels containing information as specified.

2. Produce Arc Flash Hazard Evaluation Summary Sheet listing the following additional items:

a. Bus name

b. Upstream protective device name, type, and settings

c. Bus line to line voltage

d. Bus bolted fault

e. Protective device bolted fault current

f. Arcing fault current

g. Protective device trip/delay time

h. Solidly grounded column

i. Equipment type

j. Arc flash boundary

k. Working distance

l. Incident energy

m. Required Protective Fire Rated Clothing Type and Class

3. The contractor shall submit each arc flash hazard study and all flash warning labels at least 30 days prior to energizing new electrical equipment.

4. Final documents with the exception of the labels are to be wet sealed and signed by a registered professional electrical engineer licensed in the State of Oklahoma overseeing the preparation of the study.

1.5 QUALITY ASSURANCE

A. Qualifications: Conduct the study using a power-system engineering, study or analysis organization with the following means and qualifications:

1. Five or more years experience performing this type of work

2. A proven computer program for performing 3-phase fault-duty calculations

3. A demonstrated capability for calibrating and setting protective devices.

4. Provide the services of a lead individual for the study who has a minimum of five years experience in performing 3-phase, fault-duty calculations. Certification of the study by a Registered Professional Electrical Engineer licensed in the State of Oklahoma.

B. Conduct the arc flash study using a power system engineering study or analysis organization with the following qualifications:

1. Two or more years in performing arc flash hazard studies of this type.

2. Certification of the study by a Registered Professional Electrical Engineer licensed in the State of Oklahoma.

PART 2 PRODUCTS

Not used

PART 3 EXECUTION

3.1 PREPARATION

A. General: Gather the necessary data to complete the short circuit and protective curve coordination calculations. Obtain from field surveys and shop drawings informational data pertaining to product manufacturer, type and rating of PT's, CT's circuit breakers, fusing, relays, auxiliaries, and the like. Distribution equipment and shop drawing data may be reviewed at the site.

B. Data: Estimate the lengths and sizes of cables shown on the one-line diagrams from the Contract Drawings or from field observations and measurements.

3.2 SHORT CIRCUIT STUDY AND PROTECTIVE DEVICE EVALUATION STUDY

A. General: Include in the input data for the short circuit study the power company's short circuit contribution, resistance and reactance components of the branch impedances, the X/R ratios, base quantities selected, and other source impedances.

B. Calculations: Calculate the three-phase, bolted, short circuit and single-phase, line-to-ground short circuit current values. Calculate close and latch duty values and interrupting duty values on the basis of calculated three-phase, bolted, short circuit currents at each bus. Buses include, but are not limited to, transformers, switchgears, medium-voltage motor control centers, switchboards, low-voltage motor control centers, distribution panelboards, pertinent branch circuit panels and other significant locations throughout the system. Include in the short circuit tabulations symmetrical fault currents and X/R ratios. List for each fault location, the total duty on the bus, as well as the individual contribution from each connected branch, with its respective X/R ratio.

C. Protective Device Evaluation Study: Perform a protective device evaluation study to determine the adequacy of circuit breakers, molded case switches, automatic transfer switches, and fuses by tabulating and comparing the short circuit ratings of these devices with the calculated fault currents. Apply appropriate multiplying factors based on system X/R ratios and protective device rating standards.

3.3 PROTECTIVE DEVICE COORDINATION STUDY

A. General: Perform a protective device coordination study to provide the necessary calculations and logic decisions required to select or to check the selection of power-fuse ratings, protective-relay characteristics and settings, ratios and characteristics of associated current transformers, and low-voltage, breaker trip characteristics and settings.

B. Study Items: Include in the coordination study all medium and low voltage classes of equipment from the building or plant service protective devices down to and including the highest rated device in the low-voltage motor control centers and panelboards. Include the phase and ground overcurrent protection as well as the settings of all other adjustable protective devices.

C. Plotted Data: Plot the time-current characteristics of the specified protective devices on log-log paper. On the plots, include complete titles, representative one-line diagram and legends, significant motor starting characteristics, complete parameters of transformers, and the complete operating bands of low-voltage, circuit breaker, trip curves and fuses. Indicate the types of protective devices selected, proposed relay taps, time dial and instantaneous trip settings, transformer magnetizing inrush and ANSI transformer withstand parameters, cable thermal overcurrent withstand limits and significant symmetrical and asymmetrical fault currents. Adhere to all

restrictions of the National Electrical Code and proper coordination intervals and maintain separation of characteristic curves. Furnish the coordination plots for phase and ground protective devices on a system basis. Use a sufficient number of separate curves to clearly indicate the coordination achieved.

D. Tabulation of Data: Furnish the selections and settings of the protective devices separately, in tabulated form, listing circuit identification; IEEE device number; current transformer ratios and connection; manufacturer and type; range of adjustment and recommended settings. Furnish a tabulation of the recommended power fuse selection for the medium-voltage fuses where applied in the system.

E. Settings: Furnish the protective relay characteristics, tap and time dial settings required by the coordination study to the switchgear manufacturer for selection of protective devices.

3.4 FLASH HAZARD STUDY

A. General: Perform each flash hazard study utilizing data obtained from the Short Circuit and Protective Device Coordination Study. Follow procedures established by IEEE 1584.

B. Study Items: Include all electrical equipment greater than 240-volts.

C. Tabulation of Data: Furnish in tabulated form, the results of each study, detailing for each equipment the following:

1. Flash hazard boundary

2. Limited approach boundary

3. Restricted boundary

4. Prohibited boundary

5. Incident energy level

6. Required personal protective equipment class

7. Type of fire rated clothing

D. Arc Flash Warning Labels: Provide arc flash warning labels in accordance with OSHA standards meeting the requirements of ANSI Z535.4. Position labels at the optimal height for reading when facing the equipment. Provide labels front and rear on all front and rear accessible equipment. Provide labels on every other vertical section of equipment comprised of multiple sections and at a minimum on all sections containing main and tie circuit breakers.

1. Provide arc flash warning labels for switchgear, switchboards, load interrupter switches, transformers, panelboards, industrial control panels, motor controllers (including those furnished with packaged equipment), motor control centers, safety switches, pullboxes containing exposed low or medium voltage conductors and other equipment as required by the NEC.

2. Provide labels that are printed on self-adhesive polyester with pressure-sensitive adhesive back and covered with a clear polyester film. Labels shall be suitable for use outdoors and be high-UV resistant.

3. Provide labels measuring approximately 4 inches high by 5 inches wide.

4. Where the incidental energy level is less than 40 cal/cm2, the top line on the label is to read "WARNING" in black letters on an ANSI compliant "Orange" background. Where the incidental energy level is 40 cal/cm2 or higher, the top line on the label is to read "DANGER" in black letters on an ANSI compliant "Red" background. All other lettering is to be black on a white background.

5. The second line on "WARNING" labels is to read "Arc Flash Hazard and Shock Hazard Appropriate PPE Required".

6. The second line on "DANGER" labels is to read " NO SAFE PPE EXISTS ENERGIZED WORK PROHIBITED".

7. Other label information is to include the following:

    a. Flash Protection Parameters

        (1) Hazard Distance in Inches
        (2) PPE Arc Rating in Cal/cm2
        (3) Flash Boundary in Inches

    b. Shock Protection Parameters
        (1) Exposed Line to Line Voltage
        (2) Limited, Restricted and Prohibited Approach Minimum Distances in Inches

    c. Miscellaneous Information

        (1) Electrical Equipment Designation
        (2) Upstream Overcurrent Protection Device Location

Manufacturer: Electromark, Seton, Safety Label Solutions

3.5 STUDY REPORT

A. General: Summarize the results of the power system study in a final report.

B. Presentation of Short Circuit and Coordination Report: Include the following sections in the short circuit and coordination report..

1. Executive Summary

2. Description, purpose, basis and scope of the study and a one line diagram of that portion of the power system which is included within the scope of the study

3. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short circuit duties, and commentary regarding the same

4. Tabulations of electrical distribution equipment comparing the equipment ratings to the available fault current ratings.

5. Protective-device, time–versus-current, coordination curves; tabulations of relay and circuit breaker trip settings; fuse selections, and commentary regarding the same.

6. Fault current calculations including a definition of terms and guide for interpretation of computer printout.

C. Presentation of each Flash Hazard Report. Include the following sections in the flash hazard study report:

1. Introduction

2. Executive summary

3. Recommendations and assumptions

4. One line drawing.

5. Arc flash evaluations summary spreadsheet

6. Bus detail sheets

7. Arc flash hazard warning labels.

8. Recommendations: Analyze the short circuit, protective device coordination, and arc flash calculations and highlight any equipment that is determined to be underrated or causes an abnormally high incident energy calculation.

Propose approaches to reduce the energy levels. Proposed major corrective modifications will be taken under advisement by the ENGINEER and the Contractor will be given further instructions.

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 26 05 80

ELECTRIC MOTORS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for electric motors as specified.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 09 96 00 - High Performance Coatings
2. Section 26 05 00 - Basic Electrical Materials and Methods
3. Section 26 05 33 - Electrical Raceway Systems
4. Section 26 05 53 - Electrical Identification
5. Section 26 05 26 - Grounding

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. AFBMA 10 - Metal Balls
2. NEMA CP1 - Shunt Capacitors
3. NEMA MG1 - Motors and Generators
4. NFPA 70 - National Electrical Code (NEC)

1.3 SUBMITTALS

A. General: Furnish all submittals, including the following, as specified in Division 01 and Section 26 05 00.

B. Product Data and Information: Furnish manufacturer's catalog data for each motor.

C. Shop Drawings: Furnish shop drawings for each motor detailing arrangement, wiring, conduit boxes, and motor application.

D. Certificate of Compatibility: For each motor controlled by an adjustable frequency drive, furnish a certificate that the motor is compatible with the adjustable frequency drive and the driven equipment load.

E. Quality Control: Furnish test reports for motors as follows:
1. Actual shop test reports for motors over 200 hp.

2. Witnessed test reports as specified.

F. Operations and Maintenance Manuals: Furnish operation and maintenance manuals for all motors as specified in Division 1.

1.4 QUALITY ASSURANCE

A. Codes: Comply with all local and applicable codes.

B. Regulatory Requirements: Comply with the requirements of the Regulatory Agencies having jurisdiction over this Project.

1.5 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store and handle all products and materials as specified in Division 01.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Acceptable manufacturers are listed below.

1. Nidec/U.S. Motors
2. GE

2.2 MATERIALS

A. General: Provide motors and accessories with the equipment as specified under the equipment sections.

B. Motor Requirements: Unless otherwise specified, provide motors as follows:

1. Polyphase motors of the high energy efficiency and high power factor type.

2. Motor nameplate horsepower as specified for the driven equipment.

3. Motors that operate continuously over the entire load range of the driven equipment without loading motor in excess of nameplate rating and its specified temperature limit.

4. For motors rated over 200 hp, operating at 460 volts or higher voltages, 3-phase, 60-hertz, provide squirrel cage induction or synchronous type, as specified.

5. Motors that are suitable for continuous operation with a line voltage variation within ± 10-percent of rated voltage.

6. Motors that operate continuously in a 40 degrees C ambient.

7. Inverter duty motors when powered from an adjustable frequency drive.

   a. Where required for existing motors, provide either in a qualified motor maintenance shop or at the project site.

   b. For horizontal mounted motors provide protection as follows:

      (1) Top Bearing (NDE): Bearing journal installed must be insulated or insulated ceramic or hybrid ceramic.
      (2) Drive End (DE): Install one AEGIS™ SGR Bearing Protection Ring on drive end.
      (3) AEGIS™ SGR can be installed internally on the back of the bearing cap or externally on the motor end bracket.
      (4) Colloidal Silver Shaft Coating (PN CS015) is required for this type of application

8. Provide a certificate of compatibility signed by both the motor and ground ring manufacturer confirming the ground ring being installed per the manufacturer's requirements with no detriment to proper motor operation.

C. Frequent Start Requirements: Provide motors for frequent starting as specified.

2.3 MECHANICAL PROTECTION

A. Indoor Locations:

1. For motors located in dry, clean and well-ventilated areas provide open drip-proof type.

B. Hazardous Locations: As defined in Section 26 05 00 or as shown or required by the NEC.

1. N/A

2.4 BOXES

A. General: Provide oversized conduit boxes on motors to facilitate conductor installation and auxiliary components as required.

1. Provide separate boxes for motor power leads, accessory terminals and RTD leads.

2. Make conduit box NEMA enclosure ratings compatible with motor enclosures.

3. Where shown, provide additional space in the power terminal box for the mounting and wiring of the current transformers furnished under the motor protection system.

2.5 NEMA DESIGN AND INSULATION

A. Design Classification: NEMA MG-1 Standards

B. Variable Speed Operation: Provide insulation to protect against adverse affects of a nonsinusoidal waveform.

2.6 WINDINGS

A. General: Provide copper windings unless otherwise specified.

2.7 BEARINGS

A. Ball and Roller Bearings: Use antifriction ball or roller type bearings at manufacturer's option, unless otherwise specified.

B. Regreasable Bearings: Use regreasable bearings with adequate loadings, with a AFBMA B-10 bearing life rated at least 100,000 hours, based on a reliability of 90 percent.

2.8 SERVICE FACTOR AND LOADINGS

A. Service Factor: Where motors with a 1.0 service factor are furnished, provide motors rated at least 15 percent greater than required brake horsepower.

B. Shaft Loading: Provide steady state shaft loading not to exceed 100 percent of full load rating under maximum load, excluding the service factor, unless otherwise specified.

2.9 SPEED

A. Adjustable Speed: Provide inverter duty motors specifically designed and rated for use with the adjustable speed device furnished.

2.10 TORQUE

A. General: Provide breakdown torque of 200 percent or more of motor full load torque.

B. Locked Rotor: Provide locked rotor torque of 80 percent or more of motor full load torque.

C. Inertia: Provide necessary WK^2 data for special loads to coordinate with motors.

2.11 SLIDE RAILS AND SOLE PLATES

A. General: Provide slide rails and sole plates as required for proper installation.

2.12 EFFICIENCY

A. General: Provide motors one horsepower and larger meeting the requirements as stated in Table 12-12, Full Load Efficiency for NEMA Premium Efficiency Electric Motors, in NEMA MG 1, Part 12.

2.13 NOISE

A. General: Limit motor machine noise to sound power levels listed in NEMA MG 1-12.

2.14 ACCESSORIES

A. Identification: Provide identification meeting the requirements with Section 26 05 53.

B. Space Heaters: Provide motor space heaters to prevent moisture condensation when the motor is not operating. Provide space heaters suitable for 115-volt, single phase, 60-hertz operation.

C. Resistance Temperature Detectors (RTDs): Where specified or shown, provide two motor bearing and six winding RTDs of the 100-ohm platinum, three-wire type.

D. Vibration Sensors: Provide and mount at the pump, two in a right angle at the thrust bearing, one at the suction bearing, and one at the outboard bearing, four total.

2.15 SOURCE QUALITY CONTROL

A. Shop Tests: Perform actual job motor shop tests for motors over 200 hp. Include standard commercial and additional tests listed below, and special tests listed in other sections.

B. Standard Commercial Tests: Perform the following tests in accordance with NEMA standards.

1. No load running current and speed

2. Locked rotor current

3. Dielectric routine tests

4. Motor efficiency tests

5. Motor power factor tests

C. Additional Testing: Perform the following additional tests in accordance with NEMA standards.

1. Winding resistance

2. Bearing inspection

3. Power factor at full, 3/4 and 1/2 load

4. Efficiency at full, 3/4 and 1/2 load

5. Motor starting torque

6. Bearing currents testing per manufacturer’s specifications

7. Motor frame grounding

PART 3 EXECUTION

3.1 INSTALLATION

A. General: Install motors in accordance with the manufacturer's recommendations and approved shop drawings and as specified in Division 1. Make all necessary adjustments to equipment to provide a complete operational system.

3.2 FIELD QUALITY CONTROL

A. Inspections and Tests: Perform field preliminary and final inspection and testing for motors as specified in Division 01 and as follows:

1. Preliminary Inspection:

a. Demonstrate that each motor has been properly connected.

b. Check for proper rotation by bumping prior to connecting motor to driven equipment.

2. Final Test:

a. Measure motor applied voltage and current with equipment operating at full load.

b. Operate equipment as specified.

3.3 CLEANING AND PAINTING

A. Shop Painting: Paint the motors in accordance with the requirements of Section 09 96 00.

B. Field Painting: Clean and touch up marred surfaces to match the original finish.

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 26 08 00

ELECTRICAL TESTING REQUIREMENTS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for field acceptance testing of materials and equipment provided under various other sections to determine suitability for installation and energization. Requirements of field testing and certification of electrical equipment and materials provided under various other sections to assess their equivalence to UL Inc. listing/labeling.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 26 05 19 - Wires and Cables – 600V and Below
2. Section 26 05 26 - Grounding
3. Section 26 05 80 - Electric Motors
4. Section 26 22 00 - General Purpose Dry Type Transformers
5. Section 26 24 16 - Panelboards
6. Section 26 29 23 - Adjustable Frequency Drives
7. Section 26 36 23 - Automatic Transfer Switches

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. NETA - Inter National Electrical Testing Association

2. NIST - National Institute of Standards and Technology

1.3 SUBMITTALS

A. General: Furnish all submittals including the following, as specified in Division 01 and Section 26 05 00.

1. Acceptance Testing Reports: Furnish acceptance testing reports for all equipment and materials. Include the following information:

a. Summary of the test
b. Description of material or equipment tested

c. Description of test including acceptable test values
d. Test results
e. Analysis of test results with recommendations

2. UL Testing: Furnish standard test parameters in accordance with the acceptable codes and standards for all the equipment and materials tested for equivalence to UL listing.

3. UL Test Reports and Certificates: Submit for approval test reports and certificates for all equipment and materials tested for equivalence to UL listing.

PART 2 PRODUCTS

2.1 TESTING COMPANIES

A. Acceptable Testing Companies: Acceptable testing companies are as listed below:

1. Industrial Electric & Testing

2. Sentinel Power Services, Inc.

3. Power Testing Services, LLC

4. UL Underwriters Laboratories Inc.

5. Other OSHA and NETA approved testing facilities

2.2 SOURCE QUALITY CONTROL

A. Tests: Furnish all testing and certification in accordance with the latest NETA, ANSI, IEEE and NEMA Standards to meet the UL requirements, NFPA Standards and NEC.

B. Test Equipment: Furnish all testing equipment, cables and appurtenances required to perform all tests and certifications in accordance with the following:

1. Use instruments that have been calibrated, to assure that they are within rated accuracy in accordance with NIST.

2. Select test instruments that are appropriate for the variable being measured.

PART 3 EXECUTION

3.1 UL TESTING AND CERTIFICATION

A. General: Furnish the test reports and certifications for UL equivalence prior to acceptance of all materials and equipment requiring such tests and certifications.

3.2 ACCEPTANCE TESTING

A. General: Furnish acceptance test reports prior to acceptance of all materials, equipment and installations requiring such tests.

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 26 22 00

GENERAL PURPOSE DRY TYPE TRANSFORMERS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for furnishing and installing ventilated, dry-type transformers.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 09 96 00 – High Performance Coatings
2. Section 26 05 00 – Basic Electrical Materials and Methods
3. Section 26 05 26 – Grounding

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. ASTM D 635 - Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position
2. 78 FR 23335 - Energy Conservation Program: Energy Conservation Standards for Distribution Transformers
3. NEMA ST 20 - Dry Type Transformers for General Applications
4. NFPA 70 - National Electrical Code (NEC)
5. UL 1561 - Standard for Dry-Type General Purpose & Power Transformers

1.3 SUBMITTALS

A. General: Furnish all submittals, including the following, as specified in Division 01 and Section 26 05 00.

B. Product Data and Information: Furnish manufacturer's data including:

1. KVA ratings
2. Service voltages

3. Impedance and X/R ratio
4. Number of phases
5. Taps
6. Insulation class
7. Sound level
8. Dimensions
9. Weights
10. Mounting details

C. Quality Control: Furnish the following as specified in Division 01.

1. Test Reports:

a. Certified production reports for sound-level and temperature in accordance with NEMA ST 20

2. Manufacturer's Installation Instructions

D. Operations and Maintenance Manuals: Furnish 6 copies of manufacturer's operations and maintenance manuals.

1.4 QUALITY ASSURANCE

A. UL Label: Provide UL listing label or mark showing compliance with UL 1561.

B. Provide all transformers rated 15 kVA or larger in accordance with 78 FR 23335.

1.5 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store and handle all products and materials as specified in Division 01 (and as follows:)

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted for review.

1. Eaton/Cutler-Hammer
2. Square D/Schneider Electric
3. Siemens
4. ABB

2.2 MATERIALS

A. General: Provide dry-type transformers suitable for indoor use.

B. Insulation: Provide transformers above 15 kVA with 220-degree C temperature insulation class. Provide transformers 15 kVA and below with a minimum of 180-degree C temperature insulation class.

C. Flame Retardant Materials: Provide transformers with flame retardant materials that will not support combustion as defined in ASTM D 635.

2.3 FABRICATION

A. Transformer Taps: Provide transformers rated over 15 kVA with at least two 2-1/2 percent full capacity taps above and below nominal in the primary winding. Provide transformers rated 15 kVA and below with two 5 percent taps or with four 2-1/2 percent taps below rated voltage on the primary winding.

B. Windings: Provide primary and secondary windings fabricated from copper conductors.

C. Voltage and KVA Ratings: Provide three-phase or single-phase transformers with primary and secondary voltages and kVA ratings as specified.

D. Connections:

1. Single Phase: Primary – 2-wire; Secondary – 3-wire with mid-point solidly-grounded.

E. Continuous Operations: Provide transformers suitable for continuous operation at the rated kVA with a normal life expectancy as defined in NEMA ST 20 and the performance obtained without exceeding 115 degrees C average temperature rise by resistance or 145 degrees C hot spot temperature rise in 40-degree C maximum ambient and 30-degree C average ambient. Provide transformers that do not exceed 150-degree C maximum operating temperature.

F. Electrostatic Shields: Provide electrostatic shields between windings.

G. Construction: Provide transformers with core mounting frames and enclosures of welded and bolted construction with sufficient mechanical rigidity and strength to withstand shipping, erection, and short circuit stresses.

H. Sound Levels: Provide transformers that do not exceed the following sound levels, when measured in accordance with NEMA ST 20:

Transformer kVA	Average Sound Level in dB
0 – 9	40
10 – 30	45
31 – 50	48
51 – 150	53

I. Lifting Lugs and Jacking Plates: Provide lifting lugs and jacking plates as required on the transformer.

PART 3 EXECUTION

3.1 INSTALLATION

A. General: Install all transformers and provide guards as specified by the latest NEC and ANSI standards, and in accordance with manufacturer's instructions.

B. Clearances: Provide clearance around the transformer meeting the manufacturer's recommendation.

C. Supports: Provide suitable supports for all transformers. Mount transformers on one inch of elastomeric pad sound-absorbent material.

D. Primary Disconnect: Provide primary disconnect circuit breaker or disconnect switch as shown or required.

E. Grounding: Connect transformers to grounding system in accordance with Section 26 05 26.

3.2 CLEANING AND PAINTING

A. Shop Painting: Paint transformers meeting the requirements of Section 09 96 00.

B. Field Painting: Clean and touch up scratched and marred surfaces to match the original finish.

END OF SECTION

SECTION 26 24 13

480 VOLT SWITCHBOARDS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for providing, and testing 480-volt front accessible switchboards including the following major components:

1. Stationary structure including bus bars
2. Main power circuit breakers
3. Group-mounted, molded-case distribution circuit breakers
4. Control, protection, monitoring and metering equipment

B. Related Work Specified in Other Sections Includes, But is Not Limited to the Following:

1. Section 01 79 00 - Training
2. Section 26 05 00 - Basic Electrical Materials and Methods
3. Section 26 05 26 - Grounding
4. Section 26 05 53 - Electrical Identification
5. Section 26 08 00 - Electrical Testing Requirements
6. Section 26 05 19 - Wires and Cables - 600 Volts and Below
7. Section 26 05 10 - Utility Coordination and Requirements
8. Section 40 94 13 - Process Control System Computer and Network Hardware

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. NFPA 70 - National Electrical Code (NEC)

2. IEEE C37.90 - IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus

3. IEEE C62.41 - IEEE Recommended Practice on Surge Voltages in Low Voltage AC Power Circuits

4. IEEE C62.45 - IEEE Guide on Surge Testing for Equipment Connected to Low Voltage AC Power Circuits

5. MIL-STD-220A- Method of Insertion-loss Measurement 12/1/59; with N1 and N2 (Fed/mil H-q)

6. NEMA PB 2 - Dead-Front Distribution Switchboards

7. NEMA PB 2.1 - Proper Handling, Installation, Operation and Maintenance of Dead-Front Switchboards Rated 600 Volts or less

8. UL 486A - Wire Connectors and Soldering Lugs for Use with Copper Conductors

9. UL 891 - Dead-Front Switchboards

10. UL 1283 - Electromagnetic Interference Filters

11. UL 1449 - Surge Protective Devices

B. Material Workmanship Requirements: Provide all materials and workmanship meeting the requirements of NFPA Standards and Codes.

C. Design and Testing Requirements: Provide all switchboard components designed, manufactured and tested in accordance with the latest NEMA Standards; and UL listed.

D. Installation Requirements: Install the switchboard assemblies meeting the requirements of NEC and local Electrical Codes.

1.3 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 01.

B. Product Data and Information: Furnish the following:

1. Manufacturers' catalog data on switchboard assemblies and on each component detailing materials, ratings, type, model and reference number.

2. Layout drawings customized for the project including physical details, dimensions, clearances, mounting, elevations, sections, and nameplates.

3. Electrical control schematics, wiring diagrams, internal interconnection diagrams and interconnection diagrams including equipment external to the switchboard.

4. Terminal lists for all connections.

5. Provide instruction booklets and time-current curves for each circuit breaker supplied.

6. Provide microprocessor-based metering system and overload protection systems address, memory map and instruction booklets.

7. Furnish the following information on surge protective devices (SPD):

   a. Verification that SPD devices comply with UL 1449 and UL 1283 SVR.

   b. Actual let through voltage test data in the form of oscillograph results for both the ANSI/IEEE C62.41 Category C3 (combination wave) and B3 (ringwave) tests in accordance with ANSI/IEEE C62.45.

   c. Spectrum analysis of each unit based on MIL-STD-220A test procedures between 50 kHz and 200 kHz verifying that the device's noise attenuation exceeds 50 dB at 100 kHz.

   d. Test reports from a recognized independent testing laboratory verifying the suppressor components can survive published surge current ratings on both a per mode and per phase basis using the IEEE C62.41, 8 x 20 microsecond current wave. Note: Test data on individual modules are not acceptable.

C. CONTRACTOR's Drawings: Provide switchboard installation details including concrete pad details, mounting details, conduit and cable termination details and shipping split field connection details.

1.4 QUALITY CONTROL

A. Test Reports: Provide the manufacturer's certified shop test report and field test reports for each 480-volt switchboards.

1.5 OPERATIONS AND MAINTENANCE MANUALS

A. General: Provide operation and maintenance manuals, including spare parts lists, as specified in Division 01.

1.6 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store and handle all products and materials as specified in Division 01 and as follows:

B. Storage and Protection: Store all equipment in a dry, covered, heated and ventilated location. Provide any additional measures in accordance with manufacturer's instructions.

1.7 SPARE PARTS

A. General: Provide the following spare parts:

1. One portable circuit breaker test kit unless manufacturer can provide testing software via standard laptop computer.

2. One complete solid-state sensor unit for each size furnished.

3. Three current transformers of each type and rating.

4. Two potential transformers of each type and rating.

5. Six potential transformer primary fuses.

6. Six potential transformer secondary fuses.

7. One set of control jumpers.

8. One hand crank per switchgear for circuit breaker withdrawal and insertion.

9. Three 12-ounce spray cans of the final finish for touch-up.

B. Packaging: Pack spare parts in containers bearing labels clearly designating contents and related pieces of equipment. Deliver spare parts in original factory packages. Identify all spare parts with information needed for reordering.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted for review.

1. 480 Volt Switchboard

a. Eaton/Cutler-Hammer Pow-R-Line X with a Power Defense (PD), RF-frame, insulated case circuit breaker (ICCB), with draw-out mounting main circuit breaker with Power Xpert Release 20 (PXR-20) trip unit with long time, short time, instantaneous, and ground fault (LSIG) trip

functions, and an Arc Flash Reduction Maintenance Mode Switch (ARMS) to meet NEC 240.87.

b. ABB Reliagear SWBD with Emax2 Breaker as main circuit breaker and TmaxXT feeder breakers.

c. Square DTM QED-2 Switchboards (≤600v) by Schneider Electric front accessible with individually mounted Masterpact main circuit breaker with Micrologic solid state tripping unit and group-mounted, molded-case feeder breakers.

2. Microprocessor Based Protective Relays and Metering Systems
   a. Eaton PXM-1300 meter
   b. RGM6000
   c. Square D /Schneider Electric Powerlogic

3. Surge Protective Device (SPD):
   a. Eaton
   b. Advanced Protection Technologies

4. Power Transducers
   a. Amertek Power Instruments/Scientific Columbus Type Exceltronic
   b. Amertek Power Instruments/Rochester Instrument Systems

2.2 SERVICE CONDITIONS

A. Utility Company Stationary Structure: The power supply to the switchboard will be from the Public Service Company of Oklahoma. Coordinate the circuit breaker trip units with the power company incoming feeder protection.

B. Switchboard Characteristics: Provide switchboard with the following characteristics:

1. Main Breaker: individually mounted, drawout type insulated case circuit breaker (ICCB)

2. Feeder Breakers: group-mounted fixed type, molded-case type circuit breakers.

3. Label the switchboard suitable for use as service entrance equipment.

4. Provide all components required for complete functioning units as specified and as shown using factory built standardized units, completely dead-front, totally enclosed and freestanding.

5. Design, manufacture and test all equipment in accordance with the NEC, NEMA PB2, NEMA PB2.1 and UL 891 Standards.

6. Provide the required number of units based on the necessary controls and metering as shown and specified.

C. Distribution System: Connect the switchboards to a 480-volt, 3-phase, 60-hertz, 4 wire, solidly grounded system. Income neutral from utility to be landed on Neutral Landing Pad and then connected to ground bus with removable latch.

2.3 COMPONENTS

A. Stationary Structure: Construct the stationary structure of the switchboard as follows:

1. Build each unit out of bolted structural steel members, together with formed or fitted sections of smooth sheet steel approximately 90 inches high.

2. Provide sufficient structural strength to support all the equipment mounted within, withstand the handling and shipment of the units, maintaining the proper alignment, and be rigid and freestanding.

3. Provide a formed, bolted front door panel for each compartment.

4. Reinforce panels as required to retain alignment and to support instruments, relays, and control equipment mounted thereon.

5. Provide removable plates to permit access to all compartments individually.

6. Provide suitable ventilation for the individual compartments to keep the temperature of devices and buses within the permissible temperature limits as specified by the Standards.

7. Provide a positioning mechanism for moving the removable main circuit breaker to or from the connected position.

8. Provide guides for proper alignment of all engaging parts during movement of the main circuit breaker between the connected or disconnected position.

9. Design the stationary structures and circuit breakers that are interchangeable with every other circuit breaker of the same rating.

10. Provide main buses rated not less than shown, consisting of rigidly supported insulated copper bars of suitable design and cross-sectional area to satisfactorily carry the rated current without exceeding the temperature rise as specified in the IEEE and NEMA standards.

11. Connect the bus with suitable bus clamps or bolts with lock washers.

12. Silver plate the copper bars at current-carrying connections.

13. Equip each switchboard unit with a 1/4-inch by 2-inch bare copper ground bus with a momentary rating at least equal to the highest momentary rating of the unit's circuit breaker. Extend the ground bus the entire length of the structure and comply with all applicable codes and regulations.

14. Ground each stationary unit directly to the ground bus.

15. Provide suitable lug terminals on the ground bus for connections to the station grounding system.

16. Provide steel floor channels suitable for embedding into the concrete floor for leveling and anchoring the switchboard. Drill and tap the floor channels as required. Provide bolts, nuts, and washers for anchoring the switchboard to the channel.

B. Switchboard Enclosure:

1. Provide switchboards suitable for installation indoors.

C. Main Circuit Breakers:

1. Provide 480-volt, 3-pole, 600 volt class, drawout type insulated case circuit breakers with solid state trip units rated as shown, having minimum 65,000 rms amperes interrupting rating. Provide breakers having a 100 percent ampere rating when installed in the switchboard enclosure.

2. Provide circuit breakers with tripfree, manual-operating handles, stored-energy type trip mechanism and push-to-trip button; rated for 40 degrees C ambient operation.

3. Provide circuit breakers with mechanical interlocks to prevent moving the circuit breaker to and from the connected position without tripping the circuit breaker open.

4. Provide circuit breakers that cannot be closed at any point between the operating and test position.

5. Provide means to padlock the circuit breaker in the disconnect position.

6. Provide manually operated main circuit breakers.

7. Provide control connections between the stationary structure and removable circuit breaker using self-aligning, silver plated multicontact devices.

8. Provide all circuit breakers with true rms sensing and microprocessor-based logic circuitry having the following protection features for tripping the circuit breaker.

    a. Trip Indicators
    b. Long time setting and time delay
    c. Short time setting, time delay and I^2t response.
    d. Ground fault setting, time delay and I^2t response.
    e. Short time and ground fault zone interlocking.

D. Feeder Circuit Breakers:

1. Provide circuit breakers with frame size 400 amperes and larger meeting the following;

    a. 480-volt, 3-pole, 600-volt class, fixed-mounted, molded-case circuit breakers, with solid-state trip units rated as shown, having a minimum 65,000 rms amperes interrupting rating.

    b. 80-percent ampere rating when installed in the switchboard enclosure.

    c. Provide true rms sensing and microprocessor-based logic circuitry having the following features for tripping the circuit breaker:

        (1) Long time pick-up
        (2) Short time pick-up and time delay
        (3) Instantaneous pick-up
        (4) Ground fault pick-up and time delay

2. Provide circuit breakers with frame size smaller than 400 amperes meeting the following;

    a. 480-volt, 3-pole, 600-volt class, fixed-mounted, molded-case circuit breakers with thermal-magnetic trip units rated as shown, having a minimum 65,000 rms amperes interrupting rating.

3. Provide circuit breakers with tripfree, manual-operating handles, rated for 40 degrees C ambient operation.

E. Switchboard Connections and Terminals:

1. Construct all current-carrying connections from copper having suitable capacity, bracing, insulation, temperature rating as the main bus.

2. Connect current transformers in such a way that the transformers may be removed and changed without damaging the connection.

F. Instrument Transformers:

1. Current Transformers

a. Provide dry-type current transformers, suitable for indoor service and rated as shown.

b. Provide sufficient thermal and mechanical capacity to withstand the maximum momentary current rating of the circuit breaker.

c. Provide solderless, clamp-type shorting terminal blocks for secondary connections.

d. Properly identify the polarity of all current transformers with standard marking symbols.

e. Provide current transformers with accuracy suitable for the instruments and meters specified using the normal burdens of the various devices, and not less than ANSI Standard requirements.

2. Potential Transformers

a. Provide dry-type potential transformers, suitable for indoor service. single-phase, 60 hertz, 120 volts.

b. Provide potential transformers that fit into and coordinate with the complete switchboard units, and with the instruments, relays, meters, and devices specified.

c. Rate the potential transformers not less than 100-volt-amperes at 55 degrees C ambient or 150-volt-amperes at 30 degrees C ambient thermal rating.

d. Provide potential transformers that withstand a secondary short circuit for at least one second.

e. Provide transformers meeting the requirements of the ANSI Standard accuracy classifications.

f. Provide current-limiting type primary fuses.

g. Provide secondary fuses sized for the protection of potential transformers.

3. Grounding

a. Ground current and potential transformer secondaries with a copper conductor not smaller than No. 10 AWG and connecting to the ground bus.

b. Ground potential transformer neutrals, where shown or required with a 600-volt green insulated copper conductor not smaller than No. 10 AWG.

c. Provide connections to the bus that can be easily disconnected and isolated for field testing individually.

d. Install each ground wire as a continuous run without intervening splices or terminal blocks.

e. Ground secondary circuits of metering and relaying transformers at one point only.

f. Effectively ground meter, relay and instrument transformer cases.

G. Control Devices:

1. Provide control switches of the standard rotary, multistage type suitable for the use specified.

2. Provide auxiliary relays, switches and mechanisms required for the particular manufacture of the breaker.

3. Provide a manually-operated trip bar or lever for each circuit breaker.

4. Provide provisions for manual closing each circuit breaker.

H. Microprocessor-Based Metering and Protection System: Provide a microprocessor-based metering and protection system having the following features:

1. UL recognized component meeting IEEE C37.90.

2. Housed in an enclosure suitable for door mounting.

3. Derive control power from metered line.

4. Auto ranging metering of the following values:

a. Ac amperes in each phase, 0.5 percent accuracy
b. Ac voltage, phase-to-phase, phase-to-neutral, 0.5 percent accuracy
   (1) Connect voltage sensing to line side of main breaker
c. Watts, 1 percent accuracy
d. Vars, 1 percent accuracy
e. Power factor, 2 percent accuracy
f. Frequency, 0.5 percent accuracy
g. Watt demand, 1 percent accuracy with programmable 5-, 10-, 15-, 30-minute intervals
h. Watt-hours, 1 percent accuracy
i. Percent total harmonic distortion through the 31st harmonic

5. Separate Form C (NO/NC) trip and alarm outputs contacts rated for 10 amperes at 115-volt ac or 30-volt dc resistive.

6. Addressable communications card capable of transmitting all data over Ethernet network to the plant SCADA system as shown in Section 40 94 13.

I. Surge Protective Device:

1. Provide surge protective device (SPD) equipment that complies with UL 1449 and UL 1283.

2. Provide units with a maximum continuous operating voltage that exceeds 115 percent of the nominal system operating voltage.

3. Provide SPD equipment suitable for wye configured systems.

4. Provide SPD equipment having directly connected suppression elements between line-neutral (L-N), line-ground (L-G), and neutral-ground (N-G).

5. Provide SPD equipment that distributes the surge current to all MOV components to ensure equal stressing and maximum performance and provides equal impedance paths to each matched MOV.

6. Provide high-performance EMI/RFI noise rejection filters that attenuate the electric line noise at least 55 dB at 100 kHz using the MIL-STD-220A insertion loss test method.

7. Wire internal components with connections utilizing low impedance conductors and compression fittings.

8. Provide a monitoring panel for each system that incorporates the following features:

a. Green/red solid-state indicator light to indicate which phase(s) have been damaged.
b. A flashing trouble light to indicate fault detection
c. Transient event counter
d. Audible alarm
e. Form C dry contacts for remote indication of the unit status.

9. Provide each SPD suitable for service entrance or branch location application with a minimum total surge current capable of withstanding 240kV per phase respectively or as shown.

J. Wiring:

1. Completely assemble, wire and test each switchboard section at the factory, including buses, phase, neutral and ground connections, insulators, cleats, terminals, and terminal blocks.

2. Insulate all current-carrying parts.

3. Route all secondary wiring in the front of secondary compartments in wiring troughs and terminate at approved molded type terminal blocks with numbered marking strips, conveniently located with respect to the control conduits.

4. Provide terminal blocks with covers mounted so that the wires can be grouped and laced together.

5. Mark and identify all wiring in accordance with the manufacturer's wiring diagrams.

6. Label control wiring with an identification tag that indicates the terminal number of the opposite end connection.

7. Include wire labels and terminal numbers on schematic control and wiring diagrams.

8. Provide spade connectors for wires No. 12 AWG and smaller and solderless lugs for larger sizes.

9. Provide terminals for all connections and an additional 15 percent spare terminals for all control and instrument wiring.

10. Provide No. 10 AWG stranded copper or larger with NEC Type SIS insulation for all current transformer secondary wiring.

11. Provide No. 14 AWG stranded copper or larger with NEC Type SIS insulation for all other control wiring.

K. Identification:

1. Provide identification of the switchboard and its components as specified in Section 26 05 53.

2. Install nameplates for devices located on doors so they are readable by a person 5'-8” tall standing 3'-0" in front of the equipment.

3. Locate nameplates so that they are readily associated with items labeled.

4. Where nameplates are installed on removable relays or removable device doors, install a nameplate within the relay or device.

5. Where nameplates are located on other compartments than those served, add additional engraving to identify units served.

2.4 SOURCE QUALITY CONTROL

A. Tests: Conduct shop tests after the switchboard has been assembled to determine general operating condition and circuit continuity, high voltage withstand and other safety standards.

PART 3 EXECUTION

3.1 INSTALLATION

A. General: Install the switchboards in accordance with the manufacturer's recommendations and approved shop drawings and as specified in Division 01.

B. Compliance: Install the switchboards as shown, in accordance with manufacturer’s written instruction and recognized industry practices. Comply with requirements of NEMA standards, and applicable ANSI publications.

C. Coordination: Coordinate with other work including cabling and wiring work as necessary to interface installation of switchboards with other work.

D. Torque Requirements: Tighten electrical connectors and terminals including screws and bolts, in accordance with equipment manufacturer's published torque tightening values of equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals in accordance with UL Standard 486A.

E. Fuses: Provide fuses in switchboard assemblies as required.

F. Circuit Breaker Parameters: Set the circuit breaker protection parameters in accordance with the protective coordination study specified in Section 26 05 73.

G. Ground Connections: Make equipment grounding connections for the switchboards as shown. Tighten connections in accordance with UL standard 486A for permanent and effective grounding.

H. Adjustments: Make all necessary adjustments to the equipment to provide complete and satisfactory operation of the system.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Representative: Provide a factory-trained experienced, competent, and authorized representative of the switchboard manufacturer to visit the site of the work and inspect, check, adjust if necessary, approve the equipment installation and provide training as specified in Section 01 79 00. Provide all instruments and equipment necessary to conduct required tests, adjustments and training. Have the manufacturer's representative utilize prepared comprehensive check sheets covering inspections, checks and tests required for the assembly of the switchgear. Submit copies of these documents executed and signed by the manufacturer's representative. Have the representative present when each equipment item is placed in operation. Provide representative service as often as necessary until all problems are corrected and each equipment item is installed and operating satisfactorily.

B. Certified Report: Furnish a written report certifying that the equipment:

1. Has been properly installed

2. Is in accurate alignment

3. Is free from any undue stress imposed by connections or anchor bolts, and

4. Has been operated under full load conditions and that it operated satisfactorily

C. SCADA Programming: Provide manufacturers representative at the job site as often as necessary to assist in the programming of the SCADA system in accessing the memory map of each device.

D. Tests and Inspections: Perform the following tests and inspections. Record all tests and submit a written report for approval. Retest as necessary.

1. Check all breakers, meters, power and control fuses and auxiliaries for proper size, rating, and location. Clean control panels and cubicles. Remove all shipping materials.

2. Inspect equipment and each breaker and report installation or shipping damage, loose materials, shipping blocks or contamination.

3. Torque test bus connections where field joints are made.

4. Check that all control and panel circuits are numbered and tagged and panel door legends are engraved and installed as per drawings.

5. Check equipment to determine that it is level, secured to foundations and that doors operate properly.

6. Test insulation of all control and relay circuits to ground with a suitable megohmmeter. Take suitable precautions where electronic devices, instruments and instrument transformers are involved.

7. After installation, but before any external connections are made to the switchgear, subject the switchboard to a 10-minute high potential test applied on the stationary structure and breakers. Use a test voltage of 75 percent of the standard factory production tests.

8. Test all bus, cable, wire and other equipment operating at the service voltage that is energized by closing the incoming main line breakers. This test may be witnessed by the ENGINEER.

9. Test protective trip units to verify settings and determine proper operation.

E. Training: Following completion of installation and field testing provide training for 12 employees of the OWNER in the proper operation, troubleshooting and maintenance of the equipment as outlined below. All training will be at the OWNER'S facilities at a time agreeable to the OWNER:

1. Operational Training: A minimum of two 4-hour sessions combining both classroom and hands-on instruction, excluding travel time.

2. Maintenance Training: A minimum of two 4-hour sessions combining both classroom and hands-on instruction, excluding travel time.

3.3 GROUNDING

A. System: Inspect ground system for compliance with the latest approved drawings.

B. Connections: Inspect all ground connections for evidence of looseness and/or corrosion.

3.4 CLEANING AND PAINTING

A. Standard paint process will be provided.

B. Field Painting: Touch up scratched and marred surfaces to match with original finishes.

3.5 IDENTIFICATION

A. General: Provide identification meeting the requirements of Section 26 05 53.

B. Component Identification: Identify all system components, cables and wires by labels indicating unit numbers, circuit numbers and date of installation.

END OF SECTION

SECTION 26 24 16

PANELBOARDS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for providing lighting and distribution panelboards including circuit breakers and cabinets.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 26 05 00 - Basic Electrical Materials and Methods
2. Section 26 05 53 - Electrical Identification
3. Section 26 05 26 – Grounding
4. Section 26 29 53 – Control Components and Devices

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. NEMA PB 1 - Panelboards

2. UL 67 - Panelboards

3. Fed. Spec. W-P-115 - Power Distribution Panel

4. UL 486A - Wire Connectors and Soldering Lugs for Use With Copper Conductors

5. NFPA 70 - National Electrical Code (NEC)

1.3 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 01 and Section 26 05 00.

B. Product Data and Information: Provide the manufacturer's catalog data for panelboards, circuit breakers and accessories.

C. Operations and Maintenance Manuals: Furnish operation and maintenance manuals for the panelboards as specified in Division 01.

1.4 QUALITY ASSURANCE

A. Codes: Provide all materials and workmanship meeting the requirements of the NFPA, the National Electrical Code and local codes.

1. Design, fabricate and test the panelboards in accordance with applicable NEMA standards.

2. Provide panelboards suitable for operation at their standard nameplate ratings in accordance with applicable standards.

1.5 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store and handle all products and materials as specified in Division 01.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted for review.

1. Panelboards

a. ABB
b. Square D/Schneider Electric
c. Eaton

2.2 MATERIALS

A. General: Provide factory-assembled fully rated dead-front type, panelboards, suitable for surface or flush mounting with branch circuit breakers and a main circuit breaker or main lugs as indicated.

1. Provide panelboards with a full capacity separate ground bus and connected to a three-phase four-wire or a single-phase three-wire service with insulated neutral buses as indicated.

2. Provide panelboards with the voltage, frequency and current ratings as indicated conforming to NEMA Standard PB 1, Fed. Spec. W-P-115, UL 67 and the NEC.

3. Provide panelboards with copper main, neutral and ground buses.

4. Where required, label panelboards suitable for use as service entrance equipment

B. Bracing: Provide main bus bracing exceeding the lowest interrupting rating of any circuit breaker installed.

C. Fabrication: Fabricate panelboards using galvanized steel. Provide cabinet fronts with doors over the circuit breakers. Provide doors fastened with concealed hinges and equipped with flush type catches.

1. Provide panelboards at least 20 inches wide, 5-3/4 inches deep, with wiring gutters on both sides.

2. Provide all panelboard trims exceeding five square feet in area with an inside permanently secured angle to support the trim during fastening. Not required with Eaton's EZ Trim design.

2.3 COMPONENTS

A. Circuit Breakers: Provide bolt-on type branch and main circuit breakers.

1. Furnish the frame sizes, trip settings and number of poles as indicated. Clearly identify the ampere trip rating on the circuit breakers.

a. For lighting panelboards, provide 20-ampere, single-pole, 120 or 277 volt circuit breakers unless otherwise shown or scheduled.

b. For distribution panelboards, provide 20-ampere, three-pole, 600-volt circuit breaker, unless otherwise shown or scheduled.

2. Provide all breakers with quick-make, quick-break, toggle mechanisms with automatic thermal-magnetic, inverse time-limit overload and instantaneous short circuit protection on all poles, unless otherwise indicated. Indicate automatic tripping by the breaker handle assuming a clearly distinctive position from the manual ON and OFF position. Design the breaker handle to be trip-free on overloads.

3. Interrupting Rating: 10,000 rms symmetrical amperes for circuit breakers on 240 volt systems or less, and 65,000 rms symmetrical amperes for circuit breakers on 277 or 480 volt systems.

4. Provide multipole breakers that utilize a common tripping bar.

5. Provide ground fault interrupter circuit breakers for all circuits serving receptacles located below grade and outdoors and as scheduled.

6. Provide full module size single-pole breakers. Do not install two-pole breakers in a single-pole module.

7. Provide all 20 ampere, one pole circuit breakers with a lug wire range suitable for the termination of #14AWG through #8AWG. For circuit breakers with higher current ratings, provide lugs adequate for the wire sizes indicated on the Contract drawings.

8. Provide circuit breakers 100 amperes and smaller with a 60/75 degree C cable temperature rating.

B. Surge Protective Devices (SPD): Provide each panelboard with a surge protection device.

2.4 ACCESSORIES

A. Directories: Provide directories in accordance with Section 26 05 53.

B. Circuit Breaker Handle Lock: Where shown provide circuit breakers with handle clamp that holds the circuit breaker handle in the ON position.

C. Keying: Key all panelboards alike.

PART 3 EXECUTION

3.1 INSTALLATION

A. General: Install all panelboards in accordance with manufacturer's recommendations and approved shop drawings and as specified in Division 1 and in compliance with the requirements of NEMA standards, NEC, and applicable ANSI Publications.

B. Mounting Height: Mount all panelboards either surface or flush mounted as shown such that the height of the top operating handle does not exceed 6 feet 6 inches from the floor.

C. Coordination: Coordinate with other Work including cabling and wiring work to interface the installation of the panelboards.

D. Torque Requirements: Tighten electrical connectors and terminals, including screws and bolts, in accordance with the equipment manufacturer's published torque

tightening values for the equipment connectors. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals in accordance with UL 486A.

E. Circuit Breaker Handle Lock: Install circuit breaker handle clamp on each circuit breaker as shown.

F. Directory: Provide a laminated typewritten directory with the following information:

1. Circuit number
2. Area served
3. Utilizing equipment

3.2 CLEANING AND PAINTING

A. Shop Painting: Paint the panelboards as specified in Section 09 96 00.

B. Field Painting: Touch up scratched and marred surfaces to match the original finish.

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 26 29 23

ADJUSTABLE FREQUENCY DRIVES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for providing, installing, and testing the 480-volt adjustable frequency drives. Provide drives in individual free-standing enclosures, wall mounted enclosures, or incorporated into motor control centers, as shown. Furnish harmonic studies as specified. As indicated on drawing, Furnish one spare Adjustable Frequency Drive to OWNER not including the two installed.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 01 79 00 - Training
2. Section 09 96 00 - High Performance Coatings
3. Section 26 05 00 - Basic Electrical Materials and Methods
4. Section 26 05 19 - Wires and Cables - 600 Volts and Below
5. Section 26 05 60 - Electrical Requirements For Shop-Assembled Equipment
6. Section 26 05 53 - Electrical Identification
7. Section 26 05 26 - Grounding
8. Section 26 30 00 - Control Components and Devices
9. Section 26 80 00 - Electrical Testing Requirements
10. Section 26 05 80 - Electric Motors

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. NEMA ICS 1 - General Standards for Industrial Control and Systems

2. NEMA ICS 2 - Industrial Control and Systems Controllers, Contactors and Overload Relays rated 600V.

3. NEMA ICS 3 - Industrial Control and Systems Factory Built Assemblies

4. NEMA ICS 7 - Industrial Control and Systems: Adjustable Speed Drives

5. NEMA ICS 7.1 - Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable Speed Drive Systems

6. NEMA 250 - Enclosures for Electrical Equipment

7. NFPA 70 - National Electrical Code (NEC)

8. IEEE 85 - Test Procedure for Airborne Sound Measurements on Rotating Electric Machinery

9. IEEE 519 - IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

10. UL 845 - Motor Control Centers

1.3 SYSTEM DESCRIPTION

A. Basis of Design:

1. ABB ACS880-37-0570A
ACS880 Drive Cabinet Drive - Ultra Low Harmonic (37).
Input Voltage 480 VAC. 570A LD, IP42 - UL type 12

B. Design Requirements:

1. Provide adjustable frequency drives to vary the speed of NEMA standard, 3-phase, 460-volt, induction motors and driven equipment by varying the frequency and voltage applied to the motors.

2. Provide adjustable frequency drives that fit the physical space shown. Units exceeding the dimensions shown will not be acceptable.

3. Provide adjustable frequency drives that automatically restart when power is restored after a power outage. Provide control logic so the drive is allowed to restart when power is restored.

4. UL 508C listed with a minimum labeled “SCCR” of 65kAIC at 460V.

C. Rated Output Power: Provide adjustable frequency drives with an output that is at least 3 percent greater than the driven motor’s full nameplate rating.

D. Torque Output: Provide variable torque output drives as required by driven equipment.

E. Performance Requirements: Provide adjustable frequency drives to meet the following requirements of IEEE 519:

Total harmonic distortion THD (Voltage): Maximum of five percent for general distribution systems as measured at the point of common coupling.

The Ultra Low Harmonic construction of the VFD shall not contribute any significant harmonics at the input terminals of the VFD and shall maintain harmonics levels at the VFD's input terminals to levels at or below those listed in "Harmonic Control in Electrical Power Systems, IEEE Std. 519-1992." in the system that already is in compliance with the said standard.

All harmonic management devices must be internal to the VFD enclosure and supplied as a complete solution.

Each input phase of the VFD shall incorporate a symmetrical LCL filter arranged in a T- configuration. The inductors are to be series power components that carry the full current of the VFD.

The input current to the VFD shall have a total harmonic content less than 5% of full rated capability at the input terminals of the VFD on power system sized according to IEEE 519-1992 at line voltage unbalance up to 3% and under all motor load conditions.

The VFD shall operate at fundamental power factor 1.0 on the supply side under all motor load conditions.

1. Total current harmonic distortion: Not to exceed the values in Table 10.3, Current Distortion Limits for General Distribution Systems (120 V through 69000 V) of IEEE-519 at the point of common coupling.

2. Capacitor traps for controlling harmonics that require tuning to the power system are not acceptable.

3. The VFD efficiency shall be 98% or better of the full rated capability of the VFD at full speed and load. In case an alternative low harmonics solution is offered, the overall efficiency of the VFD and the harmonic mitigation components shall meet the efficiency requirement.

4. The VFD shall be rated to operate from 3-phase power at 380 to 690 VAC +10/-10%. The overvoltage trip level shall be a minimum of 30% over nominal, and the undervoltage trip level shall be a minimum 35% under the nominal voltage.

5. Input power factor: The VFD shall operate at fundamental power factor of 1.0 on the supply side under all motor load conditions.

6. Operate an induction motor as specified, including a high-efficiency, high-power factor, premium-duty motor, with no detriment to motor life.

7. Operate an induction motor without exceeding the motor sound and power decibel level listed and measured in accordance with NEMA MG1, Tables 9-2 and 9-3.

8. Operate under the following ambient conditions:

   a. Ambient Temperature: 0 to 40 degrees C
   b. Humidity: 0 to 95 percent

1.4 SUBMITTALS

A. General: Furnish all submittals, including the following, as specified in Division 01 and Section 26 05 00.

B. Product Data and Information: Furnish catalog data including rating and descriptive literature of all components and systems.

C. Shop Drawings: Furnish the following shop drawings customized for the project:

1. Calculated heat loss data of VFDs

2. Bill of materials including manufacturers name and catalog number

3. Outline drawings showing dimensions, arrangement, elevations, identification of components and nameplate schedule for all units

4. Interconnection wiring diagrams

5. Individual schematic control diagrams for each unit

6. One-line diagrams

7. Obtain and enter full performance data for all motors shown

8. Certification that the adjustable frequency drives are compatible with the motors and the equipment loads to be driven

D. System harmonic distortion study: Furnish a system harmonic distortion study as follows:

1. Obtain data on utility services, plant loads and plant operation. Verify electrical service rating including transformer size, short circuit capacity and X/R ratio.

2. Prepare a harmonic distortion study of plant electrical system to determine voltage and current harmonics at the point of common coupling for worst case speed and load settings.

3. Confirm that the submitted adjustable frequency drives limit the electrical disturbances below the 5 percent THD (voltage) and below the harmonic current distortion per Table 10.3 as established by IEEE 519.

4. Point of Common Coupling: The point of common coupling is defined as at the overcurrent device external of and directly upstream of the adjustable frequency drive assembly.

5. Include analysis of all data with recommendations.

E. Quality Control: Furnish test reports, certificates of inspection and manufacturer's instructions.

F. Operations and Maintenance Manuals: Furnish operations and maintenance manuals as specified in Division 1.

1.5 QUALITY ASSURANCE

A. Standards: Provide all adjustable frequency drives manufactured in accordance with referenced standards.

B. UL Label: Provide a UL Inc. Label or certification of listing by C.S.A. or other recognized testing organization for each adjustable frequency drive.

C. Codes: Manufacture and install each adjustable frequency drive in accordance with the NEC and local codes.

D. Failure to Meet the Harmonic Requirement as Determined by Field Measurement: If the installed adjustable frequency drives fail to meet the harmonic limits specified, modify the adjustable frequency drives as follows at no additional cost to the OWNER.

1. Provide additional harmonic reduction equipment until the specified limit is achieved. Equipment which requires expanding on the physical footprint of the adjustable frequency drive previously approved is to be submitted for approval.

2. In the event that harmonic distortion limits cannot be achieved, replace the adjustable frequency drive equipment with equipment that conforms to this specification.

1.6 DELIVERY, STORAGE, AND HANDLING

A. General: Deliver, store and handle all products and materials as specified in Division 01 (and as follows :)

B. Shipping and Packing: Rigidly brace and protect against weather, damage, and undue strain, all structures, equipment and materials.

C. Storage and Protection: Furnish clean storage facilities for all equipment delivered but not installed. Provide conditioned air for storage facilities in accordance with the equipment manufacturer's recommendations.

D. Spare Parts: Furnish spare parts at the same time as the associated adjustable frequency drive. Deliver the spare parts to the OWNER after completion of the work.

1.7 SPARE VFD, PARTS, AND SERVICE

A. General: Furnish the following spare parts for each type of drive and each group of similar sized drives.

1. Furnish one spare Adjustable Frequency Drive to OWNER not including the two installed.

2. All parts recommended by the manufacturer in published literature as spare parts. As a minimum, provide the following:

a. Six of all sizes and types of power and control fuses

b. Six LED displays of each color

c. One speed indicator meter relay

d. Two of each type of push button and selector switch used

e. Two keypads of each type used

f. Two printed circuit boards of each type used

g. Four filter capacitors of each size used

h. Four diodes of each type used

i. Four transistors, gate turn off thyristors IGBT's or SCRs of each type used

j. Three 12-ounce spray cans of the final finish for touch-up

k. Where recommended or listed parts are included in a non-field serviceable assembly, provide one complete replacement assembly for each size VFD being provided.

B. Packaging: Package spare parts in containers bearing labels identifying all spare parts for reordering. Deliver spare parts in original factory packages.

C. Extended Warranty and Service: Provide proposals for each as follow:

1. Submit a detailed proposal for providing extended warranty coverage at one year intervals. Include coverage the same as provided under the initial warranty.

2. Submit a detailed proposal for providing an annual service contract agreement covering all manufacturer recommended service procedures and maintenance.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Acceptable manufacturer is listed below.

1. ABB

2.2 DESIGN

A. Input Disconnect: Provide an input circuit breaker with an interrupting rating of 65,000 rms symmetrical amperes.

B. Each input phase of the VFD shall incorporate a symmetrical LCL filter arranged in a T-configuration. The inductors are to be series power components that carry the full current of the VFD.

C. Converter Section: The VFD shall employ an active AC to DC rectifier (commonly referred to as an active supply unit).

D. Filter Sections: Provide dc link reactor and filter capacitors as required.

E. The input current to the VFD shall have a total harmonic content less than 5% of full rated capability at the input terminals of the VFD on power system sized according to IEEE 519-1992 at line voltage unbalance up to 3% and under all motor load conditions.

F. The VFD shall have the ability to boost output voltage by up to 10% relative to input voltage to protect the motor from a line voltage sag.

G. Control Circuit: Provide with a control circuit conforming to the logic shown on the Contract Drawing schematic diagrams or as otherwise described in the equipment specifications. The run permissive logic shall include a auxiliary contact signal from the local disconnect switch at the motor (where provided or otherwise shown) which will deactivate the drive whenever the motor disconnect switch is opened.

H. Control Devices: Provide a digital operator keypad located on the front door to allow setting of all programmable parameters and the following control functions:

1. Enable Switch
2. E-stop Push Button
3. E-stop Reset Button
4. Speed control settings
5. Speed meter with hertz and 0-100 percent scales
6. Output ammeter
7. Elapsed time meter
8. Diagnostics package with fault indication and reset push button

I. Control Features: Provide a control system for each drive that allows the following functions:

1. Remote, isolated 4-20 ma speed control input
2. Isolated 4-20 ma speed output
3. Alarm outputs
4. ON/OFF status output
5. Additional features and controls as specified with the driven equipment

J. Internal Control Adjustments: Include the following control adjustments for each drive:

1. Acceleration time, 4 to 60 seconds
2. Deceleration time, 4 to 60 seconds
3. Minimum speed limit
4. Maximum speed limit
5. Inverter current limit
6. Supply undervoltage trip

K. Protection Features: Provide the following drive protection features:

1. Input line current limiting fuses rated 200,000 rms symmetrical amperes short circuit current.

2. Electronic overcurrent protection for instantaneous overload

3. AC input line undervoltage protection, adjustable from 60-100 percent nominal voltage with time delay adjustment and low speed override.

4. Overfrequency protection

5. Phase loss protection

6. DC overvoltage protection

7. Logic supply voltage low level protection

8. Line-to-line and line-to-ground output short circuit protection

9. Line-to-line and line-to-ground surge arresters sized for 480-volt 3-phase grounded wye system

10. Overload capability of 110% of the motor FLA based on the NEC ratings for 60 seconds

11. Control circuit fuses

12. Overtemperature protection

13. Diagnostics module to indicate protection trip conditions

L. Communications: Provide analog and discrete wiring for signals shown on VFD schematic in drawing set. Provide an addressable communication card capable of transmitting data over an Ethernet network to each Pump Control Panel (PCP-W1/W2) Ethernet IP or Modbus TCP depending on client preference as specified in Section 26 09 13. Example communication module is an ABB FENA-21 Adapter. The following data to be transmitted is including, but not limited to:

1. Speed Command

2. Run Command

3. VFD Reset

4. VFD Interlock

5. Cause of Trip

6. Speed Feedback

7. Running

8. Fail

2.3 COMPONENTS

A. General: Provide circuit breakers, fuses, transformers, push buttons, switches, indicating lights, relays and timers as specified in Section 26 30 00.

B. Power Solid State Components: Provide power solid state switching components with a one minute current rating greater than 110 percent of rated current for variable torque drives or 150 percent of rated current for constant torque drives.

C. Programmable Controller: Provide programmable controller as specified in Section 40 94 43 - Instrumentation.

D. Control Power Transformer: Furnish a constant voltage control power transformer to maintain control power with supply voltage variations from 70-110 percent nominal.

E. Printed Circuit Boards: Apply a clear conformal coating of acrylic to all printed circuit boards.

2.4 ENCLOSURES

A. General: Provide adjustable frequency drives in NEMA 1 filtered and gasketed enclosures with full rear cover plates.

B. Top Entry/Exit for AC ducting.

C. Backpack or Base Plinth for Conduit Entry/Exit.

2.5 IDENTIFICATION

A. General: Provide identification of the adjustable frequency drives and their components as specified in Section 26 05 53.

B. Nameplates: Install nameplates for devices located on doors so they are readable to a person 5'-8” tall standing 3'-0" in front of the equipment.

C. Location: Locate nameplates so that they are readily associated with items labeled.

D. Additional Nameplate: Where nameplates are installed on removable relay or device doors, install an additional nameplate within the relay or device.

E. Additional Engraving: Where nameplates are located on other compartments than those served, add additional engraving to identify units served.

2.6 WIRING:

A. General: Provide internal wiring with stranded switchboard wire having 600-volt rated, flame-resistant, type SIS insulation. Use No. 14 AWG wire for control interconnections. Provide power connections as required for the service.

B. Wire Marker: Provide wire markers at each end of all wires.

C. Wiring to Door Mounted Devices: Where wiring connections are made to equipment mounted on hinged doors, provide connections with extra flexible wires suitably cabled together and cleated.

D. Terminal Blocks: Provide wiring of all control connections to all external connections through individual, positive-latch, pull-apart type control terminal blocks rated 600-volts. Locate terminal blocks for front access.

E. Terminal for External Connections: Provide sufficient terminals for all devices external to the adjustable frequency drive.

2.7 SOURCE QUALITY CONTROL

A. Shop Test: Shop test each adjustable frequency drive in accordance with IEEE and NEMA standards, including high potential tests and other standard tests for that particular class of equipment. Notify the OWNER fourteen (14) days prior to start of factory testing so that the OWNER, at his option, may witness the testing.

1. After final assembly, test each adjustable frequency drive at full load with application of line-to-line and line-to-ground bolted faults and show that the adjustable frequency drive trips electronically without device failure.

2. After all tests have been performed, burn-in each adjustable frequency drive for 40 hours at 100 percent inductive or motor load.

3. After the burn-in cycle is complete, subject each adjustable frequency drive to a 30 minute cycling motor load test before inspection and shipping.

B. Operational Tests: After the equipment has been completely assembled, perform operational test to determine operating conditions and circuit continuity. Provide pushbuttons and selector switches to simulate all control input contacts and

indicating lights to indicate all control outputs. Provide a 4-20ma signal generator to simulate analog signals.

C. Test Equipment: Provide all equipment, devices, instrumentation, and personnel required to perform the tests. Upon satisfactory completion of the test, submit two (2) certified copies of the test report to the ENGINEER. Component failure during testing will require repeating any test associated with the failure or modified components to demonstrate proper operation.

PART 3 EXECUTION

3.1 INSTALLATION

A. General: Install all equipment in accordance with the manufacturer's recommendations and approved shop drawings and as specified in Division 1.

B. Protective Adjustments: Set all circuit breakers per the approved short circuit and coordination study.

C. Operational Adjustments: Set all operational devices for proper system operation.

D. Cable Connections: Terminate and label all field wiring per approved drawings.

3.2 FIELD QUALITY CONTROL

A. Inspections: Inspect, adjust and check the installation for physical alignment, cable terminations and ventilation.

B. Tests: Perform the following field tests:

1. Close and open each circuit breaker to test operation

2. When site conditions permit, energize and de-energize each equipment item served by each drive, testing the complete control sequence of each item including acceleration and deceleration over complete operating range.

3. Harmonic Measurement: Perform a harmonic system analysis to demonstrate full compliance with IEEE 519 voltage and current harmonic distortion requirements specified. Accurately measure the amplitude of the harmonic current imposed on the 60 hertz sine wave with a harmonic spectrum analyzer. Provide additional harmonic reduction equipment to meet the specified limits. If the harmonic distortion limits are not achieved, replace the adjustable frequency drive equipment with equipment that conforms to this specification.

4. Operate each adjustable frequency drive with driven equipment at full load and test for hot spots.

5. Test Reports: Furnish detailed test reports of all tests indicating test performed, discrepancies found, and corrective action taken.

C. Manufacturer's Field Services Representative: Provide the services of a factory-trained service engineer, specifically trained on the adjustable frequency equipment to assist in installation, start-up, testing, calibration, placing into operation and provide training, as specified in Section 01 79 00.

1. Provide a service engineer when each drive is placed into operation.

2. Provide a service engineer at the jobsite as often as necessary until all problems are corrected and the equipment installation and operation are satisfactory.

3. Following completion of installation and field testing provide training for 12 employees of the OWNER in the proper operation, troubleshooting and maintenance of the equipment as outlined below. All training will be at the OWNER'S facilities at a time agreeable to the OWNER:

   a. Operational Training: A minimum of two 4-hour sessions combining both classroom and hands-on instruction, excluding travel time.

   b. Maintenance Training: A minimum of two 4-hour sessions combining both classroom and hands-on instruction, excluding travel time.

4. Provide service engineer at the job site as often as necessary to assist in the programming of the SCADA system in accessing the memory map of each device.

5. Provide replacement spare parts which may have been used during the course of startup and testing.

3.3 CLEANING AND PAINTING

A. Shop Painting: Paint the adjustable frequency drive equipment as specified in Section 09 96 00.

B. Field Painting: Furnish three 12-ounce spray cans of the final finish for touch-up. Touch-up scratched and marred surfaces to meet the requirements of Section 09 90 00.

END OF SECTION

SECTION 26 29 53

CONTROL COMPONENTS AND DEVICES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for providing manual starters, motor controllers and remote-control stations. In addition, the requirements for control components and devices for use in equipment provided under various other sections.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 09 96 00 - High Performance Coatings
2. Section 26 05 00 - Basic Electrical Materials and Methods
3. Section 26 05 19 - Wires and Cables - 600 Volts and Below
4. Section 26 29 23 - Adjustable Frequency Drives
5. Section 26 05 53 - Electrical Identification
6. Section 26 05 26 - Grounding

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. NEMA ICS 2 - Industrial Control Devices, Controllers and Assemblies

2. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)

3. UL 486A - Wire Connectors and Soldering Lugs for Use With Copper Conductors

1.3 SYSTEM DESCRIPTION

A. Design Requirements: Provide equipment capable of operating in an ambient temperature range of 0 to 40 degrees C and humidity of up to 90 percent noncondensing.

B. Motor Controllers: Provide motor controllers suitable for 240-volt, single-phase, three-wire, 60-hertz operation.

C. Control Devices: Provide control devices suitable for operation at 120-volts, 60-hertz, unless specifically noted otherwise.

D. Insulation Class: Provide control equipment and devices that meet the requirements of the 600-volt insulation class.

1.4 SUBMITTALS

A. General: Furnish all submittals, including the following, as specified in Division 01 and Section 26 05 00.

B. Product Data and Information: Furnish catalog data for all associated equipment and devices.

C. Shop Drawings: Furnish shop drawings customized to the project for manual starters, motor controllers and remote-control stations that include the following:

1. Outline drawings showing dimensions, identification of components and a nameplate schedule for all units.

2. Bill of materials including manufacturers' name and catalog number.

3. Individual schematic and wiring diagrams for each motor controller

D. Equipment Ratings: Obtain and enter full performance details on all motors and other equipment being served on the above drawings.

1.5 QUALITY ASSURANCE

A. Codes: Provide motor starters that are in accordance with NEMA ICS 2.

1. Provide motor starters that are in accordance with the NEC and local codes.

B. UL Listing: Provide UL-listed motor starters.

1.6 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store, and handle all products and materials as specified in Division 01.

B. Storage and Protection: Store all equipment and materials in a dry, covered, heated and ventilated location. Provide any additional measures in accordance with manufacturer's instructions.

1.7 SPARE PARTS

A. General: Furnish the following spare parts:

1. One of each type of motor starter.

B. Packaging: Pack spare parts in containers bearing labels clearly designating contents and related pieces of equipment. Deliver spare parts in original factory packages. Identify all spare parts with information needed for reordering.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted for review.

1. Motor Starters:

a. Rockwell Automation/Allen-Bradley
b. General Electric Company
c. Eaton/Cutler-Hammer
d. Square D/Schneider Electric
e. Eaton/Crouse-Hinds

2. Control Relays:

a. Rockwell Automation/Allen-Bradley
b. Eaton/Cutler-Hammer
c. Square D/Schneider Electric
d. General Electric Company

3. Surge Protective Devices (SPD)

a. Thomas & Betts/Current Technologies, Inc.
b. Eaton/Cutler-Hammer

4. Rubber Work Mats

a. Salisbury by Honeywell
b. North American Mat
c. White Equipment

2.2 MOTOR CONTROLLERS

A. General: Provide 240-volt, 1-phase, 60-hertz, across-the-line, combination motor circuit protector magnetic starters with individual control power transformers.

B. Magnetic Starters: Provide magnetic starters as follows:

1. Full voltage non-reversing or full voltage reversing, as required.

2. Starter contacts of the replaceable, spring-loaded, wedge type with silver-cadmium oxide plated contact surfaces.

3. Provide replaceable coils of the epoxy sealed type.

4. Thermal Overload Elements: Class 20 thermal overload element and all required accessories. Provide size five and larger starters with current transformer operated overload relays.

a. Size the overload relays after approval of the corresponding motor.

b. Provide and adjust overload relays that match the associated motor nameplate running-current rating.

c. Provide a set of isolated, normally-open and normally-closed contacts for each overload relay.

C. Motor Circuit Protectors: Provide a motor circuit protector for each combination starter as follows:

1. Molded-case, air-break type designed for 600-volt, 60-hertz service with an interrupting capacity of 65,000 rms symmetrical amperes at 240 volts.

2. No thermal elements.

3. Magnetic trip units capable of being set from 700 to 1,300 percent of the motor full-load amperes.

D. Control Components: Provide push buttons, switches, indicating lights, transformers, relays, and timers as specified herein under paragraph 2.5.

E. Enclosures: Provide motor controllers installed in NEMA 250 rated enclosures as follows:

AREA	ENCLOSURE
Above grade indoor	NEMA 12 – Industrial

2.3 CONTROL COMPONENTS

A. Push Buttons, Selector Switches and Indicating Lights:

1. Provide heavy-duty, oiltight, 30.5 mm, push-button or selector switch control stations arranged for flush-panel mounting.

2. Provide the additional switches, relays, and other electrical accessories necessary to control and safeguard the operation of the associated equipment.

3. Provide 30.5 mm, low-voltage, push-to-test, LED type indicating lights suitable for operation at 120-volt, 60-hertz ac control circuit voltages.

4. Color code indicating lights to match Bird Creek Pumping Station and TMUA's color schema in general, for example:

Red	- Motor off or valve closed
Green	- Motor on or valve open
Amber	- Alarm or trouble condition
Magenta	- Fault

B. Control Power Transformer: Provide an individual, control power transformer for each starter to derive the 120 volts for the unit's control circuit. Provide transformers with sufficient capacity to meet the energy demands for all related control components including relays, solenoids and other indicated items. Provide dual fuses on the primary and one fuse on the secondary. Ground the unfused leg of the secondary to the enclosure.

C. Elapsed Time Meters: Provide nonreset-type elapsed time meters to register up to 9999.9 hours, having square cases suitable for panel mounting and having coils for 120-volt, 60-hertz operation.

D. Control and Latching Relays: Provide control and latching relays of 600-volt class, machine-tool quality with convertible contacts. Provide relay-operating contacts rated at a minimum of 10 amperes, 120 volts, 60 hertz.

E. Current Switches: Provide current switches as follows:

1. General: Provide electric current switches to accomplish specified control functions.

2. Construction: Provide current switches of a solid state type with compatible current and voltage ratings. Provide sensors complete with in-rush delay, single set joint adjustment, power and status LED's and adjustable trip set point with accuracy of +/- 2 percent of range. UL listing and NEMA 12 sealing is required. Provide with two normally open dry contacts.

3. Design: Provide switches designed for a 5 to 185 degree F and 0 to 95 percent humidity, and of a power induced type. Sensors with external power supply are not acceptable.

2.4 SURGE PROTECTIVE DEVICES (SPD):

A. Provide SPD equipment that complies with UL 1449 and UL 1283.

B. Provided units with a maximum continuous operating voltage that exceeds 115 percent of the nominal system operating voltage.

C. Provide SPD equipment suitable for wye configured systems.

D. Provide SPD equipment having directly connected suppression elements between line-neutral (L-N), line-ground (L-G) and neutral-ground (N-G).

E. Provide SPD equipment that distributes the surge current to all MOV components to ensure equal stressing and maximum performance and provides equal impedance paths to each match MOV.

F. Provide high-performance EMI/RFI noise rejection filters that attenuate the electric line noise at least 55dB at 100 kHz using MIL-STD-220A insertion loss test method.

G. Wire internal components with connections utilizing low impedance conductors and compression fittings.

H. Provide SPD suitable for location application and minimum surge current per mode as follows:

1. Switchboard: UL 1449, Type 1/2, 250kA

2. 120/240V Panelboard: UL 1449, Type 2, 80kA

I. Location: Install SPD as follows:

1. Switchboard: Mount SPD is a suitably sized removable unit compartment with a circuit breaker disconnect sized in accordance with the manufacturer's

recommendations. Locate the SPD unit compartment immediately downstream of the main circuit breaker.

2. Panelboard: Mount SPD internally or externally to minimize lead length. Provide a branch circuit breaker disconnect sized in accordance with the manufacturer's recommendations. Locate the SPD unit branch circuit breaker immediately downstream of the main circuit breaker or main lugs.

2.5 RUBBER WORK MATS:

Provide a three foot wide rubber work mat on the floor in front of each switchgear, switchboard and motor control center. The mat will be long enough to cover the full length of the line-up. Provide mats that are 1/4 inch thick with beveled edges, canvas back and solid type with corrugations running the entire length. Mats will be guaranteed to be free from cracks, blow holes or other defects detrimental to their mechanical and electrical strengths. Mats will meet all OSHA requirements and those of ANSI/ASTM J6.7 – 1935 (R1971) / D178, Type 2, Class 2.

PART 3 EXECUTION

3.1 INSTALLATION

A. General: Install all equipment in accordance with the manufacturer's recommendations and approved shop drawings and as specified in Division 1.

B. Mounting: Mount manual starters, motor controllers and remote control stations 4 feet 6 inches from the finished floor up to their centerlines, unless otherwise shown. Mount all devices at least ½ inch away from concrete wall surfaces.

C. Adjustments: Set all motor circuit protectors and circuit breakers based on the approved short circuit and coordination study.

D. Overloads: Adjust the thermal overloads on each phase of each starter unit for the actual motor installed.

E. Cable Connections: Terminate and label all field wiring per the approved diagrams.

F. Torque Requirements: Tighten electrical connectors and terminals, including screws and bolts, in accordance with equipment manufacturers' published torque tightening recommendations. Where manufacturers' torquing requirements are not available, tighten connectors and terminals in accordance with UL Standard 486 A.

3.2 FIELD QUALITY CONTROL

A. Inspections: Inspect, adjust and check the installation for physical alignment, cable terminations and ventilation.

B. Operation and Maintenance: Furnish operation and maintenance instructions as specified in Division 01.

END OF SECTION

SECTION 26 32 13

PACKAGED ENGINE GENERATOR SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Controls and Instrumentation, System Commissioning and Division 01 Specification Sections, apply to this section.

B. Generator to be replaced in kind with similar kW and amp ratings depending on market availability.

1.2 SUMMARY

A. This section includes packaged engine-generator sets for standby power with the following features:

1. Spark-Ignited Engine.
2. Natural Gas Fuel Supply System.
3. Control and monitoring.
4. Generator overcurrent and fault protection.
5. Generator, exciter, and voltage regulator.
6. Outdoor engine generator enclosure (where selected).
7. Vibration isolation devices (where applicable).

B. Related Sections include the following:

1. Section 01 79 00 - Training
2. Section 03 31 00 - Cast-in-Place Concrete
3. Section 26 05 00 - Basic Electrical Materials and Methods
4. Section 26 05 19 - Wires and Cables - 600 Volts and Below
5. Section 26 05 26 - Grounding
6. Section 26 05 33 - Electrical Raceway Systems
7. Section 26 05 53 - Electrical Identification

1.1 DEFINITIONS

A. EPS: Emergency power supply.

B. EPSS: Emergency power supply system.

C. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Include thermal damage curve for generator.
3. Include time-current characteristic curves for generator protective device.
4. Include fuel consumption in gallons per hour (liters per hour) at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
5. Include generator efficiency at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
6. Include airflow requirements for cooling and combustion air in cubic feet per minute (cubic meters per minute) at 0.8 power factor, Provide Drawings indicating requirements and limitations for location of air intake and exhausts.
7. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:

1. Dimensioned Outline Drawings of Equipment Unit: With engine and generator mounted on rails, identify center of gravity and total weight for provided components; fuel tank, enclosure, silencer, base tank, each piece of equipment not integral to the engine generator.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams indicating terminal markings for engine generators and functional relationship between all electrical components.
7. Rigging Information: Indicate location of each lifting attachment, generator-set center of gravity, and total package weight in submittal drawings.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for engine generator, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source Quality-Control Reports: Including, but not limited to, the following:

1. Certified summary of prototype-unit test report. Perform tests at rated load and power factor. Provide the following test results:

    a. Maximum Power Level
    b. Maximum Motor Starting (sKVA)
    c. Structural Soundness
    d. Torsional Analysis
    e. Transient Response
    f. Alternator Temperature Rise
    g. Engine Cooling Requirements (unit mounted radiator)
    h. Harmonic Analysis (per IEEE-115 and ANSI-100)
    i. Voltage Regulation
    j. Endurance Testing

2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Report of factory test on units to be shipped for this Project, indicating evidence of compliance with specified requirements.
4. Report of sound generation.
5. Report of exhaust emissions indicating compliance with applicable regulations.
6. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

C. Field quality-control reports. Field start up report and unit in-service documentation, including load bank test results if applicable.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. Include manufacturer's recommended maintenance and periodic testing plan in accordance with NFPA 110, Chapter 8.

B. Furnish extra materials required by local Authority Having Jurisdiction (AHJ) and defined in project documents that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.5 QUALITY ASSURANCE

A. The generator set covered by these specifications shall be designed, tested, rated, assembled and installed in accordance with all applicable standards below:

1. CSA C22.2, No. 14-M91 Industrial Control Equipment.
2. CSA C22.2, No. 100 Motors and Generators
3. CSA 282-15
4. EN 61000-6
5. EN 55011
6. FCC Part 15 Subpart B
7. ISO 8528
8. IEC 61000
9. UL 508

10. UL 2200
11. UL 142
12. Designed to allow for installed compliance to NFPA 37, NFPA 70, NFPA 99 and NFPA 110

B. Manufacturer Qualifications:

1. Current certificate holder for ISO 9001 compliance.
2. The power system shall be produced by a manufacturer who has produced this type of equipment for a period of at least 25 years and who maintains a service organization of factory-authorized generator technicians available twenty-four hours a day throughout the year.
3. Manufacturing and assembly of products must be done in the United States using domestically sourced materials to the extent practical.

C. Installer Qualifications: An authorized representative who is trained and certified by the manufacturer on stationary power systems.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty: 5 Year Comprehensive from date of Substantial Completion.
2. A Comprehensive Warranty is defined as the manufacturer covering replacement parts, labor, and limited technician travel costs for covered warranty repairs during the listed warranty period. A Limited warranty is defined as the manufacturer covering replacement parts, labor, and limited technician travel costs for the first 2 years and then replacement parts for the remainder of the listed warranty period.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Generac Power Systems, Inc.; 35 kW, 4.5L with a A0060044N21 - 60kW alternator. The single-phase generator shall be rated for 35 kW at 240 volts and 60 Hz, at 0.8 power factor lagging while operating at an maximum ambient temperature of 122 Fahrenheit and maximum altitude of 3500 feet above sea level without reduction in electrical output capacity. Comparable products by one of the following will also be considered:

1. Generac Power Systems, Inc.
2. Kohler Co.

B. Source Limitations: Obtain packaged engine generators and auxiliary components from single source from single manufacturer. "Source Limitations: Obtain packaged engine generators and auxiliary components from single supplier. The equipment supplied and installed shall meet the

requirements of NEC and all applicable local codes and regulations. All equipment shall be new, of current production. There shall be one source responsibility for warranty; parts and service through a local representative with factory certified service personnel.

C. Requests for substitutions shall be made a minimum of ten (10) days prior to bid date. Manufacturers catalog data and a completed generator sizing model using the proposed manufacturer's generator sizing software shall accompany each request and authorized acceptance shall be addenda only. Should any substitutions be made, the contractor shall bear responsibility for the installation, coordination and operation of the system as well as any engineering and redesign costs, which may result from such substitutions.

2.2 PERFORMANCE REQUIREMENTS

A. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.
3. Comply with NFPA 99.
4. Comply with NFPA 110 requirements for Level 1 EPSS.

B. UL Compliance: Engine generator assembly and factory enclosure (if provided) shall be UL 2200 listed.

C. Engine Exhaust Emissions: Comply with applicable US EPA, State and Local Government requirements. Spark-ignited Stationary Emergency: Engines shall be certified by the manufacturer to comply with 40 CFR Part 60 Subpart JJJJ, Table 1, Emission Standards for Stationary Emergency SI Engines and Table 2, Requirements for Performance Tests.

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

C. Power Rating: Standby.

D. Service Load: The generator set shall be a Generac model 35 kW, 4.5L with a A0060044N21 - 60kW alternator. It shall provide 35 kW and 35 kVA while operating at the maximum ambient operating temperature and elevation specified in the project documents.

E. Power Factor: 0.8 lagging.

F. Frequency: 60 Hz.

G. Voltage: 240 Volts ac.

H. Phase: Single Phase, Three Wire.

I. Induction Method: Naturally aspirated or Turbocharged.

J. Governor: Adjustable isochronous, with speed sensing.

K. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

L. Nameplates: For each major system component to identify manufacturer's name, model and serial number of component.

M. Engine Generator Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
2. Transient Voltage Performance: Not more than 6.42 percent variation for 50 percent step-load increase or decrease at unity power factor. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 2.2 Hertz variation for 50 percent step-load increase or decrease at unity power factor. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined in accordance with NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start time to comply with NFPA system requirements.

2.4 ENGINE PERFORMANCE

A. Fuel: Natural gas shall be "pipeline grade" meeting the following conditions:

1. Methane number 80 or greater.
2. High heating value shall be within the range of 950 - 1,150 BTU/scf.
3. Hydrogen sulfide shall not exceed 0.3 g/100 scf.
4. Total sulfur shall not exceed 20 g/100 scf.
5. Water vapor content shall not exceed 0.32 g/100 scf.

B. Rated Engine Speed: 1800 rpm.

C. Lubrication System to be engine mounted.

1. Oil filter shall be engine-mounted replaceable cartridge type with integral bypass valve, in accordance with manufacturer recommendations.

2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

D. Jacket Coolant Heater: Jacket water heater shall be sized per NFPA110 and UL listed to ensure that genset will start within the specified time period and ambient conditions.

E. Integral Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator set mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gauge glass and petcock.
3. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
4. Maximum Ambient Operating Temperature on Radiator: 104 degrees F (40 degrees C).
5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.

    a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and noncollapsible under vacuum.
    b. Meets SAE 100R1A Type S, EN853 1SN, ISO 1436-1 Type 1SN
    c. a Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

F. Muffler/Silencer:

1. Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

G. Air-Intake Filter: Heavy duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

H. Starting System: 12 or 24-V electric, with negative ground.
1. Cranking Cycle: As required by NFPA 110 for system level specified.
2. Battery: Lead acid, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle as required by NFPA 110 for system level specified.
3. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35 minimum continuous rating.
4. Battery Charger: Current-limiting, automatic-equalizing, and float-charging type designed for lead-acid batteries. Unit shall comply with UL 1236 and NFPA 110 Section 5.6.4.6 for Level 1 systems.:

2.5 FUEL SYSTEM – NATURAL GAS

A. Comply with NFPA 37.

B. Operating Pressure: 5 inches of water column.

C. Flowrate: Maximum gas flow demand at 100% load: 446 cubic feet per hour.

2.6 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts engine generator. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

C. Provide minimum run time control set for 15 minutes with override only by operation of a remote emergency-stop switch.

D. Control panel must comply with UL 508. The controller shall meet ASTM B117 (salt spray test).

E. Connection to Building Management: Provide connections for data transmission of indications to remote data terminals via Modbus.

F. Environmentally Hardened Design: Open circuit boards, edge cards, and PC ribbon cable connections are unacceptable.

G. PCB Construction: Circuit boards with surface-mounted components to provide vibration durability. Circuit boards utilizing large capacitors or heat sinks must utilize encapsulation methods to securely support these components.

H. Configuration:

1. Operating and safety indications, protective devices, basic system controls, and engine gauges shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from engine generator vibration. Panel powered from the engine generator battery.

I. Control and Monitoring Panel:

1. Digital engine generator controller with integrated touch screen, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. Instruments: Located on the control and monitoring panel and viewable during operation.

    a. Engine lubricating-oil pressure gauge.
    b. Engine-coolant temperature gauge.

c. DC voltmeter (alternator battery charging).
d. Running-time meter.
e. AC voltmeter, for each phase.
f. AC ammeter, for each phase.
g. AC frequency meter.
h. Generator-voltage adjusting feature.

3. Controls and Protective Devices: Controls, shutdown devices, and common alarm indication, including the following:

a. Cranking control equipment.
b. Run-Off-Auto switch.
c. Control switch not in automatic position alarm.
d. Overcrank alarm.
e. Overcrank shutdown device.
f. Low-water temperature alarm.
g. High engine temperature pre-alarm.
h. High engine temperature.
i. High engine temperature shutdown device.
j. Overspeed alarm.
k. Overspeed shutdown device.
l. Low fuel main tank.

1) Low-fuel-level alarm shall be initiated when the level falls below that required for operation for duration required for the indicated EPSS class.

m. Coolant low-level alarm.
n. Coolant low-level shutdown device.
o. Coolant high-temperature prealarm.
p. Coolant high-temperature alarm.
q. Coolant low-temperature alarm.
r. Coolant high-temperature shutdown device.
s. EPS load indicator.
t. Battery high-voltage alarm.
u. Low cranking voltage alarm.
v. Battery-charger malfunction alarm.
w. Battery low-voltage alarm.
x. Lamp test.
y. Contacts for local and remote common alarm.
z. Remote manual stop shutdown device.
aa. Total engine run hours, non-resettable.
bb. Engine generator metering, including voltage, current, hertz, kilowatt, kilovolt ampere, and power factor.

J. External Alarm & Status Relays: Provide a separate terminal block, factory wired to Form C dry contacts, for each alarm and status condition required by Building Management or other external systems as shown on electrical drawings.

K. Common Remote Panel with Common Audible Alarm: Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.

L. Remote Alarm Annunciator: An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

1. Overcrank alarm.
2. Low water-temperature alarm.
3. High engine temperature pre-alarm.
4. High engine temperature alarm.
5. Low lube oil pressure alarm.
6. Overspeed alarm.
7. Low fuel main tank alarm.
8. Low coolant level alarm.
9. Low cranking voltage alarm.
10. Contacts for local and remote common alarm.
11. Audible-alarm silencing switch.
12. Air shutdown damper when used.
13. Run-Off-Auto switch.
14. Control switch not in automatic position alarm.
15. Fuel tank derangement alarm.
16. Fuel tank high-level shutdown of fuel supply alarm.
17. Lamp test.
18. Low-cranking voltage alarm.
19. Generator overcurrent-protective-device not-closed alarm.

M. Remote Emergency-Stop Switch: Provide remote emergency stop switch in quantity and style as shown on electrical drawings. Electrical contractor to coordinate exact location with engineer and local AHJ.

N. Data Logging:

1. Event Logging – the controller keeps a record of up to 8,000 events with date and time locally for warning and shutdown faults. This event log can be downloaded onto a USB storage device or onto a PC through the service program.
2. Event Snapshot – the control system shall capture 15 seconds of critical data around the time a fault or warning. This data shall be viewable on the controller and downloadable.
3. Data Logging – the controller shall allow customized parameters to be logged based on a start trigger from the controller interface.

    a. The parameters are selectable from all monitored parameters.
    b. The sample period shall be configurable from 1 second to 1 day.
    c. The collected data shall be stored on a USB storage device plugged into the control panel.

2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices shall be coordinated to optimize selective tripping when a short circuit occurs.

1. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.

2. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Overcurrent Protective Device:

1. Unit mounted circuit breakers. Rating, ampacity, accessories, as shown on drawings or as listed below:
2. Molded-case circuit breaker, thermal-magnetic type; 80 percent rated; complying with UL 489:

   a. Tripping Characteristic: Designed specifically for generator protection.
   b. Trip Rating: 175A
   c. Mounting: Adjacent to, or integrated with, control and monitoring panel.

C. Generator Controller Integrated Alternator Protective Functions:

1. Short-time I^2t function : Generator controller-based function shall continuously monitor current level in each phase of alternator output, integrate alternator heating effect over time, and predict when thermal damage of alternator will occur. As overcurrent heating effect on the alternator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator. When signaled by generator protector or other engine generator protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits.
2. Long-time function: Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.
3. Short-circuit fault clearing: Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

E. Range: Provide range of output voltage by adjusting the excitation level.

F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity. Stator shall be skewed construction to minimize harmonic voltage distortion.

G. Enclosure: Drip proof.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator:

1. Voltage Regulator: Solid-state type, separate from exciter. The digital voltage regulator shall be microprocessor based with fully programmable operating and protection characteristics. The regulator shall maintain steady-state generator output voltage within +/- 0.25% for any constant load between no load and full load. The regulator shall be capable of sensing true RMS. The regulator shall provide an adjustable Volts/Hz slope regulation characteristic in order to optimize voltage and frequency response for site conditions.
2. Alternator Excitation: Permanent Magnet Generator (PMG) shall provide excitation power for optimum motor starting and short circuit performance.
3. The generator must accept rated load in one-step.
4. System Transient Voltage Performance: Alternator shall be capable of supplying 43 sKVA with a voltage dip not more than 35% at 0.3 starting power factor. Sustained voltage dip data or manufacturer-published SKVA numbers based on unity PF alternator-only dynamometer testing will not be accepted.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point. The strip heater shall be wired directly to the incoming power distribution panel or load center.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

2.9 OUTDOOR ENGINE GENERATOR ENCLOSURE

A. Basis of design is a standard weather protected enclosure.

B. Generator packaged within manufacturer's weather protective, sound attenuated enclosure. Enclosure and generator set shall be UL 2200 Listed as a system.

C. Enclosure Construction: Minimum 14 gauge construction. Roof construction shall be raised-seam, gasket-free interlocking panels. Rivets shall not be used on external painted surfaces. Design shall be rodent resistant.

D. Doors shall be equipped with lift-off pin and sleeve type hinges to allow access to the engine, alternator, and control panel. Hinges shall be adjustable for door alignment. Hinges and all exposed fasteners shall be stainless steel. Each door shall be equipped with minimum 2-point latching mechanism and identical keys. Perimeter of all door openings shall include polyethylene gasket.

E. Upward discharging exhaust hood for engine cooling airflow and exhaust.

F. Engine exhaust silencer mounted within enclosure discharge hood.

G. Enclosure Finish: Electrostatic applied powered paint, baked and finished to manufacturer's specifications. Finish system shall be subjected to the following tests:

1. ASTM D1186 - 87; 2.5+ mil Paint Thickness
2. ASTM D3363 - 92a; Material Hardness
3. ASTM D522 - B; Resistance to Cracking
4. ASTM D3359 - B; Adhesion
5. ASTM B117 D 1654; Resistant to Salt Water Corrosion
6. ASTM D1735 D 1654; Resistant to Humidity
7. ASTM 2794 93 (2004); Impact Resistance
8. SAE J1690 - UV Protection"

H. Enclosure Color: Manufacturer's standard color, or custom color matched based on architect's design with color sample provided to generator manufacturer.

I. Wind Rating: Enclosure shall be constructed to attain basic wind speed rating of 110 MPH; WIF 1.15, Exposure Category "C", Building Classification "Enclosed", Topographic Factor Kzt = 1. Wind Design Pressures: windward, 20.6 lb/ft^2; leeward, -12.9 lb/ft^2; roof, -18.0 lb/ft^2."

J. Snow Load Rating: Minimum 70 pounds per square foot.

K. Engine-Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for two hours with ambient temperature at top of range specified in system service conditions.

L. Sound Insulation: Enclosure and air discharge hood completely lined with reflective silver mylar faced sound attenuating closed cell foam that meets UL 94 HF1 standards for flammability (FMVSS 302 test method). Roof sound insulation panels shall include additional mechanical retention.

M. Sound Performance: The engine generator, while operating at full rated load, shall not exceed 74.00 dBA average measured at 23 ft (7 meters) from the engine generator in a free field environment.

N. Louvers: Fixed-engine, cooling-air inlet and discharge. Stormproof and drainable louvers prevent entry of rain and snow.

O. Distribution Panel for Accessory Loads: Accessory Load Panel: Provide an internal, factory mounted and wired, electrical distribution panel to serve accessory loads; including:

1. Engine block heater
2. Battery charger
3. Accessory outlets
4. Other accessories (if included)

P. Convenience Outlet: Factory-wired convenience 120v duplex-outlet within enclosure, GFCI.

2.10 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment for units with a ratings 750kw or below.

1. Material: Standard neoprene separated by steel shims.

B. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.11 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with IEEE 115 and with NFPA 110, Level 1 Energy Converters.

B. Project-Specific Equipment Tests: Before shipment, factory test engine generator and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
2. Test generator, exciter, and voltage regulator as a unit.
3. Full load run.
4. Maximum power.
5. Voltage regulation.
6. Transient and steady-state governing.
7. Single-step load pickup.
8. Safety shutdowns.
9. Report factory test results within 10 days of completion of test.

2.12 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.

B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service in accordance with requirements indicated:

1. Notify Project Manager in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without written permission.

3.3 INSTALLATION

A. Comply with NECA 1 and NECA 404.

B. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.

C. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases or steel dunnage as indicated on drawings.
2. Coordinate size and location of mounting bases for packaged engine generators.
3. Install unit with vibration isolation devices described in section 2.11.

D. Tests and Inspections: The supplier of the electric generating plant and associated items covered herein shall provide factory certified technicians to inspect the completed installation and to perform an initial startup inspection to include:

1. Ensuring the engine starts (both hot and cold) within the specified time.
2. Verification of engine parameters within specification.
3. Verify no load frequency and voltage, adjusting if required.
4. Test all automatic shutdowns of the engine-generator.
5. Perform a load test of the electric plant, ensuring full load frequency and voltage are within specification by using building load.

E. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here, including, but not limited to, single-step full-load pickup test.

F. Battery and Charger Tests:

1. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions.
2. Verify that measurements are within manufacturer's specifications."

G. System Integrity Tests: Verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.

H. Coordinate tests with tests for transfer switches and run them concurrently.

I. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

J. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

K. Remove and replace malfunctioning units and retest and reinspect as specified above.

L. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.

M. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations.

3.4 DEMONSTRATION

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

3.5 FIELD QUALITY CONTROL

A. Tests and Inspections: The supplier of the electric generating plant and associated items covered herein shall provide factory certified technicians to inspect the completed installation and to perform an initial startup inspection to include:

1. Ensuring the engine starts (both hot and cold) within the specified time.
2. Verification of engine parameters within specification.
3. Verify no load frequency and voltage, adjusting if required.
4. Test all automatic shutdowns of the engine-generator.
5. Perform a load test of the electric plant, ensuring full load frequency and voltage are within specification by using building load.

B. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here, including, but not limited to, single-step full-load pickup test.

C. Battery and Charger Tests:

1. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions.
2. Verify that measurements are within manufacturer's specifications."

D. System Integrity Tests: Verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.

E. Coordinate tests with tests for transfer switches and run them concurrently.

F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

H. Remove and replace malfunctioning units and retest and reinspect as specified above.

I. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.

J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations.

3.6 MAINTENANCE SERVICE

A. Repair Service Capabilities:

1. The generator set supplier shall maintain service parts inventory for the entire power system at a central location which is accessible to the service location 24 hours per day, 365 days per year. The manufacturer of the generator set shall maintain a central parts inventory to support the supplier, covering all the major components of the power system, including: engines, alternators, control systems, paralleling electronics, and power transfer equipment.
2. The generator set shall be serviced by a local service organization that is trained and factory certified in generator set service. The supplier shall maintain an inventory of power system replacement parts in the local service location. Service vehicles shall be stocked with critical replacement parts. The service organization shall be on call 24 hours per day, 365 days per year. The service organization shall be physically located within 50 miles of the site.
3. The manufacturer shall maintain model and serial number records of each generator set provided for at least 20 years.

B. Preventative Maintenance Service Agreement: The supplier shall include as a line item adder in the proposal, a one-year maintenance service agreement. The maintenance shall be performed by factory authorized service technicians capable of servicing both the engine generator set(s) and the transfer switch(es). This agreement shall include semi-annual preventative maintenance visits to verify operation and/or complete the following:

1. All periodic engine maintenance as recommended by the service manual.
2. All electrical controls maintenance and calibrations as recommended by the manufacturer.
3. All auxiliary equipment as a part of the emergency systems.
4. The supplier shall guarantee emergency service.
5. All expendable maintenance items are to be included in this agreement.
6. A copy of this agreement and a schedule shall be provided in the submittal documents, detailing scope of work and preventative maintenance service visit interval.

3.7 DEMONSTRATION

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

END OF SECTION

SECTION 26 36 23

AUTOMATIC TRANSFER SWITCHES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for providing automatic transfer switch (with bypass isolation) including control modules to provide completely automatic operation.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 01 79 00 - Training
2. Section 09 96 00 - High Performance Coatings
3. Section 26 05 00 - Basic Electrical Materials and Methods
4. Section 26 05 26 - Grounding
5. Section 26 05 53 - Electrical Identification
6. Section 26 05 19 - Wires and Cables - 600 Volts and Below

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. NFPA 70 - National Electrical Code (NEC)

2. NEMA ICS 10 - AC Automatic Transfer Switches

3. UL 486A - Wire Connectors and Soldering Lugs For Use With Copper Conductors

4. UL 1008 - Standard for Automatic Transfer Switches

1.3 SYSTEM DESCRIPTION

A. Design Requirements: Provide equipment capable of operating in an ambient temperature range of 0 to 40 degrees C and humidity of up to 90 percent noncondensing.

1. Arrange the equipment to be convenient and readily front accessible for inspection and maintenance of all devices, terminals and wiring. (NOTE:

When provided with a bypass isolation switch include access on at least one side.)

1.4 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 01 and Section 26 05 00.

B. Product Data and Information: Provide manufacturer's data for all associated equipment and devices indicating dimensions, size, voltage ratings, current ratings, withstand and interrupting ratings.

C. Shop Drawings: Provide shop drawings for automatic transfer switches to include the following:

1. Outline drawings showing arrangement, elevations and identification of components.

2. Bill of materials including manufacturers' name and catalog number.

3. Interconnecting wiring diagrams, where required.

4. Individual schematic and wiring diagrams.

D. Quality Control: Furnish the following test reports and certificates as specified in Division 01:

1. Certified Shop Test Reports for the automatic transfer switch and related components.

E. Operation and Maintenance Manuals: Furnish operation and maintenance manuals as specified in Division 01.

1.5 QUALITY ASSURANCE

A. Codes: Manufacture all automatic transfer switches in accordance with NEMA ICS10, and UL 1008.

1. Manufacture and install each automatic transfer switch in accordance with the NFPA 70 and local codes.

B. UL Label: Provide each automatic transfer switch with a UL label.

1.6 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store, and handle all products and materials as specified in Division 01.

B. Shipping and Packing: Provide all structures, equipment and materials rigidly braced and protected against weather, damage, and undue strain during shipment.

C. Storage and Protection: Store all equipment and materials in a dry, covered, heated and ventilated location. Provide any additional measures in accordance with manufacturer's instructions.

1.7 SPARE PARTS

A. General: Provide the following spare parts:

1. Two complete replacements of all indicating lamps and fuses used in the installation.
2. Two of each special tool required for maintenance.
3. Three 12-ounce spray cans of the final finish.

B. Packaging: Pack spare parts in containers bearing labels clearly designating contents and related pieces of equipment. Deliver spare parts in original factory packages. Identify all spare parts with information needed for reordering.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted for review.

1. Automatic Transfer Switch

a. Schneider Electric
b. Eaton
c. ABB

2.2 AUTOMATIC TRANSFER SWITCHES

A. Description: Provide enclosed, double-throw automatic transfer switch with single operating mechanism.

B. Configuration: Electrically-operated, mechanically held with required relays, controls, and contacts.

2.3 RATINGS

A. Voltage: 120/240V

B. Switched Poles: 2

C. Amperage: 200A with fully rated neutral

D. Loads: Combination tungsten, ballast, resistance, and inductive loads.

E. Withstand and Closing Ratings: 10,000 minimum rms symmetrical amperes at 240V, when used with molded-case circuit breaker.

F. 100A and larger automatic transfer switches shall be UL listed for 3 and 30 cycle close and withstand ratings.

2.4 COMPONENTS

A. Contacts: Provide silver surfaced main contacts protected by a separate renewable arcing contact. Mechanically lock normal and emergency contacts by the operating linkage when in the open or closed position. Provide an operating linkage that will not permit a neutral position when a failure of any coil or disarrangement of any part occurs. Provide a switch with a "center off" feature and suitable time delay on transfer to allow any back EMF to diminish prior to transferring to either source.

B. Operating Mechanism: Isolate the mechanical driving system and mechanical interlocks to be electrically dead. Do not use molded plastic parts for the operating linkage between the electrical operator and the main operating shaft of the switch.

C. Main Bearings: Radial, ball-bearing type.

D. Sensing and Control Relays: Continuous-duty, industrial type with wiping contacts rated 10 amperes minimum.

E. Control Logic: Solid-state, microprocessor-based with generator exercise accessories.

F. Arc Barriers: Provide arc barriers and arc suppression for each pole.

2.5 ACCESSORIES

A. Indicating Lights: Provide 30.5 mm, LED type indicating lights mounted in the cover of the enclosure to indicate the following:

1. Normal source available
2. Standby source available
3. Load connection to normal source
4. Load connection to standby source.

B. Test Switch: Mount in the cover of the enclosure to simulate failure of normal source.

C. Transfer Switch Auxiliary Contacts: Provide the following auxiliary contacts rated for 10 amperes at 120 volts.

1. Normal power position: 2 set N.O., 2 set N.C.
2. Standby power position: 2 set N.O., 2 set N.C.
3. Normal power failure monitor: 2 sets N.O., 2 sets N.C.

D. Normal Source Monitor: Monitor voltage and frequency on each phase of the normal source.

E. Standby Source Monitor: Monitor voltage and frequency on each phase of the standby source.

F. In-Phase Monitor: Monitor phase timing of the normal and standby sources.

G. External Manual Operator: Equip with an operator which allows the manual transfer from one source to the other with the door closed.

H. Monitoring Communications: Ethernet with MODBUS RTU.

I. Adjustable Time Delay Transfer Logic: Provide adjustable, solid-state, time delays for the following functions:

1. Normal to standby: 0-5 minutes
2. Standby to normal: 0-30 minutes

2.6 ENCLOSURE

A. Enclosure: NEMA Type 1

B. Accessibility: Provide an enclosure with all current carrying contacts and parts readily accessible from the front for maintenance and inspection without removal of the switch panel, disconnecting of the operating linkage, or disconnecting of power conductors.

2.7 AUTOMATIC SEQUENCE OF OPERATION

A. Controller: Provide a programmable, microprocessor-based controller to provide an automatic sequence of operation as follows:

1. Initiate time delay to start standby source engine generator: Signal from normal source monitor.

    a. Normal Source Monitor: Initiate when normal source voltage drops below 85 percent from rated nominal value or frequency varies more than 5 percent from rated nominal value.

    b. Time Delay to Start Emergency Source Engine Generator: Adjustable from 0.5 to 10 seconds, initially set at 1 second.

2. Initiate transfer load to standby source: Signals from normal source monitor, emergency source monitor, and in-phase monitor.

    a. Normal Source Monitor: Initiate when normal source voltage drops below 70 percent from rated nominal value or frequency varies more than 10 percent from rated nominal value.

    b. Emergency Source Monitor: Initiate when emergency source voltage is at least 90 percent of rated nominal value and frequency is within 5 percent of rated nominal value.

    c. In-Phase Monitor: If normal and emergency sources are energized, initiate when sources are synchronized to within 15 electrical degrees.

    d. Time Delay to Transfer Load to Emergency Source: Adjustable from 0 to 5 minutes, initially set at 2 seconds.

3. Initiate retransfer load to normal source: Signals from normal source monitor and in-phase monitor.

    a. Normal Source Monitor: Initiate when normal source voltage is at least 90 percent of rated nominal value and frequency is within 5 percent or rated nominal value.

b. In-Phase Monitor: Initiate when sources are synchronized to within 15 electrical degrees.

c. Time Delay To Transfer Load to Normal Source: Adjustable from 0 to 30 minutes, set at 10 minutes. Bypass time delay in event of emergency source failure.

d. Time Delay To Shut Down Standby Source Engine Generator: Adjustable from 0 to 30 minutes, initially set at 15 minutes.

4. Generator Exerciser: 7-day timer to schedule automatic exercising of the engine generator without transferring load.

5. Bypass Exerciser: Bypass exerciser control in event of normal source failure during exercising period.

PART 3 EXECUTION

3.1 INSTALLATION

A. General: Install all equipment in accordance with the manufacturer's recommendations and approved shop drawings and as specified in Division 01.

B. Cable Connections: Terminate and label all field wiring per the approved diagrams.

C. Torque Requirements: Tighten electrical connectors and terminals, including screws and bolts, in accordance with equipment manufacturers' published torque tightening recommendations. Where manufacturers' torquing requirements are not available, tighten connectors and terminals in accordance with UL Standard 486 A.

3.2 FIELD QUALITY CONTROL

A. Inspections: Inspect, adjust and check the installation for physical alignment, cable terminations and ventilation.

B. Adjustments: Make all necessary adjustments to the equipment to provide complete and satisfactory operation upon completion of the Contract.

C. Tests: Perform field tests as follows:

1. Inspect and test the installation with respect to the safety requirements of NFPA 70 pertaining to grounding and insulation resistance.

2. Demonstrate proper operation of the automatic transfer switch by simulating conditions.

3. Repair or replace defective materials at no cost to the OWNER.

3.3 OPERATION DEMONSTRATION

A. Manufacturer's Representative: Provide the services of the automatic transfer switch manufacturer's representative to assist in installation, start-up, field testing, calibration, placing into operation and providing training, as specified in Section 01 79 00. The representative is required to carry out a thorough inspection of the installation and certify that the installation is correct and complete in accordance with the manufacturer's instruction and to confirm that the automatic transfer switch is ready for the final acceptance. Also to instruct operating personnel in the operation and maintenance of the automatic transfer switch.

B. Training: Following completion of installation and field testing provide training for employees of the OWNER in the proper operation, troubleshooting and maintenance of the equipment as outlined below. All training will be at the OWNER'S facilities at a time agreeable to the OWNER:

1. Operational Training: A minimum of two 4-hour sessions combining both classroom and hands-on instruction, excluding travel time.

2. Maintenance Training: A minimum of two 4-hour sessions combining both classroom and hands-on instruction, excluding travel time.

3.4 CLEANING AND PAINTING

A. Shop Painting: Paint automatic transfer switches in accordance with Section 09 96 00.

B. Field Painting: Clean and touch up any scratched or marred surface to match original finish.

END OF SECTION

SECTION 31 10 00

SITE CLEARING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for clearing of all areas within the Contract limits and other areas shown, including work designated in permits and other agreements, in accordance with the requirements of Division 1.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 02 41 00 - Demolition
2. Section 31 23 16 - Excavation - Earth and Rock
3. Section 31 23 23 - Backfilling
4. Section 32 90 00 - Landscape Work

1.2 DEFINITIONS

A. Clearing: Clearing is the removal from the ground surface and disposal, within the designated areas, of trees, brush, shrubs, down timber, decayed wood, other vegetation, rubbish and debris as well as the removal of fences.

B. Grubbing: Grubbing is the removal and disposal of all stumps, buried logs, roots larger than 2 inches, matted roots and organic materials.

PART 2 MATERIALS

Not Used

PART 3 EXECUTION

3.1 TREE REMOVAL

A. Tree Removal Within Property Limits: Remove trees and shrubs within the property limits unless otherwise indicated.

1. Remove trees and shrubs to avoid damage to trees and shrubs designated to remain.

2. Grub and remove tree stumps and shrubs felled within the property limits to an authorized disposal site. Fill depressions created by such removal with material suitable for backfill as specified in Section 31 23 23.

B. Tree Removal Outside Property Limits: Do not cut or damage trees outside the property limits unless shown to be removed or unless written permission has been obtained from the property owner. Furnish three copies of the written permission before removal operations commence.

3.2 TREES AND SHRUBS TO BE SAVED

A. Protection: Protect trees and shrubs within the construction site that are so delineated or are marked in the field to be saved from defacement, injury and destruction.

1. Work within the limits of the tree drip line with extreme care using either hand tools or equipment that will not cause damage to trees.

a. Do not disturb or cut roots unnecessarily. Do not cut roots 2 inches and larger unless approved.

b. Immediately backfill around tree roots after completion of construction in the vicinity of trees.

c. Do not operate any wheeled or tracked equipment within drip line.

2. Protect vegetation from damage caused by emissions from engine-powered equipment.

3. During working operations, protect the trunk, foliage and root system of all trees to be saved with boards or other guards placed as shown and as required to prevent damage, injury and defacement.

a. Do not pile excavated materials within the drip line or adjacent to the trunk of trees.

b. Do not allow runoff to accumulate around trunk of trees.

c. Do not fasten or attach ropes, cables, or guy wires to trees without permission. When such permission is granted, protect the tree before making fastening or attachments by providing burlap wrapping and softwood cleats.

d. The use of axes or climbing spurs for trimming will not be permitted.

e. Provide climbing ropes during trimming.

4. Remove shrubs to be saved, taking a sufficient earth ball with the roots to maintain the shrub.

   a. Temporarily replant if required, and replace at the completion of construction in a condition equaling that which existed prior to removal.

   b. Replace in kind if the transplant fails. Provide transplanting, planting, and watering and guarantee as specified in Section 32 90 00.

5. Have any tree and shrub repair performed by a tree surgeon properly licensed by the State in which the Work is constructed and within 24 hours after damage occurred.

3.3 CLEARING AND GRUBBING

A. Clearing: Clear all items specified to the limits shown and remove cleared and grubbed materials from the site.

   1. Do not start earthwork operations in areas where clearing and grubbing is not complete, except that stumps and large roots may be removed concurrent with excavation.

   2. Comply with erosion, sediment control and storm management measures as specified in Division 1.

B. Grubbing: Clear and grub areas to be excavated, areas receiving less than 3 feet of fill and areas upon which structures are to be constructed.

   1. Remove stumps and root mats in these areas to a depth of not less than 1 foot below the subgrade of sloped surfaces.

   2. Fill all depressions made by the removal of stumps or roots with material suitable for backfill as specified in Section 31 23 23.

C. Limited Clearing: Clear areas receiving more than 3 feet of fill by cutting trees and shrubs as close as practical to the existing ground. Grubbing will not be required.

D. Burning: Do not burn without written permission from the Fire Marshall. If perishable material is burned, burn under the constant care of a competent watchman.

1. Burn at such times and in such a manner that material designated to remain on the property, the surrounding cover and adjacent property will not be jeopardized.

2. Dispose of ashes off-site or properly cover or combine with soils material before restoration.

3. Comply with applicable laws and ordinances.

3.4 TOPSOIL

A. Stripping: Strip existing topsoil from areas that will be excavated or graded prior to commencement of excavating or grading and place in well-drained stockpiles in approved locations.

END OF SECTION

SECTION 31 23 16

EXCAVATION - EARTH AND ROCK

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for performing opencut excavations to the widths and depths necessary for constructing structures, pipelines and conduits including excavation of any material necessary for any purpose pertinent to the construction of the Work.

B. Related Work Specified In Other Sections Includes, But is Not Limited to, the Following:

1. Section 03 31 00 - Cast-in-Place Concrete
2. Section 31 10 00 - Site Clearing
3. Section 31 23 23 - Backfilling
4. Section 31 41 00 - Shoring, Sheeting and Bracing

1.2 DEFINITIONS

A. Earth: "Earth" includes all materials which, in the opinion of the ENGINEER, do not require blasting, barring, or wedging for their removal from their original beds. Specifically excluded are all ledge and bedrock and boulders or pieces of masonry larger than one cubic yard in volume.

B. Rock: "Rock" includes all materials which, in the opinion of the ENGINEER, require blasting, barring or wedging for removal from their original beds and which have compressive strengths in their natural undisturbed state in excess of 300 psi. Boulders or masonry larger than one cubic yard in volume are classed as rock excavation.

1.3 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 1.

B. Dewatering Excavation Plan: Develop an excavation dewatering plan that considers site ground and groundwater conditions, the type and arrangement of the equipment to be used and the proper method of groundwater disposal. Prepare the dewatering plan before beginning excavations below groundwater. Maintain one

copy of the dewatering plan at the project site to be available for inspection while all dewatering operations are underway.

1.4 SITE CONDITIONS

A. Actual Conditions: Make any geotechnical investigations deemed necessary to determine actual site conditions.

B. Underground Utilities: Locate and identify all existing underground utilities prior to the commencement of Work.

C. Quality and Quantity: Make any other investigations and determinations necessary to determine the quality and quantities of earth and rock and the methods to be used to excavate these materials.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 GENERAL

A. Clearing: Clear opencut excavation sites of obstructions preparatory to excavation. Clearing in accordance with Section 31 10 00, includes removal and disposal of vegetation, trees, stumps, roots and bushes, except those specified to be protected during trench excavation.

B. Banks: Shore or slope banks to the angle of repose to prevent slides or cave-ins in accordance with Section 31 41 00.

C. Hazardous Materials: If hazardous materials not specifically shown or noted are encountered, proceed in accordance with General Conditions Article 4.06, Hazardous Environmental Condition at Site.

3.2 TRENCH EXCAVATION

A. Preparation: Properly brace and protect trees, shrubs, poles and other structures which are to be preserved. Unless shown or specified otherwise, preserve all trees and large shrubs. Hold damage to the root structure to a minimum. Small shrubs may be preserved or replaced with equivalent specimens.

B. Adequate Space: Keep the width of trenches to a minimum, however provide adequate space for workers to place, joint and backfill the pipe properly.

1. Do not allow the clear width of the trench at the level of the top of the pipe to exceed the sum of the outside diameter of the pipe barrel plus 20 inches for pipe 4 through 24 inches in diameter nor the outside diameter of the pipe barrel plus 2 feet for pipe more than 24 inches in diameter, unless otherwise approved.

2. In sheeted trenches, measure the clear width of the trench at the level of the top of the pipe to the inside of the sheeting.

3. Should the maximum trench widths specified above be exceeded without written approval, provide concrete cradle or encasement for the pipe as directed. No separate payment will be made for such concrete cradle or encasement.

C. Depth: Excavate trenches to a minimum depth of 6 inches below the bottom of the pipe or the bottom of encasement for electrical ducts, unless otherwise shown, specified or directed, so that bedding material can be placed in the bottom of the trench and shaped to provide a continuous, firm bearing for duct encasement, pipe barrels and bells.

D. Unstable Materials: If unstable material is exposed at the level of the bottom of the trench excavation, excavate the material in accordance with the subsection headed "Authorized Additional Excavation".

1. When in the judgment of the ENGINEER the unstable material extends to an excessive depth, the ENGINEER may advise, in writing, the need for stabilization of the trench bottom with additional select fill material or a crushed stone or gravel mat or the need to provide firm support for the pipe or electrical duct by other suitable methods.

2. Payment for such trench stabilization will be made under the appropriate Contract Items or where no such items exist, as a change in the Work.

E. Length of Excavation: Keep the open excavated trench preceding the pipe or electrical duct laying operation and the unfilled trench, with pipe or duct in place, to a minimum length which causes the least disturbance. Provide ladders for a means of exit from the trench as required by applicable safety and health regulations.

F. Water: Allow no water to rise in the trench excavation until sufficient backfill has been placed to prevent pipe or duct flotation.

3.3 SHORT TUNNEL EXCAVATION

A. Short Tunnel Requirements: In some instances, trees, shrubs, utilities, sidewalks and other obstructions may be encountered, the proximity of which may be a hindrance to opencut trench excavation. In such cases, excavate by means of short tunnels in order to protect such obstructions against damage.

1. Construct the short tunnel by hand, auger or other approved method approximately 6 inches larger than the diameter of pipe bells or outer electrical duct encasement.

2. Consider such short tunnel work incidental to the construction of pipelines or conduits and all appurtenances. The need for short tunnels will not be grounds for additional payment.

3.4 EXCAVATION FOR JACKING AND AUGERING

A. Jacking and Augering Requirements: Allow adequate length in jacking pits to provide room for the jacking frame, the jacking head, the reaction blocks, the jacks, auger rig, and the jacking pipe. Provide sufficient pit width to allow ample working space on each side of the jacking frame. Allow sufficient pit depth such that the invert of the pipe, when placed on the guide frame, will be at the elevation desired for the completed line. Tightly sheet the pit and keep it dry at all times.

3.5 ROCK EXCAVATION

A. Rock Excavation: Excavate rock within the boundary lines and grades as shown, specified or required.

1. Rock removed from the excavation becomes the property of the CONTRACTOR. Transport and dispose of excavated rock at an off site disposal location. Obtain the off site disposal location.

2. Remove all shattered rock and loose pieces.

B. Structure Depths: For cast-in-place structures, excavate the rock only to the bottom of the structure, foundation slab, or drainage blanket.

C. Trench Depth: For trench excavation in which pipelines or electrical ducts are to be placed, excavate the rock to a minimum depth of 6 inches below the bottom of the pipe or duct encasement and refill the excavated space with pipe bedding material. Include placing, compacting and shaping pipe bedding material in the appropriate Contract Items.

D. Manhole Depths: For manhole excavation, excavate the rock to a minimum depth of 8 inches below the bottom of the manhole base for pipelines 24 inches in diameter and larger and 6 inches below the bottom manhole base for pipelines less than 24 inches in diameter. Refill the excavated space with pipe bedding material. Include placing, compacting and shaping pipe bedding material for manhole bases in the appropriate Contract Items.

E. Over-excavated Space: Refill the excavated space in rock below structures, pipelines, conduits and manholes, which exceeds the specified depths with Class D concrete, crushed stone or other material as directed. Include refilling of over-excavated space in rock as part of the rock excavation.

F. Other Requirements: Follow, where applicable, the requirements of the subsections on "Trench Excavation" and "Structure Excavation".

G. Payment: Rock excavation, including placing, compacting and shaping of the select fill material, will be paid for under the appropriate Contract Items or where no such items exist, as a change in the Work.

H. Blasting: Do not use blasting as a method of excavation.

3.6 FINISHED EXCAVATION

A. Finish: Provide a reasonably smooth finished surface for all excavations, which is uniformly compacted and free from irregular surface changes.

B. Finish Methods: Provide a degree of finish which is ordinarily obtainable from blade-grade operations, except as otherwise specified in Section 31 23 23.

3.7 PROTECTION

A. Traffic and Erosion: Protect newly graded areas from traffic and from erosion.

B. Repair: Repair any settlement or washing away that may occur from any cause, prior to acceptance. Re-establish grades to the required elevations and slopes.

C. Other Requirements: Conduct all Work in accordance with the environmental protection requirements specified in Division 1.

3.8 AUTHORIZED ADDITIONAL EXCAVATION

A. Additional Excavation: Carry the excavation to such additional depth and width as authorized in writing, for the following reasons:

1. In case the materials encountered at the elevations shown are not suitable.

2. In case it is found desirable or necessary to go to an additional depth, or to an additional depth and width.

B. Refill Materials: Refill such excavated space with either authorized Class D concrete or compacted select fill material.

C. Compaction: Where necessary, compact fill materials to avoid future settlement.

D. Payment: Additional earth excavations so authorized and concrete or select fill materials authorized for filling such additional excavation and compaction of select fill materials will be paid for under the appropriate Contract Items or where no such items exist, as a change in the Work.

3.9 UNAUTHORIZED EXCAVATION

A. Stability: Refill any excavation carried beyond or below the lines and grades shown, except as specified in the subsection headed "Authorized Additional Excavation", with such material and in such manner as may be approved in order to provide for the stability of the various structures.

B. Refill Materials: Refill spaces beneath all manholes, structures, pipelines, or conduits excavated without authority with Class D concrete or compacted select fill material, as approved.

C. Payment: Refill for unauthorized excavation will not be measured and no payment will be made therefor.

3.10 SEGREGATION STORAGE AND DISPOSAL OF MATERIAL

A. Stockpiling Suitable Materials: Stockpile topsoil suitable for final grading and landscaping and excavated material suitable for backfilling or embankments separately on the site in approved locations.

B. Stockpile Locations: Store excavated and other material a sufficient distance away from the edge of any excavation to prevent its falling or sliding back into the excavation and to prevent collapse of the wall of the excavation. Provide not less than 2 feet clear space between the top of any stockpile and other material and the edge of any excavation.

C. Excess Materials: Transport and dispose of surplus excavated material and excavated material unsuitable for backfilling or embankments at an off site disposal location. Obtain the off site disposal location.

3.11 REMOVAL OF WATER

A. Water Removal: At all times during the excavation period and until completion and acceptance of the WORK at final inspection, provide ample means and equipment with which to remove promptly and dispose of properly all water entering any excavation or other parts of the WORK.

B. Dry Excavations: Keep the excavation dry.

C. Water Contact: Allow no water to rise over or come in contact with masonry and concrete until the concrete and mortar have attained a set and, in any event, not sooner than 12 hours after placing the masonry or concrete.

D. Discharge of Water: Dispose of water pumped or drained from the Work in a safe and suitable manner without damage to adjacent property or streets or to other work under construction.

E. Protection: Provide adequate protection for water discharged onto streets. Protect the street surface at the point of discharge.

F. Sanitary Sewers: Discharge no water into sanitary sewers.

G. Storm Sewers: Discharge no water containing settleable solids into storm sewers.

H. Repair: Promptly repair any and all damage caused by dewatering the Work.

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 31 23 23

BACKFILLING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Backfill all excavation to the original surface of the ground or to such other grades as may be shown or required. For areas to be covered by topsoil, leave or stop backfill 12 inches below the finished grade or as shown. Obtain approval before backfilling against masonry structures. Remove from all backfill, any compressible, putrescible, or destructible rubbish and refuse and all lumber and braces from the excavated space before backfilling is started. Leave sheeting and bracing in place or remove as the work progresses.

B. Equipment Limitations: Do not permit construction equipment used to backfill to travel against and over cast-in-place concrete structures until the specified concrete strength has been obtained, as verified by concrete test cylinders. In special cases where conditions warrant, the above restriction may be modified providing the concrete has gained sufficient strength, as determined from test cylinders, to satisfy design requirements for the removal of forms and the application of load.

C. Related Work Specified In Other Sections Includes, But is Not Limited to, the Following:

1. Section 31 10 00 - Site Clearing

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. ASTM D 1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))

1.3 SUBMITTALS

A. Provide all submittals, including the following in accordance with Division 1.

1. Certified laboratory reports of all proposed backfill material.

PART 2 PRODUCTS

2.1 BACKFILL MATERIAL - GENERAL

A. General: Backfill with sound materials, free from waste, organic matter, rubbish, boggy or other unsuitable materials.

B. General Materials Requirements: Conform materials used for backfilling to the requirements specified. Follow common fill requirements whenever drainage or select fill is not specified. Determine and obtain the approval of the appropriate test method where more than one compaction test method is specified.

C. Frozen Materials: Do not use frozen material for backfilling.

2.2 SELECT FILL

A. Materials for Select Fill: Use gravel, crushed stone, limestone screenings or other granular or similar material as approved which can be readily and thoroughly compacted to 95 percent of the maximum dry density obtainable by ASTM D 1557.

1. Grade select fill between the following limits:

U.S. Standard Sieve	Percent Passing by Weight
2 inch	100
1-1/2 inch	90-100
1 inch	75-95
1/2 inch	45-70
#4	25-50
#10	15-40
#200	5-15

2. Very fine sand, uniformly graded sands and gravels, or other materials that have a tendency to flow under pressure when wet are unacceptable as select fill.

2.3 COMMON FILL

A. Materials for Common Fill: Material from on-site excavation may be used as common fill provided that it can be readily compacted to 90 percent of the maximum dry density obtainable by ASTM D 1557, and does not contain

unsuitable material. Select fill may be used as common fill at no change in the Contract Price.

B. Granular Materials On-Site: Granular on-site material, which is fairly well graded between the following limits may be used as granular common fill:

U.S. Standard Sieve	Percent Passing by Weight
3 inch	100
#10	50-100
#60	20-90
#200	0-20

C. Cohesive Materials On-Site: Cohesive site material may be used as common fill.

1. The gradation requirements do not apply to cohesive common fill.

2. Use material having a liquid limit less than or equal to 40 and a plasticity index less than or equal to 20.

D. Material Approval: All material used as common fill is subject to approval. If there is insufficient on-site material, import whatever additional off-site material is required which conforms to the specifications and at no additional cost.

2.4 PIPE BEDDING

A. Gradation for Small Piping: For pipe 18 inches or less in diameter, comprise pipe bedding of material 90 percent of which will be retained on a No. 8 sieve and 100 percent of which will pass a 1/2-inch sieve and be well graded between those limits.

B. Gradation for Large Piping: For pipe larger than 18 inches in diameter, use the same pipe bedding material as specified for smaller pipe or use a similar well graded material 90 percent of which will be retained on a No. 8 sieve and 100 percent of which will pass a 1-inch sieve.

PART 3 EXECUTION

3.1 ELECTRICAL DUCT AND PRECAST MANHOLE BEDDING

A. Bedding Compaction: Bed all electrical ducts and precast manholes in well graded, compacted, select fill conforming to the requirements except as otherwise

shown, specified, or required. Extend electrical duct bedding a minimum of 6 inches below the bottom of the duct encasement for the full trench width. Compact bedding thickness no less than 6 inches for precast concrete manhole bases.

B. Concrete Work Mats: Cast cast-in-place manhole bases and other foundations for structures against a Class D concrete work mat in clean and dry excavations, unless otherwise shown, specified or required.

C. Bedding Placement: Place select fill used for bedding beneath electrical ducts and precast manhole bases, in uniform layers not greater than 9 inches in loose thickness. Thoroughly compact in place with suitable mechanical or pneumatic tools to not less than 95 percent of the maximum dry density as determined by ASTM D 1557.

D. Use of Select Fill: Bed existing underground structures, tunnels, conduits and pipes crossing the excavation with compacted select fill material. Place bedding material under and around each existing underground structure, tunnel, conduit or pipe and extend underneath and on each side to a distance equal to the depth of the trench below the structure, tunnel, conduit or pipe.

3.2 PIPE BEDDING

A. Hand Placement: Place select fill pipe bedding by hand from the bottom of the excavation to 1 foot over the top of the pipe in uniform layers not greater than 6 inches in loose thickness. Tamp under pipe haunches and thoroughly compact pipe bedding in place with suitable mechanical or pneumatic tools to not less than 95 percent of the maximum dry density as determined by ASTM D 1557 (Modified Proctor).

B. Stone Placement: Do not place large stone fragments in the pipe bedding or backfill to 1 foot over the top of pipes, nor nearer than 2 feet at any point from any pipe, conduit or concrete wall.

C. Unallowed Materials: Pipe bedding containing very fine sand, uniformly graded sands and gravels, or other materials that have a tendency to flow under pressure when wet is unacceptable.

3.3 BEDDING PLACEMENT AND BACKFILL FOR PIPE IN SHORT TUNNEL

A. Bed pipelines or electrical ducts placed in short tunnels in select fill or Class D concrete. Completely fill the remainder of the annular space between the outside of the pipe wall and the tunnel wall with select fill, suitable job-excavated material, or Class D concrete, as approved. Suitably support pipelines or ducts in short tunnels to permit placing of backfill suitably tamped in place.

3.4 TRENCH BACKFILL

A. General: Backfill trenches from 1 foot over the top of the pipe, from the top of electrical duct bedding or as shown to the bottom of pavement base course, subgrade for lawns or lawn replacement, to the top of the existing ground surface or to such other grades as may be shown or required.

B. Materials: Provide select fill, suitable job-excavated material or other material, as specified and as approved for trench backfill.

C. Depth of Placement - General: Except under pavements, walkways, railroad tracks, and street or highway appurtenances, or as otherwise specified, place trench backfill in uniform layers not greater than 9 inches in loose thickness and thoroughly compact in place using suitable mechanical or pneumatic equipment. Compact backfill to not less than 90 percent of the maximum dry density as determined by ASTM D 1557.

D. Depth of Placement - Traffic Areas and Under Utilities: Where pavements, walkways, railroad tracks and street or highway appurtenances are to be placed over trenches and under utilities or utility services crossing the trench, provide trench backfill using select fill placed in uniform layers not greater than 9 inches in loose thickness and thoroughly compacted in place with equipment as specified above. Compact backfill to not less than 95 percent of the maximum dry density as determined by ASTM D 1557.

E. Depth of Placement - Undeveloped Areas: In nondeveloped areas and where select fill material or hand-placed backfill are not specified or required, place suitable job-excavated material or other approved backfill in lifts not exceeding 12 inches in loose thickness. When the trench is full, consolidate the backfill by jetting, spading, tamping or puddling to ensure complete filling of the excavation. Mound the top of the trench approximately 12 inches to allow for consolidation of backfill.

F. Dropping of Material on Work: Do trench backfilling work in such a way as to prevent dropping material directly on top of any conduit or pipe through any great vertical distance. Do not allow backfilling material from a bucket to fall directly on a structure or pipe and, in all cases, lower the bucket so that the shock of falling earth will not cause damage.

G. Distribution of Large Materials: Break lumps up and distribute any stones, pieces of crushed rock or lumps which cannot be readily broken up, throughout the mass so that all interstices are solidly filled with fine material.

3.5 STRUCTURE BACKFILL

A. Use of Select Fill: Use select fill underneath all structures, and adjacent to structures where pipes, connections, electrical ducts and structural foundations are to be located within this fill. Use select fill beneath all pavements, walkways, and railroad tracks, and extend to the bottom of pavement base course or ballast.

1. Place backfill in uniform layers not greater than 8 inches in loose thickness and thoroughly compact in place with suitable approved mechanical or pneumatic equipment.

2. Compact backfill to not less than 95 percent of the maximum dry density as determined by ASTM D 1557.

B. Use of Common Fill: Use common granular fill adjacent to structures in all areas not specified above, unless otherwise shown or specified. Select fill may be used in place of common granular fill at no additional cost.

1. Extend such backfill from the bottom of the excavation or top of bedding to the bottom of subgrade for lawns or lawn replacement, the top of previously existing ground surface or to such other grades as may be shown or required.

2. Place backfill in uniform layers not greater than 8 inches in loose thickness and thoroughly compact in place with suitable equipment, as specified above.

3. Compact backfill to not less than 90 percent of the maximum dry density as determined by ASTM D 1557.

C. Use of Clay: In unpaved areas adjacent to structures for the top 1 foot of fill directly under lawn subgrades use clay backfill placed in 6-inch lifts. Compact clay backfill to not less than 90 percent of the maximum dry density as determined by ASTM D 1557.

1. Use clay having a liquid limit less than or equal to 40 and a plasticity index less than or equal to 20.

3.6 COMPACTION EQUIPMENT

A. Equipment and Methods: Carry out all compaction with suitable approved equipment and methods.

1. Compact clay and other cohesive material with sheep's-foot rollers or similar equipment where practicable. Use hand held pneumatic tampers elsewhere for compaction of cohesive fill material.

2. Compact low cohesive soils with pneumatic-tire rollers or large vibratory equipment where practicable. Use small vibratory equipment elsewhere for compaction of cohesionless fill material.

3. Do not use heavy compaction equipment over pipelines or other structures, unless the depth of fill is sufficient to adequately distribute the load.

3.7 FINISH GRADING

A. Final Contours: Perform finish grading in accordance with the completed contour elevations and grades shown and blend into conformation with remaining natural ground surfaces.

1. Leave all finished grading surfaces smooth and firm to drain.

2. Bring finish grades to elevations within plus or minus 0.10 foot of elevations or contours shown.

B. Surface Drainage: Perform grading outside of building or structure lines in a manner to prevent accumulation of water within the area. Where necessary or where shown, extend finish grading to ensure that water will be carried to drainage ditches, and the site area left smooth and free from depressions holding water.

3.8 RESPONSIBILITY FOR AFTERSETTLEMENT

A. Aftersettlement Responsibility: Take responsibility for correcting any depression which may develop in backfilled areas from settlement within one year after the work is fully completed. Provide as needed, backfill material, pavement base replacement, permanent pavement, sidewalk, curb and driveway repair or replacement, and lawn replacement, and perform the necessary reconditioning and restoration work to bring such depressed areas to proper grade as approved.

3.9 INSPECTION AND TESTING OF BACKFILLING

A. Sampling and Testing: Sampling and testing of all in-place backfill will be provided by the OWNER as specified in Division 1. If initial testing reveals non-compliance with Contract requirements, all additional testing will be made at the Contractor’s expense.

B. Correction of Work: Correct any areas of unsatisfactory compaction by removal and replacement, or by scarifying, aerating or sprinkling as needed and recompaction in place prior to placement of a new lift.

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 31 25 00

SLOPE PROTECTION AND EROSION CONTROL

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: The requirements for providing slope protection and erosion control practices for all areas within the contract limits and other area indicated, including work designated in permits and other agreements, as specified in Division 1.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 31 10 00 - Site Clearing
2. Section 31 23 16 - Excavation - Earth and Rock
3. Section 31 23 23 - Backfilling
4. Section 32 90 00 - Landscaping Work

1.2 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 1.

B. Erosion and Sediment Control Plan: Submit an Erosion and Sediment Control Plan conforming to the requirements of the City of Tulsa and of the Oklahoma Department of Environmental Quality (DEQ)

C. Submit copies of all required permits to the ENGINEER before performing any work.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 EROSION AND SEDIMENT CONTROL PLAN

A. General: Prepare an Erosion and Sediment Control Plan to include erosion control practices as specified in the most current edition of the ODOT standard specification.

B. Contents: Prepare the Erosion and Sediment Control Plan to include but not limited to the following information:

1. Total square area disturbed by excavation.

2. Quantity of erosion control practices to be provided. For instance, feet of vegetative control, feet of interceptor ditches, feet of berms, cubic feet of silt traps, etc.

3. Approximate square feet of area controlled by the erosion control practices as specified in the Erosion and Sediment Control Plan, and the type of erosion control practices, whether permanent or temporary.

4. Topographical or plan maps of construction area with areas marked to indicate erosion control practices used.

5. Drainage area, including construction site.

6. Area of construction site in acres that fall in the following slope categories:

    a. 0-2 percent slope
    b. 3-4 percent slope
    c. 4-6 percent slope
    d. 6 percent and storm slope

7. A summary of the disposition of the collected sediment from the slope areas listed in Item 6.

C. Availability: Keep the Erosion and Sediment Control Plan at the construction site at all times available for inspection for the entire construction period.

D. Ordinances: Comply with all erosion and siltation control ordinances in effect and required by governing bodies having jurisdiction over the construction site and provide appropriate control measures as required.

E. Payment: Include the cost of the erosion control in the Contract Price. No separate payment will be made for these items unless otherwise specified.

3.2 EROSION AND SEDIMENT CONTROL

A. Provide necessary precautions and facilities to protect all indicated areas within the Contract limits from discharges resulting from construction operations, excessive erosion runoff of the construction site, silting and any other contamination resulting from construction work. Provide erosion control practices conforming to the specified requirements and to include but not limited to the following provisions:

1. Place all erosion and siltation control measures prior to or as the first step in grading.

2. Mulch and seed all storm and sanitary sewer trenches not in streets within ten (10) days after backfill. Do not allow more than 500 feet of trenches to be open at any one time.

3. Place all excavated material on the uphill side of trenches where possible. Do not place materials in stream beds. Seed any stockpiled material which remains in place longer than thirty days with temporary vegetation and mulch.

4. Mulch and seed all temporary earth berms, diversions, erosion barriers and temporary stockpiles with temporary vegetative cover within 10 days after grading.

5. Do not stockpile or otherwise place dredged, excavated or other material, at any time, in or near a stream bed which may increase the turbidity of the water. If turbidity producing materials are present, hold surface drainage from cuts and fills within the construction limits and from borrow and waste disposal areas in suitable sedimentation ponds or grade surface drainage to control erosion within acceptable limits. Provide and maintain temporary erosion and sediment control measures such as berms, dikes, drains, or sedimentation basins, if required to meet the above standards, until permanent drainage and erosion control facilities are completed and operative. Hold to a minimum the area of bare soil exposed at any one time by construction operations.

6. Drain wet dredged material for a minimum of 7 days. Store the material for drainage to a maximum height of 4 feet.

7. Provide temporary erosion and sediment control measures to include but not be limited to the following:

    a. Installation (and ultimate removal) of silt screens.

b. Straw bales and silt traps around construction areas for all required structures.

c. Diked area with earth berm and silt trap for draining dredged material.

d. Straw bales with silt traps along top of slope of fill area plus seeding and mulching of entire fill area not otherwise protected.

END OF SECTION

SECTION 31 41 00

SHORING, SHEETING AND BRACING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Work required for protection of an excavation or structure through shoring, sheeting, and bracing.

B. Related Work Specified In Other Sections Includes, But is Not Limited to, the Following:

1. Section 31 23 16 - Excavation - Earth and Rock
2. Section 31 23 23 - Backfilling

1.2 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 1.

B. CONTRACTOR's Submittals: Submit a CERTIFICATE (ONLY), signed and sealed by a Licensed Professional Engineer experienced in Structural Engineering and registered in the State where the construction will be performed, that certifies that the Licensed Professional Engineer has evaluated and approved the CONTRACTOR's excavation plan and has prepared complete design calculations and working drawings for the shoring, sheeting and bracing, not specifically shown on the Contract Drawings, which will be used for excavation support. Provide a separate CERTIFICATE for each excavation before starting the excavation. Where commercially manufactured trench boxes are to be used, provide a CERTIFICATE from the CONTRACTOR's Licensed Professional Engineer stating the conditions under which the trench boxes will be used.

1.3 REFERENCES

A. Codes and standards referred to in this Section are:

1. All Federal, State and local laws and regulations applying to the design and construction of shoring, sheeting and bracing.

2. National Bureau of Standards Building Science Series 127 "Recommended Technical Provisions for Construction Practice in Shoring and Sloping Trenches and Excavations."

PART 2 PRODUCTS

2.1 MANUFACTURERS AND MATERIALS

A. Use manufacturers and materials for shoring, sheeting and bracing as recommended by the CONTRACTOR's Licensed Professional Engineer who designed the shoring, sheeting, and bracing. Where wood lagging is to be left in place use oak or treated fir or treated pine. Use only environmentally safe treatment for wood lagging.

PART 3 EXECUTION

3.1 SHORING, SHEETING AND BRACING INSTALLATION

A. General: Provide safe working conditions, prevent shifting of material, prevent damage to structures or other work, and avoid delay to the work, all in accordance with applicable laws and regulations. Properly shore, sheet, and brace all excavations that are not cut back to the proper slope, as determined by the CONTRACTOR's Licensed Professional Engineer.

1. Take sole responsibility for the design and adequacy of shoring, sheeting and bracing not shown on the Contract Drawings.

2. Take sole responsibility for the methods of installation of the shoring, sheeting and bracing.

B. Arrange shoring, sheeting and bracing so as not to place any strain on portions of completed work until the general construction has proceeded far enough to provide ample strength.

C. If the CONTRACTOR or its Licensed Professional Engineer is of the opinion that at any time the CONTRACTOR's excavation plan, shoring, sheeting or bracing is inadequate or unsuited for the purpose, take immediate and appropriate action. Provide a new CERTIFICATE if the CONTRACTOR's excavation plans, shoring, sheeting or bracing require modifications.

D. Monitoring: Periodically monitor horizontal and vertical deflections of sheeting, shoring and bracing.

E. Accurately locate all underground utilities and take the required measures necessary to protect them from damage. All underground utilities shall be kept in service at all times as specified in Division 1.

F. Remove shoring, sheeting and bracing as the excavation is refilled in a manner to avoid the caving in of the bank or disturbance to adjacent areas or structures or pipe bedding.

1. Carefully fill voids left by the withdrawal of the shore, sheeting and bracing. No separate payment will be made for the filling of such voids.

2. If pipe bedding is disturbed, re-compact it to meet specified density requirements.

G. Permission for Removal: Obtain permission from the CONTRACTOR's Licensed Professional Engineer before the removal of any shoring, sheeting or bracing. Retain the responsibility for injury to structures or to other property or persons for failure to leave such shoring, sheeting and bracing in place even though permission for removal has been obtained.

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 32 90 00

LANDSCAPING WORK

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Soil, soil preparation, soil tests, excavation, planting, seeding, sodding, pruning, edging, fertilizing and maintenance.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 31 23 16 - Excavation, Earth and Rock
2. Section 31 23 23 - Backfilling

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. ASTM C 33 - Specification for Concrete Aggregates

1.3 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 1.

B. Soil Tests: Submit soil test results.

C. Maintenance Instruction Manual: Upon completion of the landscaping work and prior to final payment, furnish a landscaping maintenance manual. Include complete and detailed instructions on the recommended maintenance procedure to be followed for maintaining lawns and each species of plant material. Include a schedule of all planted and seeded materials and all pertinent growing and maintenance information and requirements for watering, fertilizing, lime applications, spraying, cultivating, pruning and weed control.

1.4 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store and handle all products and materials as specified in Division 1 (and as follows:)

B. Top Soil: Deliver top soil in a dry state without enough moisture to allow it to be packed or squeezed into a ball.

C. Balled and Bare Root Plants: Immediately after delivery, set all balled plants on the ground with the balls well protected with soil. Water and properly maintain all plants until planting. Plant or heel in bare rooted plants which cannot be planted immediately upon delivery. No materials heeled in for more than a week may be used. Before the roots are covered, open bundler and separate the plants.

D. Grass Seed: Deliver grass seed in standard size bags of the vendor, showing weight, analysis and name of vendor. Store the seed so as not to impair its effectiveness.

E. Sod: Deliver sod to the site in fresh condition and within two days of the time it has been dug.

F. Fertilizer: Deliver fertilizer mixed as specified, in standard size bags, showing weight, analysis and the name of the manufacturer. Store the fertilizer in a weatherproof storage place in a manner that will keep it dry without affecting its effectiveness.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Seeding and Sodding: Sow grass seed between August 15th and October 15th unless sowing between March 15th and June 1st is permitted. Sow seed when the wind velocity is below 5 mph. Place sod between August 15th and October 15th or between March 15th and June 1st, or during the season or seasons which are normal for such work as determined by weather conditions and accepted practice in the locality and as approved.

B. Planting: Unless otherwise directed, plant deciduous material from March 1st to June 1st and from September 1st to December 1st. Plant evergreen material from April 1st to June 1st and from September 1st to November 1st.

1.6 WARRANTY

A. General: Apply the warranty to all seeded, sodded and planted areas. Have the warranty period commence after the final acceptance of all landscaping work exclusive of all replacement plant materials.

B. Plant Material: Warranty plant materials for a period of one year.

C. Seeded Areas: Warranty seeded lawn areas to the time of establishment of an acceptable uniform stand of grass.

D. Sod: Warranty sod to 30 days following the first cutting.

1.7 MAINTENANCE

A. General: Maintain all seeded, sodded and planted areas during the warranty period.

B. Grass Areas: Maintain all seeded and sodded areas to well establish a uniform stand of weed-free grass. Reseed or resod areas failing to develop a uniform stand.

C. Trees, Shrubs and Ground Covers: Cultivate trees, shrubs and ground covers and weed and water when necessary, but not less than twice a month, to prevent plant material from dying. Replace any plant material which is found to be dead or dying during the warranty period to original specifications upon request. Include the full cost of replacing dead or dying plant material in the Contract Amount. No separate payment will be made for replacements. Maintain plant material to be alive, in good growing condition and free of weeds.

D. Replacement: Replace plant material and resod or reseed only during the specified planting seasons and warranty the replacement material for the same period of time as the original material.

PART 2 PRODUCTS

2.1 SOIL

A. Topsoil: Provide a natural friable top soil of the region, rich in organic matter, without any material toxic to plant growth and of uniform quality, free of large roots, sticks, hard clay, weeds, brush, stones over 1-inch in maximum dimension or other litter or waste products. Provide topsoil containing no decomposed stone, salts or alkali, and not less than 15 parts per million of available nitrates, 3 parts per million of available phosphorus, 15 parts per million of potash, and having a pH of not less than 6.0 nor more than 7.2 at a depth of 8 inches below the surface of the field from which it is removed. Provide topsoil with a mechanical analysis as follows:

Sieve	Percentage Passing
1 inch	100
1/4 inch	97-100
No. 100	40- 60

B. Planting Soil: Prepare planting soil by mixing 10 parts of topsoil with fertilizer and 1 part of peat moss.

2.2 GRASS SEED AND SOD

A. Grass Seed: Provide a fresh, clean, new crop of grass seed composed of 35 percent Pennlawn Fescue and 15 percent Red Top and 50 percent Improved Kentucky Blue Grass. Provide seed components free of noxious weed seeds and having not less than the following purity and germination:

Component	Percent Purity	Percent Germination
Pennlawn Fescue	95	85
Improved Blue Grass	85	75
Red Top	75	70

Tag each sack in accordance with the agricultural seed laws of the United States and the State of Oklahoma. Show on each tag the producer's guarantee as to the year grown, the percentage of purity, the percentage of germination and the tests by which the percentages were determined. Provide seed for this project having a test date within 6 months of the date of sowing.

B. Sod: Provide nursery-grown Improved Kentucky Blue Grass sod, free of weeds, a minimum of 1-inch thick of dense growth and cut with sharp edges in 18-inch widths and not less than 3 feet long. Sod which has been grown on peat or which has been dug more than two days previous to delivery or which has been allowed to have the roots dry out or on which the grass has turned brown will not be accepted.

2.3 PLANT MATERIALS

A. General: Provide plant materials that are true to species or variety, sound, healthy, vigorous acclimated plants free from defects, disfiguring knots, sun-scaled injuries, abrasions of the bark, plant diseases and insect eggs, borers and all other forms of infestations. Provide material that has normal, well-developed branch systems and vigorous root systems and that is freshly dug, nursery-grown stock grown under the same climatic conditions as the Project location. Provide material grown under climatic conditions similar to those in the locality of the project for at least 2 years and transplanted or root pruned at least in the last 3 years.

B. Plant Size: Dimension a plant as it stands in its natural position. Measure trees under 4 inches in caliper at a point 6 inches above the ground and trees more than 4 inches in caliper at a point 12 inches above ground. Provide the stock of a fair average of the minimum and maximum sizes specified. Do not cut back large shrubs to sizes specified.

C. Balled, Burlapped and Platformed Plants: Dig balled and burlapped, as well as balled and platformed, plants with sufficient roots and a solid ball of earth securely held in place by burlap and stout natural fiber rope. Manufactured balls are not

acceptable. Provide balled and platformed plants with sturdy platforms of a size equal to the diameter of the horizontal midsection of the ball of earth.

D. Bare-Rooted Plants: Dig bare-rooted plants with sufficient root spread and depth to ensure full recovery and development of the plants. Cover roots for these plants with a uniformly thick coating of mud by being puddled immediately after they are dug.

2.4 COMMERCIAL FERTILIZER

A. Provide all commercial mixture fertilizer uniform in composition, free flowing, conforming to state and federal laws and suitable for application with equipment designed for that purpose. Provide fertilizer with organic, inorganic or combined elements with the following composition by weight:

1.	Nitrogen	10 percent
2.	Phosphorus pentoxide	20 percent
3.	Potash	10 percent

2.5 ACCESSORIES

A. Tree Wrap: Provide new, clean, plain, 8-ounce weight burlap material 6 inches wide for wrapping tree trunks.

B. Weed Barrier Fabric: Provide Pro-5 fabric as manufactured by the DeWitt Co., or equal.

C. Gravel: Provide smooth river bed gravel of solid or mixed color range to be as selected and meeting the requirements of ASTM C 33 and graded according to Size No. 467, Table II.

D. Mulch: Provide ground corn cobs, wood chips, tree barks, buckwheat hulls or other approved materials for mulch.

E. Edging: Provide commercial hot-rolled steel edging plate, 4 inches wide and 1/8-inch thick. Fabricate edging in sections with loops pressed from or welded to the face of sections at 30-inch centers to receive 16-inch long tapered steel stakes. Provide edging finished with the manufacturer's standard paint.

2.6 TESTS

A. Sample: Submit a 10-ounce sample of the proposed topsoil to a testing laboratory in sealed containers to prevent contamination.

B. Analysis: Analyze the topsoil sample to determine the amount of lime necessary and the appropriate fertilizer mix and quantity required for planting, seeding and sodding.

PART 3 EXECUTION

3.1 GRADES

A. General: Existing and final contours shown depict finished grades after completion of landscaping work.

B. Lawn Grades: Grade lawns to meet walks, curbs and adjoining surfaces after uniform settlement of surfaces. Correct water pockets or ridges which appear after surface settlement takes place on or before the end of the guarantee period.

3.2 EXCAVATION FOR PLANTING

A. General: Obtain approval for all plant locations before excavation. Remove from the site all material that is surplus and unsuitable for backfill.

B. Ground Cover and Grass Areas: Excavate for ground cover and grass areas to the required depths for grass to receive 6 inches of topsoil and for groundcover to receive 6 inches of planting soil.

C. Plant Pits: Excavate plant pits with vertical sides and a circular outline.

1. Dig tree and evergreen pits at least twice the diameter of the ball, and deep enough to permit an 8-inch layer of compacted planting soil beneath the ball.

2. Dig shrub pits a minimum of twice the diameter of the ball and deep enough to allow 6 inches of compacted planting soil beneath the ball.

D. Drain: Install french drains for all trees, ornamental trees, and evergreens planted on berms and other locations where the grade permits, from bottom of planting pit to the finished grade with a trench 9 inches wide, filled with a 6-inch thick layer of 3/4-inch washed gravel. Cover the gravel layer with a filter mat before backfilling the trench with soil.

3.3 SOIL CONDITIONING

A. Disking: Before the application of topsoil, sodding or seeding, disk the area to be seeded, sodded or planted with groundcover to a depth of 6 inches. Continue the disking until the subsoil surface is sufficiently broken to provide a good bond between subsoil and topsoil. Spread 6 inches of planting soil over the disked area to a uniform depth and density.

B. Ground Limestone: Incorporate ground limestone, if required by the results of the soil test report, into the upper 3 inches of planting soil. Uniformly spread fertilizer and mix into the soil to a depth of 1-1/2 inches or as recommended by the manufacturer.

3.4 SEEDING AND SODDING

A. Seeding: Sow seed at the rate recommended by the seed producer. Evenly rake the surface after seeding with a fine-tooth rake. Mulch all newly seeded areas and cover with a minimum of 1/4-inch of straw or hay, approximately at the rate of 1 bale per 1,000 square feet, then thoroughly wet.

B. Sodding: Lay sod in such a manner that the surface is smooth and even and all edges abut one another tightly. Water and roll sod so that a bond is produced between the prepared topsoil and the sod. On slopes greater than 3 to 1, stake installed sod with approved wooden sod stakes at a minimum rate of three stakes per square yard of sod.

3.5 PLANTING

A. Layout: Outline locations for trees, shrubs, evergreens and bed and stake for approval. Obtain location approval prior to commencing planting operations.

B. Setting Plants: Set plants plumb and straight with the crown at finished grade. Compact soil around the base of the ball, and fill the void 3/4 of the way up from the bottom. Water each plant immediately. After the water has completely drained, fill the plant pits to finished grade. Properly spread out roots of bare root plants and carefully work topsoil among them. Cut off any broken or frayed roots with a clean cut. Form a shallow basin, the size of the ball with a ridge of soil to facilitate watering. After that operation is completed, apply a second watering immediately. Finish all planting pits and beds within a period of 3 days following installation. Construct tree saucers, cultivate and outline planting pits with a neat edge, when necessary.

C. Mulching: Immediately after planting operations are completed, cover all tree and shrub pits with mulch to a minimum depth of 2 inches. Limit mulch for trees to saucer diameter and, for shrubs, the entire shrub bed.

D. Pruning: Prune each tree and evergreen with clean, sharp tools in accordance with standard horticultural practice to preserve the natural character of the plant. Remove suckers and all dead, broken or badly bruised branches.

E. Wrapping: Wrap the tree trunks of all trees with burlap tree wrapping securely tied with suitable cord at top and bottom and at 2-foot intervals along the trunk.

Overlap the wrapping 2 inches top and bottom and entirely cover the trunk from the ground to the height of the second branch, neat and snug.

F. Guying: Guy trees as necessary to be plumb and straight through final inspection. Remove guy wires at completion of project.

G. Watering: During planting, thoroughly saturate the soil around each plant with water and as many times later as seasonal conditions require until the end of the guarantee period.

3.6 EDGING

A. General: Establish a neat edge where planting areas meet grass areas, with spade or edging tools, immediately after all planting and seeding is completed. Establish good flowing curves as shown. Maintain edging until the end of the guarantee period.

3.7 GRAVELED AREAS

A. General: Lay a weed barrier in accordance with the manufacturer's recommendations and top with a 4-inch layer of gravel. Edge graveled areas with metal edging.

END OF SECTION

SECTION 40 05 03

MECHANICAL IDENTIFICATION

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for furnishing and installing identification materials and devices for the mechanical systems.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 09 96 00 - High Performance Coatings

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. ASME A13.1 - Scheme for the Identification of Piping Systems.

1.3 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 1.

B. Product Data: Submit the manufacturer's technical product data and installation instructions for each identification material and device required.

C. Samples: Submit samples of each color, lettering style, and other graphic representation required for each identification material or system. Provide a mock-up type sample installation.

D. Maintenance Data: Include product data and schedules in the appropriate operation and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide the specified items from firms regularly engaged in the manufacture of identification devices of types and sizes required, whose products have been in satisfactory use in similar service for not less than (5) years.

1.5 SPARE PARTS

A. Spares: Furnish a minimum of 5% extra stock of each mechanical identification material required, including additional numbered valve tags (not less than 3) for each piping system, additional piping system identification markers, and additional plastic laminate engraving blanks of assorted sizes.

1. Where stenciled markers are provided, clean and retain the stencils after completion of stenciling and include used stencils in the extra stock, along with the required stock of stenciling paints and applicators.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted.

1. Identification Materials

a. Allen Systems, Inc.
b. Brady (W.H.) Co.; Signmark Div.
c. Industrial Safety Supply Co., Inc.
d. Seton Name Plate Corp.

2.2 MATERIALS

A. Provide the manufacturer's standard products of categories and types required for each application as referenced in other Division 40 sections. Where more than a single type is specified for an application, selection is at the CONTRACTOR's option, but provide a single selection for each product category. Comply with ASME A13.1 for lettering size, length of color fields, colors and viewing angles of identification devices.

2.3 PAINTED IDENTIFICATION MATERIALS

A. Stencils: Provide metal stencils, prepared for the required applications with a letter sizes generally complying with the recommendations of ASME A13.1 for piping and similar applications, but not less than 1-1/4 inches high letters for ductwork and not less than 3/4-inch high letters for access door signs and similar operational instructions.

B. Stencil Paint: Provide a standard exterior type stenciling enamel, black, except as otherwise indicated, for either brushing grade or pressurized spray-can form and grade.

C. Identification Paint: Provide a standard identification enamel of the colors indicated or, if not otherwise indicated for piping systems, comply with ASME A13.1 for colors.

2.4 PLASTIC TAPE

A. General: Provide the manufacturer's standard color-coded pressure-sensitive (self-adhesive) vinyl tape, not less than 3 mils thick.

B. Width: Provide 1-1/2 inch wide tape markers on pipes with outside diameters (including insulation, if any) of less than 6 inches, 2-1/2 inches wide tape for larger pipes.

C. Color: Except where another color selection is indicated comply with ASME A13.1.

2.5 UNDERGROUND-TYPE PLASTIC LINE MARKER

A. Provide the manufacturer's standard permanent, bright-colored, continuous-printed plastic tape, intended for direct-burial service; not less than 6 inches wide x 4 mils thick. Provide tape with printing which most accurately indicates the type of service of the buried pipe.

1. Provide multi-ply tape consisting of a solid aluminum foil core between 2-layers of plastic tape.

2.6 ENGRAVED PLASTIC-LAMINATE SIGNS

A. General: Provide engraving stock melamine plastic laminate, complying with FS L-P-387, in the sizes and thicknesses required, engraved with the engraver's standard letter style of the sizes and wording indicated, black with white core letter color except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of the substrate.

B. Thickness: Provide tags 1/8 inch thick, except as otherwise indicated.

C. Fasteners: Provide self-tapping stainless steel screws, or contact-type permanent adhesive where screws cannot or should not penetrate the substrate.

2.7 PLASTIC EQUIPMENT MARKERS

A. General: Provide the manufacturer's standard laminated plastic, color coded equipment markers conforming to the following color code:

1. Green: Cooling equipment and components.

2. Yellow: Heating equipment and components.

3. Yellow/Green: Combination cooling and heating equipment and components.

4. Blue: Equipment and components that do not meet any of the above criteria.

5. For hazardous equipment, use colors and designs recommended by ASME A13.1.

B. Nomenclature: Include the following, matching terminology on schedules as closely as possible:

1. Name and drawing number

2. Equipment service

3. Design capacity

4. Other design parameters such as pressure drop, entering and leaving conditions, rpm, etc.

C. Size: Provide approximate 2-1/2-inch x 4-inch markers for control devices, dampers, and valves; and 4-1/2-inch x 6-inch for equipment.

2.8 PLASTICIZED TAGS

A. Provide the manufacturer's standard pre-printed or partially preprinted accident-prevention tags, of plasticized card stock with a matte finish suitable for writing, which are approximately 3-1/4-inch x 5-5/8-inch, with brass grommets and wire fasteners, and with appropriate pre-printed wording including large-size primary wording (as examples; DANGER, CAUTION, DO NOT OPERATE).

2.9 LETTERING AND GRAPHICS

A. General: Coordinate names, abbreviations and other designations used in mechanical identification Work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by the manufacturers or as required for proper identification, operation and maintenance of mechanical systems and equipment.

B. Multiple Systems: Where multiple systems of the same generic name are shown and specified, provide identification which indicates the individual system number

as well as the service (as examples; Boiler No. 3, Air Supply No. 1H, Standpipe F12).

PART 3 EXECUTION

3.1 PREPARATION

A. Surface Preparation: Degrease and clean surfaces to receive adhesive for identification materials.

1. Prepare surfaces in accordance with Section 09 96 00 for stencil painting.

3.2 INSTALLATION

A. General: Install tags and markers in accordance with the manufacturer's recommendations and approved shop drawings and as specified in Division 1.

B. Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces, install the identification after completion of the covering and painting. Install the identification prior to installation of acoustical ceilings and similar removable concealment.

3.3 MECHANICAL EQUIPMENT IDENTIFICATION

A. General: Install engraved plastic laminate signs on or near each major item of mechanical equipment and each operational device, as specified if not otherwise specified for each item or device. Provide signs for the following general categories of equipment and operational devices:

1. Main control and operating valves, including safety devices and hazardous units such as gas outlets

2. Meters, gauges, thermometers and similar units

3. Fuel-burning units including boilers

4. Pumps, compressors, chillers, condensers and similar motor-driven units

5. Fans, blowers, primary balancing dampers and mixing boxes

6. Packaged HVAC central-station or zone-type units

7. Tanks and pressure vessels

8. Strainers, filters, humidifiers, water treatment systems and similar equipment

B. Lettering Size: Use a minimum 1/4 inch high lettering for name of unit where viewing distance is less than 2 feet 0 inches, 1/2-inch high for distances up to 6 feet 0 inches, and proportionately larger lettering for greater distances. Provide secondary lettering of 2/3 to 3/4 of the size of the principal lettering.

C. Text of Signs: In addition to the name of the identified unit, provide lettering to distinguish between multiple units, inform the operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

3.4 ADJUSTING AND CLEANING

A. Adjusting: Relocate any mechanical identification device which has become visually blocked by the Work of this division or other divisions.

B. Cleaning: Clean the face of identification devices, and glass frames of valve charts.

END OF SECTION

SECTION 40 05 17

STEEL PIPE AND FITTINGS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for providing steel pipe and fittings, except for steel pipe in buried applications, as follows:

1. Steel pipe and fittings include all fabricated and wrought steel pipe fittings. Use steel pipe only where specifically shown or specified. Provide pipe of the flanged, screwed, welded, grooved-type coupling joint or plain end type of the sizes and thicknesses as shown or specified.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 01 45 50 - Leakage Test
2. Section 09 96 00 - High Performance Coatings
3. Section 33 13 00 - Disinfection
4. Section 40 05 10 - Erecting and Jointing Interior Piping
5. Section 40 05 16 - Ductile Iron Pipe and Fittings
6. Section 40 05 18 - Miscellaneous Pipe and Fittings
7. Section 40 42 00 - Mechanical Insulation - Process

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. AWWA C200 - Steel Water Pipe 6 In. and Larger
2. AWWA C205 - Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 In. and Larger - Shop Applied
3. AWWA C207 - Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In.
4. AWWA C208 - Dimensions for Fabricated Steel Water Pipe Fittings
5. AWWA C210 - Liquid Epoxy Coating Systems for Interior and Exterior of Steel Water Pipelines

6. AWWA M11 - Steel Water Pipe: A Guide for Design and Installation

7. ASTM A 47 - Specification for Ferritic Malleable Iron Castings

8. ASTM A 53 - Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

9. ASTM A 181/A181M - Specification for Carbon Steel Forgings, for General Purpose Piping

10. ASTM A 197 - Specification for Cupola Malleable Iron

11. ASTM A 283/A283M - Specification for Low and Intermediate Tensile Strength Carbon Steel Plates, Shapes and Bars

12. ASTM A 307 - Specification for Carbon Steel Bolts and Studs, 50,000 psi Tensile

13. ASTM A 536 - Specification for Ductile-Iron Castings

14. ASTM D 2000 - Classification System for Rubber Products in Automotive Applications

15. ASME B16.1 - Cast Iron Flanges and Flanged Fittings

16. ASME B16.21 - Non-metallic Gaskets for Pipe Flanges

17. ASME B16.3 - Malleable Iron Threaded Fittings

18. ASME B16.5 - Steel Pipe Flanges and Flanged Fittings: NPS 1/2 through 24 with Appendixes

19. ASME B16.9 - Factory-Made Wrought Steel Butt welding Fittings

20. ASME B36.10 - Welded and Seamless Wrought Steel Pipe

1.3 SYSTEM DESCRIPTION

A. Design Standards: Use dimensions for steel pipe in accordance with ASME B36.10, unless specified otherwise.

1. Provide pipe of 6-inch diameter and smaller not less than Schedule 40.

2. Provide pipe of 8- through 16-inch diameter not less than Schedule 30.

3. Provide pipe 18- through 30-inch diameter with a wall thickness of not less than 3/8 inch.

4. Provide pipe 36 inches in diameter and larger with a wall thickness of not less than 1/2 inch.

B. Small Steel Pipe: Provide steel pipe less than 30 inches in diameter meeting the requirements of ASTM A 53.

C. Large Steel Pipe: Provide steel pipe 30 inches in diameter and larger meeting the requirements of AWWA C200 and fabricated of plates meeting the requirements of ASTM A 283/A283 Grade D.

1. Fabricate pipe with straight-seam welds or spiral-seam welds.

2. Provide welds with a smooth uniform cross section to provide pipe with a neat external appearance.

3. Fabricate the pipe with not more than two longitudinal seams and with girth seams not less than 7 feet apart.

4. The pipe and fitting diameters of 30 inches and larger, as shown or specified, are inside diameters.

1.4 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 1.

B. Submit the following shop drawings:

1. Flanged, screwed, welding and mechanical coupling fittings and pipe, couplings, harnessing and special fittings. When special designs or fittings are required, show the Work in large detail and completely describe and dimension the special or fitting.

2. Fully Dimensioned layout of pipe, fittings, couplings, sleeves, expansion joints, supports, anchors, harnessing, valves and equipment. Label pipe size, type and materials on drawing and include schedule.

3. Cross sections showing elevation of pipe, fittings, sleeves, couplings, supports, anchors, harnessing, valves and equipment.

4. Catalog data for pipe, couplings, harnessing and fittings.

C. Quality Control: Submit the following certifications:

1. Certificate of compliance for pipe, fittings, couplings, sleeves, cleanouts and harnessing.

2. Welders' certifications.

1.5 QUALITY ASSURANCE

A. Utilize certified welders, having current certificates conforming to the requirements of the ASME code to perform all welding on steel pipelines.

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver, store and handle pipe, fittings and couplings as specified in Division 01 and Section 40 05 10.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted.

1. Steel pipe and fittings

a. U.S. Steel
b. L.B. Foster
c. Northwest Pipe Company

2. Coatings

a. Kop-Coat
b. Tnemec

2.2 MATERIALS

A. Fittings

1. Manufacture fittings for steel pipe to standard dimensions, suitable for the pressures specified. Provide steel fittings of the same or heavier wall thickness as the pipe of which they are a part.

a. Provide fittings used in pipelines 2-inch diameter or smaller of the screwed pattern.

b. Provide fittings used in pipelines 2.5-inch diameter or larger of the seamless steel welded type or flanged type, except as shown or specified otherwise.

B. Flanges and Flanged Joints

1. Flanges: Unless otherwise shown, provide all flanges for steel pipe, except blind flanges, of the slip-on welding type with hubs meeting the requirements of AWWA C207 Class D and made of metal meeting the requirements of ASTM A 181 Class 60

a. Attach the flanges to the barrel of the pipe with two continuous fillet welds.

b. Provide plain faced blind flanges in accordance with ASME B16.5 Class 150.

2. Flanged Joints: Make flanged joints with bolts or bolt studs with a nut on each end.

a. Provide bolts, stud bolts, and nuts meeting the requirements of ASTM A 307 Grade B and ASME B16.1.

b. Provide bolts which have a 1/4-inch projection beyond the nut when joint with gasket is assembled.

3. Gaskets: Provide rubber gaskets for flanged joints meeting the requirements of AWWA C207 as modified and supplemented herein. Provide 1/8-inch thick gaskets. Provide full face gaskets for pipe sizes 12 inches in diameter and smaller. Provide ring type gaskets for pipe larger than 12 inches in diameter.

4. Insulation: Provide insulated flanged joints as required. Provide flange insulation kits to include flange insulating gasket, flange bolt insulating sleeves, and flange bolt insulating washers.

PART 3 EXECUTION

3.1 INSTALLATION

A. General: Install all steel pipe and fittings in accordance with the manufacturer's recommendations and approved shop drawings and as specified in Division 01 and Section 40 05 10.

3.2 LEAKAGE TESTING

A. Cleaning: Flush clean and test all pipes after installation.

B. Testing: Test pipes for leaks and repair or tighten as required.

END OF SECTION

SECTION 40 80 50

PROCESS CONTROL SYSTEM COMMISSIONING

PART 1 GENERAL

1.1 SUMMARY

Provide all labor, materials, equipment and incidentals as shown, specified, and required to furnish and install all equipment and coordinate all activities necessary to perform check-out and start-up of the equipment installed as part of the TMUA Raw Water Pump Station Facility Assessment project.

A. CONTRACTOR: Retain the services of a SYSTEM INTEGRATOR as selected by OWNER. Provide the services of an authorized manufacturer's representative, thoroughly knowledgeable about the installation, operation, and maintenance of the equipment, to check the equipment installation and place the equipment in operation.

B. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 01 33 00 - Submittals
2. Section 40 90 00 - Process Control System General Requirements
3. Section 40 94 13 - Process Control Systems Computer and Network Hardware
4. Section 40 94 43 - Programmable Logic Controller Systems
5. Section 40 95 13 - Process Control System Panel Enclosure and Equipment
6. Section 40 96 15 - Process Control System IO list
7. Section 40 98 00 - Process Control System Training
8. Section 40 98 50 - Process Control System Factory Acceptance Testing

1.2 SUBMITTALS

A. General: Furnish all submittals, including the following, as specified in Section 01 33 00 - Submittals.

B. Action Submittals:

1. Prior to beginning commissioning activities, submit the following for OWNER approval, meeting the sequence and schedule established by the CONTRACTOR for facilities impacted by the Contract, as well as overall commission. Submit to meet requirements per process area and for facility wide commissioning:

a. Test Plan

b. Test Forms

c. Test Schedule

d. Testing Tools

e. Test results

f. Test Logs

g. Loop Check List

h. Point to Point Wiring Diagrams

i. Preliminary Testing Results

j. Approved O&M Manual List

k. Certification that all appropriate Operator Component training has been completed.

l. Certification that the Test Engineer has reviewed all data and the system and certifies that it is ready for operation.

2. Forms

a. Submit sample test forms and test logs for review.

1.3 SYSTEM CHECKOUT AND START-UP

A. SYSTEM INTEGRATOR: Perform the following, as witnessed by the OWNER, as applicable:

1. Check and approve the installation of all Process Control System components and all cable and wiring connections between the various system components.

2. Conduct a complete system checkout and adjustment, including checking each components functions, and testing of final process control system instrument, device, computer, and network functions. Promptly correct all problems to prevent any delays in start-up of the process control system network.

B. SYSTEM INTEGRATOR: Furnish all test equipment necessary to perform the testing during system checkout and start-up.

C. SYSTEM INTEGRATOR: Responsible for initial operation of the process control system and making any required corrections, adjustment, or replacements necessary to the system to perform the intended functions.

D. SYSTEM INTEGRATOR: Furnish OWNER/ENGINEER an installation inspection report, signed by authorized representatives of CONTRACTOR, SYSTEM INTEGRATOR, and SUPPLIER, certifying that all equipment has been installed correctly and is operating properly.

1.4 INTEGRATED SYSTEM FIELD TEST

A. SYSTEM INTEGRATOR: Perform a complete system test, as witnessed by the OWNER, as applicable, to verify that all Process Control System (PCS) instrumentation and controls equipment, network hardware, and software is operating properly as a fully integrated system, and that the intended network functions are fully implemented and operational. Complete this integrated test after all process areas are demonstrated as operational and tested individually, and after individual facilities are tested and proven operational.

B. SYSTEM INTEGRATOR: Correct any defects or problems found during the test and then retest to demonstrate proper operation.

C. Refer to Part 2 of this specification for detailed Integrated System Field Test (SAT & Start-up) requirements.

1.5 30-DAY TEST

A. The 30-Day Test is a period of time during which the control system is utilized by the OWNER in day-to-day operations. The purpose of the process control system 30-Day test is to test the control system stability and completeness over time. This test is to occur in conjunction with all other systems included in the project. The intent of the test is for the system to operate without modification or repairs.

B. CONTRACTOR: Start the 30-Day Test upon written approval from the OWNER/ PROJECT REPRESENTATIVE.

C. Continue the 30-Day Test until a time frame has been achieved wherein the system (both hardware and software) availability meets or exceeds 99.7 percent for 30 consecutive days and no system failures have occurred which result in starting the 30-Day Test over. Provide system availability during the 30-Day Test to facility operating personnel for use in normal operation of the facility.

D. For the purpose of the 30-Day Test, the system is defined as all new control system work installed under this Contract, as well as any modifications made to the existing control system.

E. Terminate the 30-Day Test if one or more of the following occur. Following correction of the problem, begin a new 30 consecutive day 30-Day Test.

1. Failure to repair a hardware or software problem, causing one or more processes halt execution, within 24 consecutive hours from the time of notification failure(s).

2. Recurrent hardware or software problems: If the same type of problem occurs three times or more.

3. Programming or configuration corrections reset the 30-Day clock.

F. The following conditions constitute a system failure in determining the system availability based on the equation specified in Paragraph 1.5.G, below:

1. Loss of communications between devices on the process control system network. This includes communication between Pump Control Panels, the Woods Capacity Control Panel, Building LAN and WAN.

2. Failure of one or more network devices

3. Failures of any device impacting two or more process control system components simultaneously.

4. Failure of Power Supply: Where redundant power supplies are provided, failure of one power supply will not constitute a system failure provided the backup power supply operates properly and maintains power supply. Failure of the backup supply to operate properly and maintain supply power constitute a system failure.

5. The system is considered down if the system cannot generate the periodic reports, alarm log, or event log. The report and logs need not appear on the printer originally selected for the report.

6. Downtime caused by primary utility power failure will not count as downtime.

7. Loss of any microprocessor is considered downtime.

8. Loss of more than 5 percent of the total inputs or outputs per processor or RIO is considered downtime.

9. The accuracy and precision of all of the analog inputs and outputs must be within the limits specified, or the system is considered down.

10. The time between notifying the CONTRACTOR of a system failure and the time it has been corrected and back on line is considered downtime.

11. Shutdown of the critical systems from a software fault is considered downtime.

G. The system availability is calculated based on the following equation:

$$A = \frac{TTO}{TTO + TTR} \times 100 \text{ percent}$$

where,

A = system availability in percent
TTO = total time in operation
TTR = total time to repair

H. Time to repair is the period between the time that CONTRACTOR is notified of a system failure and the time that the system has been restored to proper operation in terms of hours with an allowance for the following dead times which is not be counted as part of the time to repair period.

1. Actual travel time for service personnel to get to the Site up to four hours per incident from the time CONTRACTOR is notified of a system failure.

2. Time for receipt of replacement parts to the Site once identified up to 8 hours per incident. Work done on the system while waiting for delivery of replacement parts does not stop the failure clock.

3. Dead time is not be counted as part of the system available period. The dead time is logged and the duration of the 30-Day Test extended for an amount of time equal to the total dead time. Totalize dead time.

I. CONTRACTOR: Furnish all parts and maintenance materials required to repair the system prior to completion of the 30-Day Test at no additional cost to OWNER. Immediately replace any parts obtained from the Contract spare parts inventory.

1.6 SPARE PARTS

Not Used

PART 2 SITE ACCEPTANCE TESTING

2.1 GENERAL

A. The Process Control System (PCS) Site Acceptance Test (SAT) is focused on verifying that all instrumentation, equipment, PLC/OIT/HMI, and controller hardware and software is working properly and that all software configurations match the requirements identified in the detailed process narratives. Successful completion of the SAT is considered to be a critical project milestone.

B. CONTRACTOR: Test the software, witnessed by OWNER / ENGINEER / PROJECT REPRESENTATIVE, under all possible process conditions in order to demonstrate the robustness of the software.

C. The SAT consists of testing using the actual field inputs/outputs once all field equipment has been installed and successfully tested.

D. Carry out SAT testing for all PLC/OIT/HMI and controller software including packaged and vendor supplied products as a whole system.

2.2 PREREQUISITES

A. Complete equipment start-ups with manufacturer representatives, including all mechanical equipment required to fully test the operation of the software. Complete process area start-ups prior to overall SAT.

B. Installed, calibrate, and test all required instrumentation prior to starting SAT. This includes communication between Pump Control Panels, the Woods Capacity Control Panel, Building LAN and WAN.

C. Install and test all required network equipment prior to starting the first facility SAT.

D. Submit the SAT & Start-Up Test plan for approval by the OWNER / ENGINEER / PROJECT REPRESENTATIVE no later than four (4) weeks in advance of the SAT.

E. Wire up, test, and sigh off 100% all process area and packaged system panel I/O prior to commencing SAT unless otherwise approved by OWNER / ENGINEER / PROJECT REPRESENTATIVE. Submit a request to defer I/O testing until after the SAT for review and approval at the same time when the SAT & Start Up test plan is submitted for review and I/O is not available. Identify the reason for deferring I/O testing in the request along with a proposed date for when to test the I/O.

2.3 START-UP TEAM

A. The Start-Up Team consists of individuals from the OWNER, ENGINEER, PROJECT REPRESENTATIVE, CONTRACTOR, SYSTEM INTEGRATOR, and Equipment Manufacturers.

B. Start-Up Team: Review the testing plan, SAT, & Start-Up Plan and revise, if necessary, at a pre-SAT & Start-Up meeting to be scheduled no later than six (6) weeks in advance of the proposed SAT period.

C. Furnish details for the SAT & Start-Up Plan to clearly identify the proposed test procedure for the equipment and software.

D. Start-Up Team: Witness the SAT testing.

E. Identify members of the Start-Up Team at the pre-SAT & Start-Up meeting. These team members will be involved throughout the process and can be changed only with the approval of the PROJECT REPRESENTATIVE.

2.4 PURPOSE AND SCOPE

A. The goal of software testing is to verify that the system released for use by the Facility's Staffs meets the contract requirements, and is error-free. Ensure that software installed or modified under the project does not adversely affect the operation of other systems currently in operation at existing OWNER facilities. All functionality that is currently available within the system must remain available at the completion of the testing.

B. Test all software installed as part of the project to confirm that the software developed, tested, and installed under the project conforms to the approved process control narratives.

C. Ensure all software meets the requirements of the project specifications including all operational control, monitoring and alarming. Integrate all vendor packaged systems as defined within the contract documents.

D. Provide testing that demonstrate that all software developed works throughout OWNER SCADA workstations. Conduct all system-wide testing concurrently with the local testing to confirm operation throughout the system.

E. Perform testing of the Emergency Power System in accordance with the requirements contained in Section 26 33 53 - Uninterruptible Power Supply System.

2.5 DEFINITIONS

A. Software Testing: Defined as the execution of a program to find its faults, and not just a process to verify its correctness.

B. Other definitions are:

1. Verification: The process of proving the program's correctness.

2. Validation: An attempt to find errors by executing a program in the controllers, Control nodes, and Monitoring nodes.

3. Debugging: Diagnosing the precise nature of a known error then correcting it. Debugging is a "fix" activity, not strictly a testing activity.

4. Errors: Human mistakes; errors in design definition or interpretation of the design by the programmer.

5. Defects: Improper program conditions that are generally the result of an error. Not all errors produce defects (as with incorrect program comments, for example).

6. Bugs: A fault that is a program defect found when the program is being tested or is in operational use. Bugs result from defects, but all defects do

not necessarily produce bugs.

2.6 OBJECTIVES

A. The following identifies the overall objectives of the PCS Site Acceptance Test:

1. Confirm and document that the PLC I/O matches the panel shop drawings in terms of input/output configuration, tagging, and function.

2. Confirm and document that the individual device logic operates all field equipment correctly and safely, as described in the detailed process control description.

3. Confirm and document that the control logic operates the facility correctly and safely, as reviewed at the FAT and also described in the detailed process control description.

2.7 APPROACH

A. As part of the testing process regression, incorporated testing into all test plans to demonstrate that any corrections made to the software do not impact other areas of the logic. Ensure that corrections/modifications have not adversely affected the previously tested (and debugged) systems and system components.

B. Perform both progressive and regressive testing:

1. Progressive testing introduces and tests new functions and uncovers problems in the newly added or modified modules and in their interfaces.

2. Regressive testing concerns the effects of newly introduced corrections or system components on all previously integrated (tested) code.

C. Goal of software testing: To ensure that the system released for use by users meets the contract requirements, is error-free, and does not adversely affect other systems.

2.8 TEST SUCCESS CRITERIA

A. Test success is based on the number of defects and the defect severity levels encountered during the testing period. The OWNER / ENGINEER / PROJECT REPRESENTATIVE at their discretion determine to restart a new SAT.

2.9 COMPLETION CRITERIA

A. Testing of software is deemed to be complete when all features, functions and information required in accordance with Section 40 90 00 (Process Control System General Requirements), drawings, and the complete functionality as described in the contract documents has been verified as present and functioning, and documented as accurate within the anticipated operating range for the process

being monitored and controlled.

2.10 PARTICIPANT AND RESPONSIBILITIES

A. SAT & Start-Up Test Planner (CONTRACTOR / SYSTEM INTEGRATOR / Equipment Mfr.):

1. Develops the complete SAT & Start-Up test plan

2. Develops the schedule

3. Coordinates all meetings identified in the contract documents to develop and implement the test plan

4. Coordinates the involvement of all team members and equipment manufacturers required to be present during testing

5. Develops/compiles the test data

6. Oversees the test planning and test plan execution of the process control system

7. Obtains approval for test plan and schedule from ENGINEER/ PROJECT REPRESENTATIVE.

B. OWNER/ENGINEER/ PROJECT REPRESENTATIVE:

1. Reviews and approves test plan

2. Documents test results and classifies defect severity

3. Identifies system “design” defects (where the design does not match the specification) and coding defects (where the system does not behave as specified)

4. Reviews test results

5. Assigns Level 1, 2, and 3 faults. Logs action required and taken in the Software Action Log

6. Assigns Level 4, 5, and 6 faults. Logs action required and taken in the Software Action Log

7. Maintains Software Action Log

8. Maintains Deficiency Log related to other trades: electrical, instrumentation, vendor packages, and others

9. Presents Corrections Requests to the OWNER for prioritization

10. Schedules approved correction request work

11. Maintains Correction Request Log

12. Coordinates with City operations staff to avoid conflicts and minimize impact to operations of construction activities

13. Participates and assists in the acceptance testing

14. Responsible for signing-off on the acceptance testing that the system is fully functional as defined within the detailed process control narrative

15. Oversee the integration of the software into the existing SCADA network

C. SYSTEM INTEGRATOR

1. Responsible for defining the procedure required to complete the SAT & Start-Up tests

2. Responsible for directing the SAT and start-up testing and for providing input to the CONTRACTOR as to which trades are required to complete the tests identified within the test plan

3. Installs and tests all software for functionality as per the detailed process control description

4. Fixes all defects

5. Documents test results and forwards to CONTRACTOR

PART 3 EXECUTION

3.1 GENERAL

A. Part 3 provides an outline of the work to be carried out by the OWNER/ENGINEER/ PROJECT REPRESENTATIVE/ CONTRACTOR/SYSTEM INTEGRATOR/Equipment Mfr. as part of the PCS Site Acceptance Test(s).

3.2 TEST SUB-PHASE

A. The types of software tests are:

1. Individual instruments, equipment, and process units: these sub-phases test/verify that devices and their larger system parts (e.g. process units and duty tables) perform as specified.

2. Intra-system Integration: tests/verifies the interfaces between units and the associated process logic related to multiple units, and facility-wide operating strategies.

3. Function: tests/verifies the functions the program is to perform as set out in the detailed process control narratives.

4. Performance/Operational: tests/verifies the system's performance under a variety of conditions (normal/abnormal) and verifies these results against the detailed process control narratives. Includes testing of the system's configuration, security, backup/recovery, and reliability in the planned network architecture.

5. System Wide Integration: tests/verifies the operation of all control areas from all OITs and HMI operator workstations.

3.3 DEFECT HANDLING

A. During testing, identify the need for corrections to the system as a result of a test failure or as a result of an incorrectly specified requirement (test did not fail, but the requirement is incorrectly specified).

B. For test failures, record the defect in the SAT test document. Immediately review and resolve all defects during the SAT period.

C. Use the following "Fault Severity Index" for handling defects:

Defect Severity Level	**Defect Description**
1	Fault causes system to crash. System rendered unusable/non-functional.
2	Fault occurs in a critical function. Function is rendered unusable. A critical function is defined as a function that is required to maintain operation of the facility without manual intervention by the operations team.
3	Fault occurs in a critical function. A portion of the function is rendered unusable.
4	Fault occurs in a non-critical function. Function is rendered unusable.
5	Fault occurs in a non-critical function. A portion of the function is rendered unusable.
6	Cosmetic (e.g. typo) and would be unlikely to result in loss of confidence by users.

D. Testing cut-off points also need to be established in the test plan and reflected in the testing schedule. Correct Level 1, Level 2, and Level 3 faults as a first priority. Do not proceed to the next sub-phase until all Level 1, 2, and 3 faults are corrected.

E. The OWNER / ENGINEER / PROJECT REPRESENTATIVE determines the

priority for correcting Level 4, 5, and 6 faults and prioritizes all Correction Requests.

F. If Correction Requests are required, they will be prepared by the PROJECT REPRESENTATIVE. Identify possible implications of not proceeding. The OWNER will authorize the work to be done under any correction request prior to implementation. CONTRACTOR: Schedule correction request work based on the project priorities.

3.4 SUCCESSFUL COMPLETION

A. The SAT is deemed successful when the following items have been completed:

1. SAT Test plan has been completed and signed-off

2. All Level 1, 2, and 3 faults identified during the SAT have been corrected and verified for correct operation

3. The completed SAT plan has been reviewed and signed off by the ENGINEER, PROJECT REPRESENTATIVE, CONTRACTOR, and SYSTEM INTEGRATOR.

3.5 FACILITY STARTUP PERIOD

A. Following successful completion of the SAT testing, the startup period may commence. OWNER, ENGINEER, PROJECT REPRESENTATIVE, CONTRACTOR, SYSTEM INTEGRATOR, and Equipment Manufacturers, are to be present during the startup period.

B. PROJECT REPRESENTATIVE maintains a log of faults/deficiencies encountered during the startup period. The CONTRACTOR / SYSTEM INTEGRATOR / Equipment Manufacturer is to immediately correct faults/deficiencies at the request of the OWNER, ENGINEER, or PROJECT REPRESENTATIVE. If any Level 1, 2, or 3 fault occurs during the startup period, the test period is restarted from Day 1 after completion of the software modifications and testing by the SYSTEM INTEGRATOR.

C. Following completion of the startup period, the fault/deficiency log is submitted to the PROJECT REPRESENTATIVE for review. Sign-off by OWNER, ENGINEER, PROJECT REPRESENTATIVE, CONTRACTOR, and SYSTEM INTEGRATOR is required at the completion of the facility startup period.

3.6 TRAINING

A. Provide training in accordance with the requirements contained in Section 40 98 00 - Process Control System Training.

3.7 MANUFACTURER'S FIELD SERVICES AND TRAINING

A. Include the services and training time of factory trained personal, as required, from each manufacturer listed, during the 30-Day Test. The OWNER can utilize this time at his discretion. Field services are based on an eight (8) hour day, Monday through Friday, during the Facility's normal working hours. All travel and living related costs are the responsibility of the CONTRACTOR.

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 40 90 00

PROCESS CONTROL SYSTEM GENERAL REQUIREMENTS

PART 1 GENERAL

1.1 SUMMARY

A. Section 40 90 00 describes the general requirements for furnishing and installing process control system (PCS) including all labor, materials, equipment and incidentals as shown, specified and required to furnish, install, calibrate and place in operation a complete system as illustrated on drawings, and as specified in the following sections.

B. Provide labor, materials, equipment, and services to store, transport, install, calibrate, and make operational the PCS work for the TMUA Raw Water Pump Station Facility Assessment project. The work includes the design shown on the drawings and specifications including instruments, field devices, networks, programming, integration, testing, and commission for all devices provided including packaged systems and control. Work also includes wiring, raceway, fittings, and connections to link and integrate the individual components and control systems at the TMUA Woods Pump Station into the existing TMUA SCADA network.

C. CONTRACTOR: Comply with the "Use of American Iron and Steel (UAIS)" requirements as contained in Section 436 of the Consolidated Appropriations Act, 2014.

D. Work Areas for This Project Include, But are Not Limited to:

1. TMUA Woods Pump Station

2. TMUA Remote SCADA

E. Related Work Specified in Other Sections Includes, But is Not Limited to, the Following:

1. Section 01 33 00 - Submittals
2. Section 40 80 50 - Process Control System Commissioning
3. Section 40 94 13 - Process Control Systems Computer and Network Hardware
4. Section 40 94 43 - Programmable Logic Controller Systems
5. Section 40 95 13 - Process Control System Panel Enclosure and Equipment
6. Section 40 96 15 - Process Control System Input and Output List
7. Section 40 98 00 - Process Control System Training
8. Section 40 98 50 - Process Control System Factory Acceptance Testing

1.2 SYSTEM SUPPLIERS

A. CONTRACTOR: Provide all labor, materials, equipment, elements, and incidentals as shown, specified in this section and related sections, and required to furnish, install, calibrate, test, start-up, and place in satisfactory operation a complete process control system.

B. CONTRACTOR: Responsible for all elements specified and provided as part of this section and related sections.

C. SYSTEM INTEGRATOR: Provide all programming, integration, testing, start-up, and commissioning services related to but not limited to PLC control system, PCS HMI systems and SCADA HMI upgrades/modifications.

D. SYSTEM INTEGRATOR: Responsible for all details necessary to properly install, adjust, configure, and place in operation the intended system.

1.3 REFERENCES

A. Regulatory Requirements

1. Code Compliance: Comply with National Electrical Code (NFPA 70) and any and all local codes, applicable to construction and installation of electrical wiring, devices, material and equipment.

2. NECA Standards: Comply with applicable portions of National Electrical Contractor's Association's "Standard of Installation".

3. UL Labels: Provide control panel components, power supplies, relays, etc., which have been listed and labeled by Underwriter's Laboratories.

B. The purpose of Contract drawings and specifications is to convey information required for complete and functioning systems. SYSTEM INTEGRATOR: Responsible for all details necessary to properly install, adjust, configure, and place in operation the intended systems. Instrument List and Input/Output List, if provided, are for convenience; their accuracy is not guaranteed.

C. Codes and Standards referred to in this Section are:

1. IEEE 802.3 10/100/1G Ethernet networks

2. ISA-S5.4 Instrument Loop Diagrams.

3. NFPA 70 National Electrical Code

4. NFPA 79 Electrical Standard for Industrial Machinery

5. UL Underwriter's Laboratory

6. NEMA National Electrical Manufacturers Association

1.4 QUALITY ASSURANCE

A. Standard Products

1. Use standard hardware and software which is fully developed, tested, and supported as a base for the Work. Provide custom modifications as specified elsewhere. Provide a fully operational, reliable system which meets the functional intent of the Specifications.

B. Software Testing Standards

1. Test programs to ensure that the software to be provided is consistent with the design parameters and that no errors occur when the programs are executed, either at machine level (PLC) or operator level (HMI).

2. Establish testing standards.

C. Revision Level

1. Update hardware and firmware to the manufacturer's latest revision level. Perform updates periodically and uniformly across enterprise system until final acceptance, as revisions are issued by the manufacturer.

2. Exceptions will be considered on a case-by-case basis and not be allowed without certification, that the original equipment manufacturer will continue to support and warranty the hardware.

3. Ensure retention of compatibility with all systems before performing any hardware, software, or firmware upgrades.

1.5 ABBREVIATIONS

A. HMI – Human Machine Interface.

B. OIT – Operator Interface Terminal

C. OWS – Operator Work Station

D. PC – Personal Computer.

E. PCS – Process Control Systems.

F. PLC – Programmable Logic Controller

G. SCADA – Supervisory Control And Data Acquisition

H. TMUA – Tulsa Metropolitan Utility Authority

1.6 DEFINITIONS

A. Process Instrumentation and Control Equipment: Instrumentation and control and monitoring components such as field elements, panels, process control systems, and associated electromechanical, electrical, and electronic accessories.

B. Process Instrumentation and Control System: Materials, equipment, and work required to implement a complete and operating system of instrumentation and control equipment.

C. PLC (Programmable Logic Controller): System includes power supply, central processing unit (CPU), communication controller, interconnect cables, and input and output interface.

D. SCADA (Supervisory Control and Data Acquisition): Computer system that operates as primary operator interface to the entire PLC network, which includes process visualization and control, data collection and storage, alarm management, and process data link to other office productivity software.

E. OIT (Operator Interface Terminal): Graphical local operator interface terminal at a PLC enclosure or control panel.

F. OWS (Operator Work Station): PC based operator system, including hardware, operating system software, and operator interface HMI system software. This is generally referred to as the SCADA or HMI workstation.

1.7 GENERAL DESCRIPTION OF WORK

A. Provide all materials and work necessary for complete and fully functional systems.

1. Provide instrumentation and controls components as well as complete system integration. Provide all mounting hardware and supports including panel mounting and the completion of all wiring terminations within control panels.

2. Integrate new equipment and instrumentation to OWNER's existing SCADA systems for monitoring and control of equipment as shown in the contract drawings. Control strategies for the PLC systems shall be as copied from Bird Creek and Canyon Lake Pump Station. The control strategies for the PLC systems shall be updated/modified and improved as required by the Owners Industrial Control System Project Coordinator.

3. Configure all I/O points as required Owners Industrial Control System Project Coordinator.

4. Commission PLC system per the requirements of section 40 80 50 - Process Control System Commissioning.

5. Ensure communication with OWNER's existing SCADA system through existing control network allowing monitoring and control of new equipment.

6. Ensure proper interface between SCADA, PLC, OIT, SCADA HMI and OWS systems and equipment provided in this contract.

7. Provide control panels and enclosures as shown on Contract Drawings and as specified in Section 40 95 13 - Process Control System Panel Enclosures and Equipment.

8. Provide necessary training for OWNER to perform all functions necessary to monitor equipment as specified in Section 40 98 00 - Process Control System Training.

9. Work is generally as shown on the drawings and as specified. Programming of each PLC/OIT/HMI is required including communication and messaging with related equipment (drives, packaged systems, generators, power monitors, etc.) Configuration of network equipment, including implementation of network security consistent with TMUA requirements is required.

10. Coordinate work with all electrical, mechanical, and structural work provided in this Contract.

11. Install, make final connections, adjust, test, start-up systems per manufacturer's instructions and recommendations.

B. Source Code Ownership

1. OWNER: Assumes ownership over/of any developed ladder logic (along with source code) including any logic associated with package control systems as well.

2. OWNER: Assumes ownership over/of any developed or modified PLC, HMI, OWS, and OIT applications (along w/ source code) including any logic associated with package control systems as well.

3. OWNER : Shall be provided with all software used to develop ladder logic, function blocks on a programming laptop enabling OWNER to make any necessary changes as required. Software used for programming the PLC, OIT, communicate with Generators, communicate with VFDs, Transfer Switches and any device that need communication software shall be on the programming laptop provided by the Contractor/System Integrator. Include software model numbers and vendor information associated with each software.

4. Software programming shall be done in Ladder Logic with Function Blocks used when needed to create PID Control loops.

5. Document all passwords and submit to the OWNER.

1.8 SUBMITTALS

A. General: Furnish all submittals, including the following, as specified in Section 01 33 00 - Submittals.

B. SYSTEM INTEGRATOR: Prior to beginning any work on this Contract, submit a plan for performing programming, site testing, commissioning, and start-up for OWNER approval.

C. Include the following information in the submittal for this section:

1. A system hardware overview that provides an overall description of the PCS equipment being added, including a detailed system configuration diagram.

2. Power and grounding interconnection diagrams. Show the grounding philosophy and implementation. Detail interconnections from the main power source. Show uninterruptible power supplies and power conditioners.

3. Interconnecting wiring and cabling diagrams. Include maximum distance limitation between panels and equipment. Include cable identification.

4. Color schedule with color and samples for panels.

D. Include the following submittal information on each hardware item:

1. General data and description. Provide bookmarked data for each provided equipment, system and instrument.

2. Engineering specifications and data sheets, annotated as necessary to describe specific hardware.

3. Dimension drawings, including exterior dimensions and clearances required, cable ingress and egress areas, cable routing and terminations.

4. Equipment weights.

5. Power and grounding requirements, wiring diagrams, and electrical schematics.

6. Heat rejections and environmental operating requirements.

7. Spare parts list, special tools and test equipment.

8. Other submittal information as required in individual specification sections.

E. Action Submittals

1. Product Data: Submit manufacturer's official and published product data, specifications, and installation recommendations for each item.

2. Shop Drawings: Submit shop drawings as per Section 01 33 00 - Submittals, and as required below. Include the following information in each submittal:

    a. Instrument index, including tag number, description, location, and calibrated range for each instrument.

    b. Individual instrument specification sheet, including manufacturer's name and complete catalog number.

    c. Panel construction drawings with dimensions, layout, and bill of materials.

    d. Panel wiring diagrams

    e. Loop diagrams

    f. Communication and digital networks diagrams

F. Include connections to Ethernet network. Identify cable, termination type, termination location, and drop lengths for each segment.

1. Format: Network schematic for each different type of network.

2. Input and Output drawings, containing, but not limited to, the following information:

    a. Line numbers and instrument tag numbers

    b. Individual component locations

    c. Actual equipment wiring terminal designations, point to point wiring, and cable shield terminations

    d. Wire type, size, and identification number

    e. Signal types (e.g., 120 VAC, 4-20 mA, pulse frequency, etc.)

    f. Contact orientations (e.g., normally open, normally closed, etc.)

    g. Equipment grounding requirements

    h. Signal boosters, interposing relays, optical isolators, and shunt resistors.

3. Completely developed graphical interface process screens, including OIT for each panel (new/modified or upgraded) and HMI screens (new/modified or upgraded).

G. Information Submittals

1. Test Reports: Provide all loop field calibration reports.

2. Factory and Field Testing: Provide the following:

a. Test Results:

(1) Pass/fail status of all digital I/O.

(2) Results of analog I/O testing.

b. Miscellaneous:

(1) Detailed step-by-step in-factory and field test procedure at least 6-weeks in advance of scheduled test date. Include sign-off sheets and punch list forms and description of configurations to be tested.

(2) Complete inventory of equipment to be tested including make, model, and serial number. Label each piece of equipment.

(3) Preventive maintenance schedule.

(4) Repair Report Forms.

(5) Spares and Consumables Report.

3. Manufacturer's Instructions: Provide manufacturer published installation manuals and operations manuals for each instrument, device, or equipment.

H. Graphics

1. CONTRACTOR: Submit static copies of each graphic screen including alarm screens indicating navigation, pop-ups, alarms, and status information.

I. Closeout Submittals: Furnish submittals as required below.

1. Project Record Documents: In addition to requirements described in Section 01 78 90 - Contract Close Out, provide the following:

a. Program documentation: Provide paper copies of all software development and configuration including listing of all register tables.

b. Include functional narrative description of the developed ladder logic to describe each control system. Ladder logic is to be annotated as specified in Section 40 94 43 - Programmable Logic Controller Systems to include functional alphanumeric description of logic elements to assist OWNER in understanding the ladder logic for troubleshooting and future modification.

c. Program copies: Provide two digital copies in CD-ROM format and USB storage drive format of fully configured systems.

d. Operator interface program copies: Provide hard copy printouts and digital copies in CD-ROM format and USB storage drive format of new or modified OWS/HMI screens and database listings.

2. Operation and Maintenance Data: Provide operation and maintenance manuals as specified in Division 1. Include the following information:

a. Recommended spare parts list.

b. Manufacturer approved repair and service centers list.

c. Replacements part sources.

d. Recommended maintenance procedures and frequencies.

3. Warranty: Provide warranty certificate as described in Section 01 78 90 - Contract Close Out.

1.9 RESPONSIBILITY

A. SYSTEM INTEGRATOR: Provide application software programming as copied from the Bird Creek and Canyon Lake Pump Station. The software programming shall be overseen and approved by the Owners Industrial Control System Project Coordinator.

B. SYSTEM INTEGRATOR: Prepare interconnecting Wiring Diagram Drawings for the Process and Instrumentation Control System. Electrical CONTRACTOR, provide interconnecting wiring and terminations for the System under Division 26, in accordance with the Interconnecting Wiring Diagram Drawings.

C. CONTRACTOR: Correct incomplete or deficient work discovered during application software programming, downloading, testing, troubleshooting, and System startup immediately. Provide interim modifications or patches as required to maintain 24 hr x 7 day operation.

D. SYSTEM INTEGRATOR: Implement configuration, coordination, and addressing of Ethernet networks for the devices specified herein and as shown on the Drawings. Where additions to existing plant networks are required, request the range of

available addresses from the OWNER and Owners Industrial Control System Project Coordinator and coordinate requirements.

E. SYSTEM INTEGRATOR: For Process Control System (PCS) control panels, components, and ancillaries specified under this section:

1. Coordinate to ensure that: The proper size, type, and number of PCS related raceways and conductors are provided and installed.

2. Complete panel fabrication drawings.

3. Provide the specified submittals, bookmarked, highlight product details/model number in each of datasheets.

4. Provide panels, components, and ancillaries.

5. Provide programming and configuration of PCS components.

6. Provide instructions, details, and advice to and coordinating with the CONTRACTOR to ensure proper installation.

7. Certify correctness of installation.

8. Verify final power and signal connections and labeling (lugging and connecting).

9. Adjust and calibrate components and devices.

10. Perform Start-up

11. Perform Testing

12. Provide the required training.

F. For systems, components, and ancillaries not provided under this Section but that are directly connected to components provided under this Section.

1. Obtain manufacturers' information regarding installation, interface, function, and adjustment.

2. For operation and control, verify that installations, interfacing signal terminations, and adjustments have been completed in accordance with manufacture's recommendations.

3. Testing to demonstrate proper interface and operation with PCS.

a. Examples of items included in this category are:

(1) Axial Flow Pumps

(2) Level, Pressure, and Flow Measurement

(3) Switchgear

(4) Motor Control Centers

(5) Electrical Generator

(6) Motor Actuated Valves and Limit Switches

1.10 APPLICATION SOFTWARE PROGRAMMING

A. The SYSTEM INTEGRATOR: Provide application software programming as required in this and related Sections. Download and test application software programming after successful completion of Process Control System Factory Acceptance Testing specified in Section 40 98 50 and Process Control System Commissioning in Section 40 80 50.

B. SYSTEM INTEGRATOR: Successfully complete application software programming, downloading, and testing prior to beginning Training Services specified in Section 40 98 00 - Process Control System Training. Refer to construction sequences and constraints that affect completion of application software programming, downloading, and testing.

C. SYSTEM INTEGRATOR: Provide a programming laptop as specified in 40 94 13 - Process Control System Computer and Network Hardware with all required licenses for all new programming software pre-loaded. Provide license numbers, software model numbers, make and vendor contact information. Provide, with the computers, licensed copies of media to reload the software. Programming laptop shall remain air gapped from the outside world and shall not be connected to external networks or internet for software updates.

D. SYSTEM INTEGRATOR: Perform all work in accordance with TMUA SCADA standards.

1.11 DELIVERY, STORAGE, AND HANDLING

A. General: Deliver, store, and handle all products and materials as specified in Section 01 60 00 - Material and Equipment.

B. Acceptance at Site: Inspect all materials and equipment against approved shop drawings at time of delivery. Immediately return for replacement or repair any equipment or materials damaged or not meeting requirements of approved shop drawings.

C. Storage and Protection: Label all equipment and materials after they have been inspected. Store all equipment and materials in dry, covered, ventilated location. Protect from harm in accordance with manufacturer's recommendations.

1.12 PROJECT/SITE CONDITIONS

A. Environmental Requirements: Protect all equipment and instruments specified herein from moisture. Site is a water pumping station. Process control equipment may be located outdoors and subject to temperatures from -20F to +120F, with rain and 100% humidity.

1.13 SEQUENCING AND SCHEDULING

A. Prerequisite Activities and Lead Times: Do not start following key Project activities until prerequisite activities and lead times listed below have been completed and satisfied:

1. Shop Drawing Reviews by ENGINEER:

a. Prerequisite: RESIDENT PROJECT REPRESENTATIVE's acceptance of Schedule of Values and Progress Schedule.

2. Training

a. Prerequisite: Associated training plan Submittal approved.

b. Prerequisite: Offsite Training plan submittal approved

PART 2 PRODUCTS

2.1 GENERAL

A. Provide hardware consisting of ruggedized components designed specifically for the site conditions. Refer to other sections for appropriate NEMA requirements.

B. Provide only new, standard, first-grade materials throughout, conforming to standards established by Underwriter's Laboratories (UL), Inc., and so marked or labeled, together with manufacturer's brand or trademark.

C. Provide material and equipment in accordance with applicable codes and standards, except as modified by the specifications.

D. Coordinate instrumentation to assure proper interface and system integration. Provide signal processing equipment, to include, but not be limited to, process sensing and measurement, transducers, signal converters, conditioners, transmitters, receivers, and power supplies. Coordinate the various subcontractors, equipment suppliers, and manufacturers.

2.2 SYSTEM ARCHITECTURE

A. SYSTEM INTEGRATOR: Responsible to configure and program the Woods Pump Station process control station to provide control and monitoring of all instruments, devices, and equipment connected to the PLC system, including the Woods Capacity Control Panel, W1/W2 Pump Control Panel as described in this Contract.

2.3 MONITORING AND CONTROL – GENERAL

A. Functional descriptions of the processes and equipment to be monitored and controlled by (or through) the Process Control System shall be copied from the Bird Creek and Canyon Lake Pump Station. The control and monitoring programming shall be modified/updated as need in coordination with the Owners Industrial Control System Project Coordinator. The Industrial Control System Project Coordinator shall oversee and approve changes required for seamless operation and monitoring of Woods Pump Station.

2.4 SYSTEM HARDWARE

A. Provide all hardware and ancillary equipment required to provide a fully functional TMUA PCS. Provide TMUA PCS components, including panel hardware, motor starters, etc. as specified in Division 40 and other Divisions.

2.5 SYSTEM INTEGRATION

A. Provide system integration of the complete TMUA PCS. System integration may require the installation of additional pieces of equipment to make the TMUA PCS a reliable, safe, maintainable, and fully functional system. Such equipment includes, but is not limited to, communication modules, terminations, wires, cables, connectors, power supplies, transceivers, transducers, signal isolators, power surge suppressers, lights, switches, circuit breakers, fuses, power receptacles, fans, and communication devices.

B. Provide all additional pieces of equipment as necessary to provide a fully integrated, fully operative TMUA PCS with fully functional signal interfaces to field instrumentation, motor controllers, and other control devices as described elsewhere.

C. System integration requires thorough testing of all system equipment and circuits under all probable system conditions to ensure a robust TMUA PCS.

2.6 GRAPHIC DISPLAY REQUIREMENTS

A. Include on the displays at a minimum all the equipment shown in the Process and Instrumentation Diagrams and described in the contract drawing and as directed by the Owners Industrial Control System Project Coordinator. Develop Graphics following requirements of High Performance HMI standards and matching the existing graphics and color schema at Bird Creek and Canyon Lake. Label all equipment as shown on the Contract Drawings or as listed in the I/O list.

B. System Integrator to develop and or modify new OIT Screens at the Capacity Control Panel and W1/W2 Pump Control Panels. System Integrator to update/modify existing SCADA HMI screens at the Remote TMUA SCADA/Control Room to Reflect the upgrades/changes made at the TMUA Woods Pump Station. The developed screens shall match the existing graphical elements i.e. color scheme, font type and size, and overall visual style as used at Bird Creek and Canyon Lake Pump Station.

C. The OIT screens and the SCADA HMI screens shall include real time monitoring, trending and data recording capabilities. At a minimum the monitoring and trending features shall match the existing capabilities. System Integrator to coordinate with the Owners Industrial Control System Project Coordinator to determine specifics of the trending and data recording features.

D. Contractor to utilize the exact color schema for OITs and HMIs as the client owned and operated Bird Creek and Canyon Lake Pump Station.

E. Provide all HMI & OIT displays with the following attributes:

1. Display window sizes:

    a. 1330 wide by 553 high with “Size to Main Window at Runtime” checked

    b. 1900 wide by 790 high

2. Pop-up displays (e.g. Set Point Displays):

    a. No set size, but size content appropriately and smaller than display window sizes as defined above

    b. Use the “On Top” Display Type

3. OIT Display Window sizes:

    a. Size normal display windows appropriately for the full screen or scaled properly as to avoid stretching

    b. Pop-up displays

        (1) Do not have to be set to fill the screen, but should use the “On Top” display type.

        (2) Background color : Grey

        (3) All Buttons Style: Recessed

(4) All standard text attributes:

(a) Arial Bold 10pt font

(b) Center aligned

(c) Either Black or White, dictated by whichever color provides the best contrast for easy readability

(5) All numeric displays and numeric inputs attributes:

(a) Courier New Bold 10pt font

(b) Right-aligned

(c) Fore Color: White

(6) Any visual graphics (e.g. tanks) will endeavor to reasonably reflect their real-world counterpart in look

(7) All grouping containers will use the panel object tool and have the following attributes:

(a) Inset border style

(b) Border width: 2

(c) Back style: Solid

(d) Pattern Style: None

(e) Back color of Dark Grey

F. Color standards for all HMI & OIT displays (specified in RGB): Contractor to use the exact color schema as used at client owned Bird Creek and Canyon Lake Pump Station.

G. HMI Tags

1. All HMI tags shall be similar to client owned Bird Creek and Canyon Lake Pump Station, coordinate with Owners Industrial Control System Project Coordinator.

2.7 CABLES AND CONNECTORS

A. Provide wiring, connectors, and cables to connect the equipment.

B. Size wiring and cables to equipment such as printers, operator workstations, and similar devices to accommodate relocation within the control rooms and operator workstation areas. Add a minimum of 25 percent of the cable length or 15 feet, whichever is greater, to the laying lengths.

C. Clearly label all cables at both ends according to requirements of electrical identification.

D. CONTRACTOR to use the same wiring color scheme as used in panels at Bird Creek and Canyon Lake Pump station to maintain consistency.

PART 3 EXECUTION

3.1 GENERAL

A. Provide the detailed hardware configuration, integration, construction, testing, startup, installation, and demonstration of all TMUA equipment.

B. Install all TMUA equipment at the OWNER's facilities in accordance with applicable federal, state and local codes. Supervise the installation and be responsible for the performance of the completed system.

C. Provide for the protection, insurance, and proper storage of equipment. In the event the equipment is damaged, for whatever reason, repair or replace, as required, the damaged equipment at no cost to the OWNER until Final Acceptance.

D. Provide coordination of the TMUA PCS for resolution of interface discrepancies between the PCS input/output hardware, panels, equipment, instrumentation, and final control devices. Where interface conflicts exist, provide resolution to the problems and document them in writing to the RESIDENT PROJECT REPRESENTATIVE. Keep Drawings current with all changes.

E. Provide programming for the entire Wood Pumping Station in coordination with Owners Industrial Control System Project Coordinator. Provide all necessary changes/updates/modifications to programming as required by the Industrial Control System Project Coordinator.

F. Provide operations and maintenance manuals, record drawings, documentation and warranty as described elsewhere in the Specifications.

3.2 EXAMINATION

A. Verify equipment locations and delivery routes prior to installation to ensure the equipment will fit in the available space. Investigate and make any field modifications necessary to allocated space for new equipment.

B. Raceways which contain space to run wiring may be used with the approval of the RESIDENT PROJECT REPRESENTATIVE. Do not damage existing equipment

or wiring. If equipment or wiring is damaged, repair or replace it at no additional cost to the OWNER. Do not interrupt control or monitoring signals or power. Obtain approval from the OWNER before pulling wires.

3.3 PROTECTION

A. Maintain site security.

1. Check in with facility staff each day while on site.

2. Verify that all enclosures, doors, and gates which were opened during the day are locked when leaving.

3. Do not leave unlocked enclosures unattended for longer than 30 minutes.

3.4 INSTALLATION AND WIRING

A. Install wiring to interface the PCS components to field devices for all points on the I/O list. Follow recommended methods and practices of the manufacturers of the field devices and the manufacturer of the PCS.

B. Resolve all interface problems. Supply all additional hardware, signal isolators, media converters, signal converters, transceivers, relays, and other required components as necessary to properly interface each field I/O point to the PCS.

C. Provide and keep a neatly marked set of record wiring drawings on the job site showing the installed location and routing of all wiring, including spares, and instrumentation cable runs. Show all terminal connections on drawings. These drawings must show as a minimum:

1. All wiring between PCS components and field devices and/or panels, including terminal and wire numbers for all wiring.

2. All PCS communication wiring and interconnection.

3. All interconnections between any PCS components.

4. All power connections to PCS components.

D. Keep drawings current with the work as it progresses, subject to inspection by the RESIDENT PROJECT REPRESENTATIVE at any time.

3.5 FIELD QUALITY CONTROL

A. Tests and Inspection: Provide tests as required in Section 40 80 50 - Process Control System Commissioning.

B. Inspection: Demonstrate that instruments, panels, programming equipment and network equipment:

1. Has not been damaged by transportation or installation,

2. Has been properly installed,

3. Has no mechanical defects,

4. Is in proper alignment, and

5. Has been properly connected.

C. Testing Process:

1. Test digital inputs and outputs by actual starting and stopping of equipment when possible, or with jumpers at field equipment terminals.

2. Test all new graphic screens developed for the OIT, SCADA HMI and verify all associated functionality. Identify and address all discrepancies.

3. Conduct all tests in presence of plant personnel, Engineer, Owners Control System Project Coordinator. Document test results.

D. Manufacturers Field Service: Provide manufacturer field service for calibration, initial setup, programming, and commissioning of each instrument.

END OF SECTION

SECTION 40 90 50

PROCESS CONTROL SYSTEM DESCRIPTION

PART 1 GENERAL

1.1 SUMMARY

A. Section 40 90 50 includes requirements for furnishing and installing instrumentation and control systems including all work and materials necessary to perform control and monitoring functions as illustrated on drawings, and as specified in this document.

B. Related work specified in other sections includes, but is not limited to the following:

1. Section 01 33 00 - Submittals
2. Section 40 05 20 - Valves
3. Section 40 80 50 - Process Control System Commissioning
4. Section 40 90 00 - Process Control System General Requirements
5. Section 40 94 13 - Process Control Systems Computer and Network Hardware
6. Section 40 94 43 - Programmable Logic Controller Systems
7. Section 40 95 13 - Process Control System Panel Enclosure and Equipment
8. Section 40 96 15 - Process Control System Input and Output List
9. Section 40 98 00 - Process Control System Training
10. Section 40 98 50 - Process Control System Factory Acceptance Testing

1.2 SYSTEM SUPPLIERS

A. CONTRACTOR: Furnish all labor, materials, equipment, and incidentals as shown, specified, and required to furnish, install, calibrate, test, start-up, and place in satisfactory operation a complete process control system.

1.3 SYSTEM DESCRIPTION

A. General Description of Work

1. Provide process control applications for the TMUA Woods Pump Station control system as shown and as specified in this document including networking and software development.

2. The Instrumentation and Control documents are requirements to assist the CONTRACTOR with the detailed design of control system including networks and communication with existing facilities' Process Control

System (PCS).

3. Perform the Site Acceptance Testing for each process equipment area individually and with other equipment as a system.

B. The Control descriptions provide the functional requirements of the Control represented in the Contract Documents.

1. Descriptions in this document are provided as follows:

a. Control system overview and general description.

b. Equipment to be controlled.

c. Major field-mounted instruments.

d. Manual control functions.

e. Automatic control functions/interlocks.

f. Indications provided at local control panels/stations.

g. Remote indications and alarms.

C. The Control descriptions are not intended to be an inclusive listing of all elements and appurtenances required to execute loop functions, but are rather intended to supplement and complement the Drawings and other Specification Sections. The Control Descriptions are the base document for the CONTRACTOR creation of the Control Strategies. Identification of required elements, documentation, and coordination between loops are to be developed during shop drawings. Finalizing and tuning of strategies, as required by process characteristics, are to be completed during start-up.

D. The project scope includes the following facilities and areas:

1. Woods Pumping Station (WPS), including the intake and discharge surge tanks, line valves, axial flow pumps and associated valves:

The purpose of the WPS is to pump potable water received from Spavinaw Lake via the Grand River Pump Station system down to the Mohawk Water Treatment plant. The Woods Pump Station is used primarily to increase the conveyance capacity of water supplied by Spavinaw water system from 63 mgd when flowing by gravity to 95 mgd during peak flow demands using the booster pumps.

During normal operation two (2) on-site axial flow pumps (Pump W1 and

W2) help maintain the conveyance capacity between the Grand River Pump Station and the Canyon Lake Pump Station by modulating pump speeds to maintain consistent flow rate and system pressure. This is done by directing the flow from Spavinaw flow lines to the two axial flow pumps, W1 and W2, by closing the Spavinaw Line valves L4 and L5. Suction and discharge surge tank levels are monitored and used as processes variables to determine the appropriate pump speeds.

In the event of pump failure, the flow is redirected back to Spavinaw Flow Lines (1 and 2) by opening line valves L4 and L5 and closing discharge valves D7 and D8 for Pump W1 and Pump W2.

2. Programmable Logic Controllers

a. Woods Capacity Control Panel

Provide a new PLC (PLC-WCCP) at the WPS within the Woods Capacity Control Panel (WCCP). Equipment within the WPS to be integrated to the new PLC includes, but is not limited to, pump Variable Frequency Drive (VFD) controls and safety monitoring (temperature and vibration), motor operated valves, valve limit switches, level sensors, and electrical equipment monitoring (power generator and microprocessor metering systems), and as shown on Contract Drawings.

b. Pump W1 Control Panel

Provide a new PLC (PLC W1) for existing axial flow pump, Pump W1 at the Woods Pump Station. The new PLC shall be installed within the new Pump W1 Control Panel. Integrate the pump discharge valve D7 (MOV), associated limit switch ZS-07, motor RTDs, Line Valve L5 and motor monitoring and control signals into the PLC W1 as shown on Contract Drawings.

Provide a Managed Networks Switch for connection between the Pump PLC-W1, associated VFD, PLC-WPS and PLC-W2 as shown on contract drawings.

c. Pump W2 Control Panel

Provide a new PLC (PLC W2) for the existing axial flow pump, Pump W1 at the Woods Pump Station. The new PLC shall be installed within the new Pump W2 Control Panel. Integrate the pump discharge valve D8 (MOV), associated limit switch ZS-08, motor RTDs, Line Valve L4 and motor monitoring and control signals into

the PLC W2 as shown on Contract Drawings.

Provide a Managed Networks Switch for connection between the Pump PLC-W2, associated VFD, PLC-WPS and PLC-W1 as shown on contract drawings.

3. Miscellaneous:

Expand the existing TMUA SCADA network as shown on Contract Drawings. Include modifications to existing switches if required, new Ethernet switches and new radio/cellular communication systems between facilities where required. The existing network is to remain in service with new points added. Modifications to the network architecture are described below:

a. WPS:

Include a new ethernet network node for the WPS control system within the new Woods Capacity Control Panel (WCCP). This control network node shall interface with the TMUA Remote SCADA system via new Cellular LTE Gateway providing monitoring capabilities and historian data.

Provide and connect the a new cellular LTE network extender/booster to the WCCP ethernet network node. SYSTEM INTEGRATOR shall be responsible for installation and connection of the cellular LTE network extender/booster to the satisfaction of the OWNER.

Connect the new ethernet network node with network switches at the Pump W1 and Pump W2 control panels.

1.4 SUBMITTALS

A. CONTRACTOR: Furnish all submittals as specified herein, and as specified in Section 01 33 00 - Submittals.

B. Action Submittals

1. Product Data: Submit manufacturer's official and published product data, specifications, and installation recommendations for each item. Bookmark each item/product data provided within the submittal.

2. Shop Drawings: Submit shop drawings as per Section 01 33 00 - Submittals, and as required below. Include the following information in each submittal:

a. I/O List complete with Instrument Ranges, Alarm levels, and setpoints.

b. Each detailed control logic permissive and interlock.

c. Complete control description/strategies further developed from the control descriptions provided in this Specification, with a breakdown on each control mode, based on requirements of Part 3.

(1) Include sufficient detail for a complete understanding of each Operator controllable setpoint, failure mode, and alarm.

(2) Include detailed ranges, setpoints, and operator adjustments in the detailed control strategy.

(3) Provide screen layouts for OIT and HMI applications including navigation, graphic standards, alarms, popups, and animation.

d. Complete and include in the submittal all graphics and process screens for all PLC control strategies and PCS control strategies.

e. Ladder logic focused diagrams, functional blocks as approved by the OWNER, and messages to carry out the program. Include the messages within the program to explain how the control program will carry out the required functions. The use of “structured text” type programing is not an acceptable alternative to ladder logic programing.

f. Configuration and data registers.

C. Closeout Submittals:

1. CONTRACTOR: Furnish submittals as required below:

a. Project Record Documents: In addition to requirements described in Division 01 78 23 - Contract Closeout, furnish the following:

(1) Program documentation: Furnish paper copies of all software development and configuration including listing of all register tables.

b. Operation and Maintenance Data: Furnish operation and maintenance manuals as specified in Division 01, including the following information:

(1) Recommended spare parts list.

(2) Manufacturer approved repair and service centers list.

(3) Replacement part sources

(4) Recommended maintenance procedures and frequencies

c. Warranty: Furnish warranty certificate as described in Division 01.

1.5 QUALITY ASSURANCE

A. General: Furnish Quality Assurance as specified in Division 01.

B. The purpose of contract drawings and specifications is to convey information required for complete and functioning systems. The SYSTEM INTEGRATOR is responsible for all details necessary to properly install, adjust, and place in operation intended systems. Preliminary Input and Output (I/O) List will be provided to the CONTRACTOR for convenience; however, their accuracy is not guaranteed.

C. Meetings

1. Schedule meetings as necessary at the ENGINEER'S designated office to jointly review control requirement submittals, and to coordinate and resolve any issues or discrepancies in regard to the operator interface software programming and implementation, and detailed PLC programming. Plan to attend meetings of one-day duration to jointly review all control requirements with the OWNER's representative and ENGINEER.

2. At a minimum, include the following in the meetings to review progress of network architecture and software graphics:

a. Kick-Off Meeting

b. Controls development at 30% development

c. Controls development at 60% development

d. Controls development at 90% development

e. Controls development at 100% development

f. Testing and start-up planning

D. When requested by CONTRACTOR, OWNER, and/or ENGINEER, SYSTEM INTEGRATOR will attend Monthly Progress Meetings and Weekly Meetings as

required and specified.

1.6 RESPONSIBILITY

A. SYSTEM INTEGRATOR: Provide application software programming as specified herein and in Section 40 90 00 - Process Control System General Requirements.

1.7 APPLICATION SOFTWARE PROGRAMMING

A. SYSTEM INTEGRATOR: Provide application software programming as specified in this and related Sections. Download and test application software programming after successful completion of:

1. Process Control System Factory Acceptance Testing, as specified in Section 40 98 50.

2. Process Control System Commissioning, as specified in Section 40 80 50.

B. Do not begin training services, as specified in Section 40 98 00 - Training, and equipment testing and start-up until SYSTEM INTEGRATOR has successfully completed application software programming, downloading, and testing.

C. Refer to Section 01 14 00 - Construction Work Sequence Limitations and Constraints for specified construction limitations and constraints that affect completion of application software programming, downloading, and testing.

1.8 DELIVERY, STORAGE, AND HANDLING

Not Required

1.9 PROJECT/SITE CONDITIONS

A. Equipment is subject to humidity, dust, noise, and elevated and reduced temperatures.

1.10 SEQUENCING AND SCHEDULING

A. Refer to Section 01 14 00 - Construction Work Sequence Limitations and Constraints.

PART 2 PRODUCTS

NOTE USED

PART 3 EXECUTION

3.1 SITE MONITORING AND CONTROL

A. Monitoring and control functions to be programmed under this Contract are outlined in the narratives described below.

B. Provide all settings adjustable based on log-in credentials.

C. Provide time delay dampening for all alarms and trips.

3.2 WOODS PUMPING STATION

A. General

The Woods Pump Station (WPS) includes the existing axial flow pumps, new pump VFDs, existing intake & discharge surge tank levels, existing motor operated valves, and associated electrical systems. Refer to the contract drawings for point of connection and equipment locations.

B. The WPS shall consists of the changes and modifications to new and existing equipment as listed below:

1. Existing Woods Pump Station Line Valves (L4, L5):

a. The two Spavinaw supply line to the Woods Pump Station consist of two (2) butterfly type motor operated valves (MOV), with one MOV and Open/Close limit switch per line.

b. Contractor shall rewire the existing line valve L4 and L5 MOVs to the new Pump Control Panels. The Line Valve L5 shall be wired to Pump Control Panel, PCP-W1 and Line Valve L4 shall be wired to Pump Control Panel, PCP-W2. The control and monitoring functionality for each of these valves shall be maintained.

c. Each of the Line Valves shall only be controlled by their respective PCP i.e. PCP-W1 shall control Line Valve L5 and PCP-W2 shall control Line Valve L4.

d. The PCPs shall open and close the respective line valves based on the operation of the Pumps. For instance, with Pump W1 in operation with discharge valve D7 open, the Line Valve L5 shall be closed prior to the Pump W1 start or as soon as pump start command is initiated.

e. The PCPs shall trigger an alarm on the OIT and SCADA screens if their respective line valves are open when the pump is in operation.

f. Provide Line Valve Open/Close status for both line valves to each PCP via OIT graphical interface.

g. Control Operation:

(1) Provide the following signals, between PCPs and their respective Line Valve MOV i.e. Line Valve L5 via hardwired connection from PCP-W1 PLC :

(a) Line Valve Open Command

(b) Line Valve Close Command

(c) Line Valve Open

(d) Line Valve Closed

(e) Line Valve Fault

(2) Provide each PCP with access to monitoring signals for all the equipment/valves controlled by the other PCP i.e. provide PCP-W2 access to monitoring signals for Line Valve L5, discharge valve D7 and Pump-W1 feedback data.

h. Control Philosophy:

(1) During gravity flow operation i.e., when the Woods Pump Station is not operational the line valves L4 and L5 shall remain open.

(2) Prior to starting Pumps W1 and W2, the line valves shall be closed diverting water to the Intake Surge Tank.

(3) Once the Pump Run Command is executed at the WCCP in Auto Mode or Locally at the PCPs, the Line Valves/Valve for the respective operational pumps shall be closed prior to turn to turning the pump on.

(4) In the event of Pump-W1 or Pump-W2 failure, the WCCP shall close the Pump W1 and Pump W2 discharge valves and open line valves L4 and L5.

(5) In the event of power loss, the the existing on-site generator shall turn on, enabling the WCCP PLC to open line valve L4 and L5 and close Pump-W1 and Pump-W2 discharge valves.

2. Existing Level Instrumentation:

a. Intake Surge Tank Level Measurement:

(1) Reuse existing Intake Surge Tank Level Transmitter (LIT-201) and rewire it to the WCCP.

b. Discharge Surge Tank Level Measurement:

(1) Reuse existing Intake Surge Tank Level Transmitter (LIT-202) and rewire it to the WCCP.

c. Control Operation:

(1) Provide the following signals, from Level Transmitters (LIT-201, LIT-202) to WCCP via hardwired connection from PLC WCCP:

(a) Pump Station Intake Surge Tank Level

(b) Pump Station Discharge Tank Level

3. Woods Pump Station Axial Flow Pumps (Pump-W1, Pump-W2):

a. General Description:

(1) Two (2) variable speed axial flow pumps will pump water from the Grand River Pump Station to the Canyon Lake Pump Station. The pumps suction header is fed from the intake surge tank and the pumps discharge to a common header.

(2) Each pump discharge piping is provided with a butterfly type motor-operated valve (MOV). The pumps shall start and stop against a closed valve, opening and closing times will be predetermined.

(3) Each Pump shall be provided with a Pump Control Panel i.e., Pump W1, Pump W2 Control Panel. Provide communication between each pump VFD and associated control panel PLC via ethernet datalink connection and hardwired connections.

(a) Each Pump Control Panel shall be responsible for controlling and monitoring all equipment associated with the respective motor i.e. Pump W1 control panel shall control the associated Pump W1 VFD, discharge MOV D7, and Line Valve L5.

(b) Each Pump Control Panel shall be equipped with an OIT. In the event of WCCP PLC failure, manual control shall be possible via the OIT at the respective pump control panels.

(4) Provide communication between each Pump Control Panel and Woods Capacity Control Panel via ethernet datalink connection. Provide communication between the two Pump W1 and Pump W2 Control Panels via ethernet datalink connection.

(5) Provide system integration of the Pump-W1 and Pump-W2 into SCADA as described herein.

(a) Provide pump speed adjustment via VFD to adjust pump speed based on a pre-determined pressure/level setpoints as measured by the intake and discharge level transmitters.
(b) Provide pump speed control accomplished primarily by a PID type control loop within the WCCP, using the level measured by intake and discharge level instruments as the process variable, with intake level used as the primary process variable.
(c) Provide capability to enter speed setpoint at the Pump Control Panel OITs. The Pump VFDs shall accept and maintain speed based on the entered speed setpoint.

b. Control Equipment:

(1) Provide system integration of the following controls equipment for pump:

(a) Local control at the VFD (VFD-W1, VFD-W2) including the following:

1) Enable Run 0/1 Switch

2) Emergency Stop

3) Emergency Stop Reset

(b) Local control at Pump Control Panel (PCP-W1, PCP-W2) via OIT screens.

1) Local, Off, Remote

2) Pump Start/Stop Command

3) Pump Speed Command/Setpoint

4) Pump Speed Feedback

5) Discharge Valve Open/Close Command

6) Discharge Valve Opened/Closed

7) Line Valve Open/Close Command

8) Line Valve Opened/Closed

9) Pump Motor Temperature High Alarm

10) Pump Vibration High Alarm

11) Pump Fault

c. Control Operation:

(1) LOR at Pump Control Panels in Remote Position:

(a) Initiated when "Remote" is selected at the respective Pump Control Panels (PCP-W1 and PCP-W2).

(b) In Remote Auto mode provide capability for Woods Capacity Control Panel (WCCP) to control the operation of Pumps-W1 and Pump-W2 via PID loop based on the levels measured at the Intake Surge Tank and Discharge. The WCCP shall also control operation of all equipment not associated with the pumps, including, existing valve limit switches, power status (ATS, PCP cabinet, generator), intrusion (building, cabinet), crossover valves, flooding, and freeze status.

(c) WCCP shall not have capabilities to control the Pump-W1 and Pump-W2 and pump associated equipment manually i.e. no Remote Manual mode of operation to

control the line valves L4, L5 and discharge valves for each pump.

(d) In Remote mode the WCCP PLC shall be the lead PLC, providing speed commands to PCP-W1 and PCP-W2. The PCPs shall accept the speed commands and operate the pumps and associated valves.

(2) LOR at PCP in LOCAL Position:

(a) Provide the capability to control the pumps manually via respective Pump Control Panels including pump start, stop, speed adjustment, pump discharge valve open/close commands and line valve open /close commands, when the LOR selector switch is in the LOCAL position at the Pump Control Panel OIT.

(b) Provide OIT graphics compatible with existing SCADA graphics, to monitor and control Pump-W1, Pump-W2, associated motors, VFDs and valves.

(3) OFF Position:

When the OFF position is selected on the respective Pump Control Panel OIT, the pump does not operate under any condition.

(4) VFD Enable Run Selector Switch:

Provide VFD pump control when the corresponding Enable 0/1 selector switch at the pump VFD is in the position “1”.

When the VFD Enable 0/1 selector switch is in position “0”, the VFD shall not operate.

(5) Provide the following signals, from the pump VFD via ethernet datalink connection and hardwire connection to respective Pump Control Panel PLC (Pump W1 or Pump W2) for displaying on corresponding OIT:

(a) RUNNING status for indication and run time totalization.

(b) ENABLED status indicating the ENABLE RUN switch at the VFD is in the position “1”

(c) FAULT status

(d) SPEED feedback (actual pump speed in rpm)

(e) TEMPERATURE HIGH-HIGH TRIP status indicating protection trip

(f) VIBRATION HIGH-HIGH TRIP status indicating protection trip

(6) Provide the following signals, from WCCP to the pump VFD via corresponding PCP using ethernet datalink connection from PLC WCCP:

(a) START/STOP COMMAND to start and stop the pumps.

(b) SPEED setpoint for pump speed control.

(7) Provide the following alarms at corresponding PCP and WCCP and Remote SCADA.

(a) PUMP FAILURE based on FAULT status.

(b) PUMP TEMP HI-HI TRIP based on Temperature High-High Trip status from VFD

(c) PUMP VIB HI-HI TRIP based on Vibration High-High Trip status from VFD.

d. VFD Tag Polling:

(1) Provide capabilities to each PLC in each PCP cabinet, allowing each PLC to poll any tag values within the associated VFD it controls.

(2) This shall allow real-time monitoring and adjustment of VFD parameters for optimal pump performance.

4. Woods Pump Station (WPS) Control Philosophy

a. During normal operation, the axial flow pumps shall operate to maintain WPS level setpoint at the Intake Surge Tank is maintained above the low-level setpoint and the Discharge Surge Tank level is maintained below the high level setpoint. This ensure that adequate pressure and flow rate is provided under all operating conditions. The

existing WPS Intake and Discharge measurement instrumentation (LIT-201, LIT-202) is used as the process variable to control the operation of the pumps.

b. The control operation for the WPS shall be delineated as follows:

(1) Woods Capacity Control Panel

(a) The Woods Capacity Control Panel shall control devices not directly associated with pump/motor operation.
(b) Monitors
1) Levels in suction and discharge tanks
2) Power status of ATS (Automatic Transfer Switch)
3) Pump Control Panel (PCP) cabinets
4) Generator status
(c) Monitors intrusion detection for the building and cabinet.

(2) Pump Control Panels (PCP-W1, PCP-W2)

(a) PCP shall control and monitor devices related to motor/pump operations for each Flowline.
(b) Monitor and controls valves (suction, discharge) associate with respective pump line.
(c) Monitor and control Line Valves associate with respective pump line.
(d) PCP shall interface Variable Frequency Drives (VFDs) and safety/permissive systems for each motor/pump.

c. WPS Discharge Pressure Control:

(a) When the Pump Start is initiated at the Woods Capacity Control Panel, the MOVs on the Spavinaw Supply Line i.e. Line Valve L4 and L5, shall close, diverting water to the Intake Surge Tank.

(b) The WCCP shall send a Pump Start signal once the Intake Surge Tank Level as measured by LIT-201 is above the operator adjustable Intake Surge Tank Low Level Setpoint.

(c) The pump discharge valves, D7 and D8 respectively, shall open as soon as the pump speed reaches 50% of rated speed. This shall allow pumps to start against a closed valve.

(d) The WCCP uses a PID loop to control and modulate pump speeds based on the Intake and Discharge Surge Tank Levels i.e. levels as measured by LIT-201 and LIT -202. The WCCP shall try to modulate pump speed such that the water level in the Intake surge tank is above the low level setpoint and the water level in the discharge surge tank is below the high level setpoint. All level setpoints shall be operator adjustable.

(e) Maintaining water level below the high level setpoint in the discharge surge tank enables a constant supply head/head-pressure to Canyon Lake downstream of Woods Pump Station.

(f) The PID loop shall use both suction and discharge tank levels are process variable for the PID loop, with suction tank level as the primary variable. The PID loop shall adjust the pump speed/speed reference setpoint.

(g) When the tank level in the Intake surge tank level goes below the low level setpoint, the pump speed shall be adjusted/reduced to allow water to go above the Intake Surge Tank Low Level Setpoint.

(h) When the tank level in the discharge surge tank goes above the high level setpoint, WCCP shall enter the discharge tank level override mode. In the discharge tank level override mode, the intake surge tank level setpoint shall be reduced to 75% (adjustable) of the Intake surge tank level setpoint and the Cv/control variable of the PID loop i.e. Pump Speed Command is reduced. Once the system stabilizes i.e. the discharge surge tank level is below the high level setpoint, WCCP shall switch back to normal operating mode.

(i) Configure the control logic to control the speed of the pumps to maintain WPS Intake and Discharge Tank Level setpoints using feedback (PID) control.

(j) Provide the following control inputs at WCCP for the Pump W1 and W2 control logic:

1) Pump Start/Stop

2) Intake Surge Tank Setpoint

3) Discharge Surge Tank Setpoint

(k) Provide the following OIT indications at WCCP:

1) Pump In Auto/Local/Off Mode

2) Speed Feedback

3) Intake/Discharge Tank Setpoint

(l) Provide control logic so that bad quality of the process variable I/O results in the control operation tripping to manual mode and alerting the change with an alarm at WCCP and Remote SCADA.

(m) In the event of Pump W1 or W2 Fault/Failure, the Pump Control Panel shall shutdown their respective pumps and close the discharge valve for each pump. The WCCP shall simultaneously open the supply line valves L4 and L5.

(n) START PERMIT signal for Pump-W1 and W2 is active when the following condition is TRUE:

1) WPS Intake Surge Tank Levels Not Low for greater than 5 seconds

AND

WPS Discharge Surge Tank Level Not High for greater than 5 seconds

AND

Line Valve L4 and L5 are closed.

(o) PROTECTION STOP signal for Pump-W1 and W2 is active when the following condition is TRUE:

1) Pump Temperature High-High Trip signal is Active

OR

2) Pump Vibration High-High Trip signal is Active

OR

3) Pump Fault Trip Signal Active.

5. WPS Standby Generator (GEN-3300 - Reference drawing BN3):

a. The existing standby generator at the WPS will provide power in the event of utility power failure

b. Provide the following signals, from the standby generator control panel via Hardwired connection to PLC WCCP, for displaying in WCCP OIT and Remote SCADA:

(1) GENERATOR RUNNING

(2) GENERATOR FAILURE

END OF SECTION

SECTION 40 94 13

PROCESS CONTROL SYSTEM COMPUTER AND NETWORK HARDWARE

PART 1 GENERAL

1.1 SUMMARY

A. Section 40 94 13 specifies requirements for providing computer and network equipment for a computer-based SCADA (Supervisory Control and Data Acquisition) system, including software package as required.

B. CONTRACTOR: Provide all labor, materials, equipment and incidentals as shown, specified, and required to furnish and implement a fully functional Process Control System.

1. Work includes all software elements of the SCADA system specified. Provide a complete SCADA system including software configuration as part of the work. The hardware required for the Process Control System is shown on the Network Architecture Diagram and is composed of the following types of major monitoring processing and control equipment units:

a. Ethernet Communication System as required.

b. Modbus Communication System as required.

c. PLCs including processors, chassis, I/O cards, communication cards, etc. as specified in related sections.

d. Operator Interface Terminals (OIT) for interfacing with PLCs

e. Human Machine Interface (HMI) computers for interfacing with PLCs

f. Network communication devices

C. Related Work Specified in Other Sections Includes, but is Not Limited to the Following:

1. Section 01 33 00 - Submittals
2. Section 40 80 50 - Process Control System Commissioning
3. Section 40 90 00 - Process Control System General Requirements
4. Section 40 94 43 - Programmable Logic Controller Systems
5. Section 40 95 13 - Process Control System Panel Enclosure and Equipment
6. Section 40 96 15 - Process Control System Input and Output List
7. Section 40 98 00 - Process Control System Training
8. Section 40 98 50 - Process Control System Factory Acceptance Testing

1.2 SYSTEM DESCRIPTION

A. The PCS network hardware to be provided under this Specification is shown on the Control Network Architecture Diagram, drawings N02 and includes the following:

1. Operator Interface Terminals (OITs)

2. Programming Laptop

3. LTE Router/Gateway

4. LTE Signal Booster

5. Managed Ethernet Network Switches

6. Communication Protocol Convertor

7. Network components, appurtenances, etc.

B. PLCs are specified under Section 40 94 43 - Programmable Logic Controller Systems.

1.3 SUBMITTALS

A. General: Provide submittals as specified herein, and as specified in Section 01 33 00 - Submittals.

B. Action Submittals:

1. Provide all documentation corresponding to SCADA software development and configuration.

2. Provide hard-copy printouts of all graphics screens.

3. Provide digital copy of the fully configured system or modifications submitted in CD-ROM format and USB storage drive format.

4. Submit requests for network address for each system and obtain these addresses from the OWNER.

5. Submit rack, communication card, and I/O card layouts with calculations for power supplies indicating power draw and heat release for each rack and power supply.

6. CONTRACTOR: Submit proof of software licenses demonstrating that the license is held by the OWNER for all licensed software.

7. CONTRACTOR: Submit detailed project specific datasheets on hardware, software packaged by system, panel, and application. Provide electronic

(editable copy) of PLC code and HMI application program. Provide programming laptop uploaded with all necessary software and licenses to the OWNER.

C. Closeout Submittals:

1. Submit fully documented electronic editable and paper copy of PLC, HMI, OIT programs, data tables, system addressing, and I/O Point lists to OWNER for their support of the system. Provide these submittals before each factory test, each system acceptance, and updated at the end of the warranty period.

2. Provide electronic (editable copy) of the fully configured PLC code and HMI application program in CD-ROM format and USB storage drive format.

3. Provide digital copy of the fully configured system or modifications submitted in CD-ROM format and USB storage drive format.

4. Provide electronic (editable copy) of PLC code and HMI application program. Provide programming laptop uploaded with all necessary software and licenses to the OWNER.

5. Provide proof of software licenses demonstrating that the license is held by the OWNER for all licensed software.

6. Submit OEM software supplied by the manufacturer for each component, including operating system, application programs, diagnostic tools, etc.

7. Provide trouble-shooting procedures for hardware supplied as specified herein.

8. Provide recommended preventive maintenance tasks, schedules, and instructions for hardware supplied as specified herein.

1.4 QUALITY ASSURANCE

A. Provide SCADA system additions and modifications by a single systems integrator who also supplies the process control hardware described in Section 40 94 43 - Programmable Logic Controller System.

B. Provide system from system manufacturer who can demonstrate a minimum of five years of experience providing Process Control Systems and is able to show evidence of at least five installations of equal or greater size to the one being specified.

1.5 WARRANTY

A. Provide warranty on the hardware and software for three years, minimum.

1.6 MAINTENANCE

A. SYSTEM INTEGRATOR: Provide recommended preventive maintenance tasks, schedules, and instructions for hardware supplied. The PM documentation must be clear, applicable to hardware provided, concise and accurate.

B. SYSTEM INTEGRATOR: Provide maintenance of the modifications to the PCS during the warranty period.

1.7 TROUBLESHOOTING

A. SYSTEM INTEGRATOR: Provide trouble-shooting procedures for hardware supplied. Provide accurate procedures, easy to understand and follow, current, and comprehensive in scope. If links to vendor website or technical support is necessary, provide up-to-date phone numbers and links.

PART 2 PRODUCTS

2.1 NETWORKS

A. Ethernet:

1. Furnish and install a process Ethernet network, arranged such that future nodes can be added at any point(s) along the network without overloading the system or requiring re-routing of the cable being installed under this Contract.

2. Provide all hardware, including but not limited to, cabling, switches, connectors, communication modules, convertors, accessories, and appurtenances to provide a fully functional Ethernet network. Provide gigabit network category rated wiring for all network wiring and connections.

3. Where redundancy is shown or specified, provide completely independent and isolated Ethernet networks. Separate VLAN on the same physical equipment is not acceptable. Keep IT network isolated from the SCADA network.

B. CONTRACTOR: Identify necessary network addresses, masking, and required custom configuration requirements for each network, and implement using configurations furnished by the OWNER. OWNER will assign these configuration requirements.

2.2 OPERATOR INTERFACE TERMINALS

A. General:

1. Operator Interface Terminals (OIT) will be utilized as the interface to the PLC for a specific subsystem or particular process, as shown on the Contract Drawings. Provide all stations functionally similar as to display arrangements, menu selections, command terminology, and data access methods.

2. Provide all OITs capable of accessing typical operator process control functions, with each station's functional environment password protected for system security and user identification. Required number of OITs to be provided is specified in the OIT schedule below.

B. OIT: Provide OIT with color meeting the following minimum requirements:

1. Display Screen Size: 15.0 inches, diagonally measured, backlighted.

2. Resolution: 1024 X 768 pixels, 24-bit color graphics.

3. Display and keypad type: Active-Matrix Color TFT LCD touch screen with LED backlight.

4. Memory: 512 MB, minimum. Shall be memory enhanced either internally or by inserting a memory card.

5. Supply Voltage: 120 VAC or 24 VDC, with manufacturers recommended power supply.

6. Communications: Ethernet (RJ-45 port).

7. Mounting: Mount unit on the front face of panel, as indicated on the Drawings.

8. NEMA rated: Furnish OIT having the same NEMA rating as the PLC panel it is installed on. Refer to Section 40 95 13 - Process Control System Panel Enclosures and Equipment) for panel schedule and ratings.

9. Provide 4 protective overlays for screen and keypads.

10. Manufacturers and Models:

a. Allen Bradley PanelView Plus 7 or newer

b. Or approved equal.(Approved equal OIT shall use the same programming software as the HMI and PLC).

C. OIT configuration programming software to be turned over to the OWNER at the completion of the project.

2.3 SCADA/HMI COMPUTERS AND SOFTWARE

A. General:

1. Operator and Engineering Workstations will be utilized as the human-machine interface (HMI). Provide OIT functionality replication utilizing the HMI platform to provide control from the Operator workstations as shown. Use a minimum of the quantity as shown. Mouse devices are the primary operator input devices with keyboards as the supplementary input device. Provide all stations functionally similar as to display arrangements, menu selections, command terminology, and data access methods.

2. Provide all Workstations functionally interchangeable, differing only in the software installed on each type, and capable of accessing both typical operator process control functions and engineering configuration functions, through configurable software environments. Furnish each Workstation's functional environment password protected for system security and user identification. Provide required number of Workstations as shown. For system manufacturers that utilize separate Workstations for Operator and Engineering configuration functions, provide a configuration that allows the Engineering configuration functions to be performed at any and all Sites where operator interface is installed.

3. Because computer specifications change rapidly, the CONTRACTOR is responsible for providing reasonably current technology, even if those specifications are not addressed in this document, the substitution/change of reasonably current technology computer shall require OWNER/Control System Project Coordinator approval before being purchased. In no circumstances will the minimum requirements not be met. The specifications listed below are based on what is reasonably available at the time of the bidding process.

B. CONTRACTOR: Responsible for coordinating workstation hardware and software with requirements as stated by the manufacturer of the HMI software.

C. Provide standard, configurable, off-the-shelf process control Computer and Server Hardware suitable for water process facilities. Provide hardware compatible with software requirements as stated by the manufacturer of the HMI software plus these requirements.

2.4 PROGRAMMING LAPTOP

A. See the requirements of Detailed Specification 40 94 43 - Programmable Logic Controller Systems.

B. **Coordinate with OWNER on the exact specifications of Laptop, including make, model, required software and hardware specifications. Provide compatible laptop bag preferable by the laptop manufacturer, that is spacious padded back with dual straps, rain cover and easy to carry. OWNERS' specification and requirements shall supersede the spec requirements listed below.**

C. **The programming laptop shall have absolute isolation from the outside world i.e. the operating system, onboard programming software etc should not connect to a cloud service for updates or operation.**

D. Software:

1. Operating System: Microsoft Windows intended for business use with all service packs and updates, full end-user licensed version. An OEM version is not accepted.

2. Adobe Acrobat Reader (Latest Edition).

3. Symantec Antivirus, Corporate (Latest Edition).

4. Network diagnostic and configuration software.

5. Any specialized or dedicated software required to meet the required functional needs of the computer and Process Control Network.

6. Provide laptop with both runtime and development software for the HMI as stated by the manufacturer of the HMI software plus these requirements.

7. Provide laptop with development software for the Operator Interface Terminals and PLC specific programming software compatible with the hardware in Specification 40 94 43 - Programmable Logic Controller Systems.

8. System Requirements:

    a. Processor: Intel Core i9-13950HX vPro (36MB cache, 24 cores)
    b. Operating System: Windows 11 Pro English
    c. Graphic Card: NVIDIA RTX 4000 Ada 12GB GDDR6
    d. RAM: 64 GB
    e. Memory: 1 TB, M.2 2280, Gen 4 PCle NVMe, SSD
    f. Display: 17.3" FHD, 60Hz, IR camera with Mic

9. Manufacturer and Model:

    a. DELL Precision 7780 Workstation

    b. Or approved equal. Latest version model.

E. It is the responsibility of the CONTRACTOR, through the services of the SYSTEM INTEGRATOR, to install, setup, configure, and place in optimum working order the Hardware, including workstations, servers, and other network devices.

2.5 NETWORK SWITCHES

A. Provide Ethernet Switches in sufficient quantity to allow connections for all nodes shown and specified. Provide switches with minimum number of ports as specified in the network switch schedule below. In addition, include 25% spare port quantity for future use.

B. SCADA Network Switches

1. Provide rail-mount type switches supplied with a mounting kit. Mount switches in PLC panels.

2. Provide switches of the managed type, with diagnostic, security, and redundancy functions/software.

3. Provide Ethernet/IP based switches, rated for 10/100 Mbit/s operation and with two (2) 1G uplink ports (SFP ports). Where stacking is required to meet port requirements, provide manufacturer linking cables and ports. Provide SFP ports with compatible SFP transceivers meeting fiber optic connector requirements of Section 40 93 50 - Fiber Optic Cable and Accessories.

4. Reference schedule below or on Drawings for required switch port quantity.

5. Operating power: 24 VDC or 120 VAC. Provide power supply by the same manufacturer as the switch.

6. Operating temperature range of 0° to 60° C.

7. Manufacturer and Model:

   a. Allen-Bradley Stratix 5700 series

   b. Or approved equal

C. Electrical Equipment (SWGR) Network Switches

1. Provide switches by electrical equipment supplier and install in a dedicated SWGR compartment.

2. Provide switches designed for harsh environmental conditions and compliant with IEEE 1613 and IEC 61850.

3. Operating temperature range: -40° to 60° C.

4. Provide switches of the managed type, with diagnostic and security functions/software.

5. Provide Ethernet/IP based switches, rated for 10/100 Mbit/s operation and with a minimum of six (6) copper ports and two (2) 1G uplink ports (SFP ports). Provide SFP ports with compatible SFP transceivers meeting fiber optic connector requirements of Section 40 93 50 - Fiber Optic Cable and Accessories.

6. Manufacturer and Model:

   a. Cisco IE3300 series

   b. Or approved equal

D. COMMUNICATION PROTOCOL CONVERTER

1. Provide rail-mount type converter supplied with a mounting kit. Mount switches in PLC panels.

2. Provide converters of the secure/managed type, with diagnostic, security, data prioritization, multiple I/O connections, RPI's for status and control of data.

3. Provide convertor compatible with the PLCs installed under the scope of the project.

4. Provide communication protocol converter to Ethernet IP from any other communication protocol to facilitate communication with the PLCs installed under the scope of the project. Refer to Network Architecture drawing N2.

5. Manufacturer and Model

   a. Prosoft PLX31-EIP-MCTCP
   b. Or Approved equal

PART 3 EXECUTION

3.1 ENVIRONMENTAL CONDITIONS

A. The complete monitoring and control system and associated input/output wiring will be used in a booster pumping station environment where there will be high energy AC fields, DC control pulses, and varying ground potentials between the transducers or input contact locations and the system components. Provide system design adequate to provide proper protection against interferences from all such possible situations. Refer to Section 40 90 00 - Process Control System General Requirements, for project site conditions.

3.2 INSTALLATION

A. Process Control System

1. SYSTEM INTEGRATOR: Responsible for providing all required hardware, software, and tools for configuring, testing, and troubleshooting the monitoring and control system.

2. SYSTEM INTEGRATOR: Complete a full setup, including assigning node and network addresses, equipment identification, and document the setup on configuration sheets. Furnish configuration sheets with clearly identify parameter settings, switch settings, software settings. Submit these sheets for record.

3.3 OIT SCHEDULE

A. Reference drawings and the following table for list of OITs to be provided as part of the project. Data presented in the following table is for the convenience of the CONTRACTOR. Provide all OITs required by the contract documents and including all components required for the operation of the equipment as described.

Name	Panel	Panel Location
WCCP OIT	Woods Capacity Control Panel	Woods Pumping Station
PCP-W1 OIT	Pump W1 Control Panel	Woods Pumping Station
PCP-W2 OIT	Pump W1 Control Panel	Woods Pumping Station
Note: Reference Section 40 95 13 - Process Control System Panel Enclosures and Equipment for panel type and rating.		

3.4 COMPUTER SCHEDULE

A. Reference Drawings and the following table for list of computers to be provided as part of the project. Data presented in the following table is for the convenience of the CONTRACTOR. Provide all computers required by the contract documents and including all components required for the operation of the equipment as described.

Computer	Location
WPS Programming Laptop	Woods Pump Station

3.5 NETWORK SWITCH SCHEDULE

A. Reference Drawings and the following table for list of network switches to be provided as part of the project. Data presented in the following table is for the convenience of the CONTRACTOR. Provide all network switches required by the contract documents and including all components required for the operation of the equipment as described.

Network Switch	Panel	Panel Location	Required Port Qty
WCCP Network Switch	Woods Capacity Control Panel	Woods Pump Station	By System Integrator
PCP-W1 Network Switch	Pump W1 Control Panel	Woods Pump Station	By System Integrator
PCP-W2 Network Switch	Pump W2 Control Panel	Woods Pump Station	By System Integrator
SWBD-1 MMS	Switch Board 1	Woods Pump Station	By System Integrator

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 40 94 43

PROGRAMMABLE LOGIC CONTROLLER SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. Section 40 94 43 specifies the technical requirements for furnishing, design, supply, programming, configuration, and testing of a Programmable Logic Controller System (PLC) including all work and materials necessary to perform control and monitoring functions as illustrated on drawings and as described in Section 40 90 50 - Process Control System Description.

B. For all work to be provided as part of this contract, include all design engineering and the supply of a PLC system with all auxiliary equipment, components, and accessories to ensure an integral, seamless, coordinated system, as is generally described below. Provide the following as a minimum:

1. Design, engineering, manufacture, assembly, configuration, shop testing, factory acceptance test, delivery, and commissioning of PLC system

2. Necessary hardware and software to interface to the OWNER's Process Control System (PCS) and REMOTE SCADA.

3. Necessary hardware and software to synchronize to a GPS based master clock.

4. Three (3) days for the Factory Acceptance Test of the hardware, logic, software, and data communication for each PLC cabinet

C. Programming and Software Configuration

1. Include all programming and software configuration for the PLC part of this Contract work, based on control & monitoring strategies described in Section 40 90 50 - Process Control System Description.

2. Ensure PLC configuration and programming complies with the recommended practices published by the hardware manufacturer. Use documented ladder logic with subroutines for programming. Follow programming and configuration convention standards published by the OWNER, if existing.

D. Related Work Specified in Other Sections Includes, but is Not Limited to the Following:

1. Section 01 33 00 - Submittals
2. Section 26 05 00 - Basic Electrical Material and Methods

3. Section 40 80 50 - Process Control System Commissioning
4. Section 40 90 00 - Process Control System General Requirements
5. Section 40 94 13 - Process Control Systems Computer and Network Hardware
6. Section 40 95 13 - Process Control System Panel Enclosure and Equipment
7. Section 40 96 15 - Process Control System IO List
8. Section 40 98 00 - Process Control System Training
9. Section 40 98 50 - Process Control System Factory Acceptance Testing

1.2 REFERENCES

A. Section 01 45 00 - Quality Control

B. American Society for Testing and Materials (ASTM):

1. ASTM D999 - Standard Test Methods For Vibration Testing Of Shipping Containers

C. Canadian Standards Organization (CSA):

1. CSA Certification Class I, Division 2, Group A, B, C, D Hazardous or nonhazardous locations

2. CSA Standard C22.2 No. 142 for Isolation Voltages

D. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C62.41 - Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.

2. IEEE Std. 472-1974/ANSI C37.90/90A-1974.

E. National Electrical Manufacturers Association (NEMA):

1. NEMA ICS 1 - General Standards for Industrial Control and Systems.

2. NEMA ICS 2 - Standards for Industrial Control Devices, Controllers and Assemblies.

3. NEMA IA 2.2 - Programmable Controllers - Equipment Requirements and Tests.

4. NEMA IA 2.3 - Programmable Controllers - Programming Languages.

5. NEMA ICS 3 - Industrial Controls and Systems: Factory Built Assemblies.

6. NEMA ICS 6 - Industrial Controls and Systems: Enclosures.

F. International Electrotechnical Commission (IEC):

1. IEC 60068-2.1 - Environmental Testing Part 2: Tests - Tests A: Cold

2. IEC 60068-2.2 - Basic Environmental Testing Procedures - Part 2: Tests - Tests B: Dry Heat.

3. IEC 60068-2.3 - Basic Environmental Testing Procedures Part 2: Tests - Test Ca: Damp Heat, Steady State.

4. IEC 60068-2.6 - Environmental Testing - Part 2: Tests - Test Fc: Vibration.

5. IEC 60068-2.27 - Basic Environmental Testing Procedures Part 2: Tests - Test: Shock.

6. IEC 61000-4.2 - Electromagnetic Compatibility (EMC) - Part 4-2: Testing and Measurement Techniques - Electrostatic Discharge Immunity Test.

7. IEC 61000-4.3 - Electromagnetic Compatibility (EMC) - Part 4-3: Testing and Measurement Techniques - Radiated, Radio-Frequency, Electromagnetic Field Immunity Test.

8. IEC 61000-4.4 - Electromagnetic Compatibility (EMC) - Part 4: Testing and Measurement Techniques - Section 4: Electrical Fast Transient/Burst Immunity Test.

9. IEC 61000-4.5 - Electromagnetic Compatibility (EMC) - Part 4: Testing and Measurement Techniques - Section 5: Surge Immunity Test.

10. IEC 61000-4.6 - Electromagnetic Compatibility (EMC) - Part 4-6: Testing and Measurement Techniques - Immunity To Conducted Disturbances, Induced By Radio-Frequency Fields.

G. International Electrical Testing Association (NETA):

1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

H. National Fire Protection Association (NFPA):

1. ANSI/NFPA 70 - National Electrical Code.

I. Underwriters Laboratories Inc. (UL): Applicable listings.

1. UL 50 - Enclosures for Electrical Equipment.

2. UL 508 - Industrial Control Equipment.

3. UL 870 - Wireways, Auxiliary Gutters, and Associated Fittings.

J. NSTA Project 1A.

K. CISPR 11 (EN 55011).

1.3 SUBMITTALS

A. Provide all submittals as specified herein, and as specified in Section 01 33 00 - Submittals.

B. Action Submittals:

1. Submit data sheets and catalog literature on each type of equipment.

2. Submit programming and installation manuals for each type of equipment.

3. Documentation:

a. Provide all documentation related to PLC software development and configuration.

b. Provide all manuals, PLC logic documentation and application programmer’s notes.

c. Provide listing of PLC register tables.

d. Provide all developed software for PLCs and associated equipment uploaded and ready to go use in a programming software.

e. Provide programming laptop with all software and licenses necessary for the OWNER to further develop or modify existing PLC programming. Include all programming and diagnostic software license numbers, equipment model numbers and vendor information.

C. Closeout Submittals: Provide submittals as required below:

1. Section 01 78 00 - Contract Closeout: Closeout procedures

2. Provide hard copy printout of all PLC logic.

3. Provide flash drive of each documented application program.

4. As-Built Drawings: Accurately record actual locations of controller cabinets and input and output devices connected to system. Include interconnection wiring and cabling information, and terminal block layouts in controller cabinets. Include copy of manufacturer's certified drawings.

5. Operation and Maintenance Data:

a. Submit bound copies of operating and programming instructions.

b. Submit description of system operation, adjusting, and testing required.

c. Submit card replacement, adjustments, and preventative maintenance procedures and materials.

d. Identify system maintenance requirements, servicing cycles, lubrication types required, and local spare part sources.

e. Provide operation and maintenance manuals in accordance with General Requirements

6. System Documentation:

a. System Abstract:

(1) Provide clear statement of task, define function of major hardware and software components.

(2) Design strategy used to implement solution.

(3) Statement of objectives.

b. System Configuration: Pictorial drawing of hardware elements, show physical location of subsystems, designation of input/output (I/O) rack address assignments, simplified connection.

c. Include complete wiring diagrams inputs and outputs for each PLC module, show point address assignments. If field devices are not wired directly to I/O module show terminal block number.

d. I/O Address Assignments: Identify each field device by address based on rack group and terminal, the type of I/O module, the device and the function the device performs in the field.

e. Internal I/O Address Assignments: Identify used and unused addresses, show type, and description.

f. Register Assignments: Identify each available system register, weather used for user storage register or I/O register.

g. Program coding printout showing each programmed instruction and associated address of each input and output.

h. Reproducible and editable stored program stored on compatible electronic media.

i. Program coding for each PLC, in annotated ladder diagram form, include the following:

(1) Program titles

(2) Multiple subtitles

(3) Date and time the documentation was last produced.

(4) Page numbering

(5) Extensive commentaries before and after each rung

(6) Contact or element description.

(7) Address for each contact

(8) Pictorial representation of each instruction (coils, contacts, etc.)

(9) Rung numbers.

(10) Rungs where each contact is used.

(11) All preset values of registers used.

(12) Identification of all internals and real inputs and outputs

(13) Mapping of all I/O for porting over to SCADA

1.4 SPARE PARTS

A. Provide the following spare parts:

1. One CPU of each type utilized.

2. One digital input module of each type utilized.

3. One digital output module of each type utilized.

4. One analog input module of each type utilized.

5. One analog output module of each type utilized.

6. One power supply assembly of each size utilized.

7. One communication module of each type utilized.

8. One dozen fuses of each size provided.

9. One dozen relays of each type utilized.

10. One backplane of each type used.

PART 2 PRODUCTS

2.1 PROGRAMMABLE LOGIC CONTROLLER

A. General

1. Provide PLC hardware in accordance with requirements contained in this Section. System Control: Allen Bradley Controllogix 1756-L73 series hardware platform. No substitutions unless approved by OWNER.

2. Provide microprocessor based PLC, industrial CPU with a minimum I/O capacity of 512 points, any mix of inputs and outputs.

3. Provide PLC containing internal or external flash memory for backup, capable of maintaining data for a minimum of one year with no power applied to the processor (power failure event). If using external flash memory, provide one (1) flash card with each CPU loaded with copy of "as commissioned" logic.

4. Provide processor capable of maintaining required data for a minimum of one year without requiring power (power failure event).

5. Program scan rate: Less than one (1) second for low resolution and less than (1) millisecond for high resolution inputs.

6. **PLC shall maintain absolute isolation from outside world i.e. the programming software shall not auto update or connect to a vendor cloud network.**

7. **Provide 24VDC IO Digital and Analog where required to facilitate existing equipment. The sinking or source IO modules shall be based on if power source is available at the device, instrument, and equipment.**

8. Diagnostics

   a. Provide PLC having standard, self-diagnostic routines provided to determine proper hardware and software operation.

   b. Provide diagnostic LEDs on the process front panel to indicate the following: Processor fault, battery low, I/O module fault, memory card missing or faulty, communications error.

9. Provide CPU equipped with a built-in port(s) for networking and

programming.

B. ControlLogix PLC System:

1.	CPU:	ControlLogix processor with non-volatile battery backed RAM. Allen Bradley 1756-L73.
2.	Power Supply:	120/220 VAC standard power supply.
3.	I/O Rack or Chassis:	Allen Bradley 1756-L73. Provide appropriate size chassis.
4.	Communication Module:	Ethernet/IP protocol enabled, 10/100Mbps, RJ-45 ports. Or Modbus TCP/IP protocol Prosoft MVI56E-MNET/MNETXT module.
5.	Discrete Input Module:	16-point, 120 VAC/24VDC. Allen Bradley 1756-IA16/1756-IB16I I/O Module as required.
6.	Discrete Output Module:	16-point, 120 VAC. Allen Bradley 1756-OA16 I/O Module as required.
7.	Analog Input Module:	8-point, 16-bit resolution, 4-20 mA DC, fully isolated inputs. Allen Bradley 1756-IF8 I/O Module as required.
8.	Analog Output Module:	8-point, 16-bit resolution, 4-20 mA DC, fully isolated outputs. Allen Bradley 1756-OF8 I/O Module as required.
9.	Analog RTD/Thermocouple Module:	8-point. Allen Bradley 1756-IRT8I I/O Module as required.
10.	Redundancy Module (If Required):	N/A

C. Programming Software:

1. Provide the latest version of RSLogix 5000 PLC programming software for Controllogix PLC platform.

2. Provide system capable of adapting to program changes without impacting the hardware, with programs protected from accidental changes by use of passwords and/or key lock switches or Cryptographic Controller Engineering Key Lock.

3. Provide capability for logic programming and I/O configuration printout.

4. Programming software to be turned over to the OWNER at the completion of the project.

D. Control Panel Security Requirements:

1. In each control panel, include network security Anomaly Detection (AD) that continuously monitors the controller's network and system time to detect intrusions and anomalous behavior. Include these required functions:

   a. Dynamic Port Connection Monitoring to record all attempts to connect any controller or communication point and capture identifying information on the intruder and event.

   b. Network Port Scanning to detect scanning for open ports that might provide access to the control network.

   c. System Time Monitoring to detect attempts to manipulate log files to conceal malicious activity.

   d. Intrusion Event Logging to record all detected anomalies and report them to SCADA software through OPC UA and standard database access for historian, alarming, and trending functions.

   e. Local LED indication within the control whenever an intrusion is detected.

2. The above may be accomplished intrinsically through the controller or via external industrial security products from the following manufacturers, the security products must maintain absolute isolation from the outside world.

   a. Hirschmann Tofino

   b. Ultra-3eti

   c. Cisco

   d. Rockwell Automation

   e. Tenable Networks

   f. Or approved equal

3. Display all security monitoring (trend, record, status) on a secure SCADA screen. Display security alarms as high priority alarms in SCADA.

4. Provide with the programming software any external security product used.

Turn over licensing to the OWNER as part of the project. The programming software shall be isolated from outside world and shall not communicate with cloud network for updates.

2.2 I/O MODULES

A. Provide each I/O module having on-board diagnostics with on-board LEDs, visible without removing any I/O cards, indicating card and point status. Digital input cards and digital output cards must have an onboard LED for each I/O showing its current state.

B. Provide output module having definable failure modes upon loss of communication with the CPU, and failure modes selectable for each input.

C. Provide all individual I/O channels individually fused and electrically isolated from the main frame CPU.

D. Provide the system with 20% spares of each I/O type at each location (per control panel) at the time of shipment to site (after successful factory testing) and 10-percent spares of each I/O type at each location (control panel) at substantial completion (after Commissioning), as a minimum.

E. Digital I/O

1. Shielded cable: not required.

2. Provide digital inputs to monitor dry contact closures, sourced from the PLC enclosure.

3. Normal wetting voltage for the digital inputs: 120 VAC or 24 VDC supplied by the PLC from power supply within control panel.

4. Provide digital inputs optically isolated or galvanically isolated between field contacts and internal logic voltages.

5. Provide digital outputs to energize terminal block style interposing relays as specified in Section 40 95 13 - Process Control System Panel Enclosures and Equipment.

6. Provide digital I/O modules having status lights to indicate when each point is active.

F. Analog I/O

1. Provide analog input modules having a minimum of two (2) dedicated solid state analog to digital (A/D) converter per module. Provide analog output modules having one (1) dedicated solid state digital to analog converter (D/A) per output. Provide modules with conversion resolution of 13 bits plus a sign bit for a total of 14 bits or better.

2. Provide input analog-to-digital and output digital-to-analog converters having an absolute accuracy of 0.1 percent of full scale of the signal.

3. Provide current type analog inputs that provide 24 VDC power to the sending transmitter, or accept an isolated current signal from a field powered transmitter. Individually fuse each analog input.

4. Provide analog outputs that provide 4-20 mA DC current and are capable of driving 750 ohm loads.

5. Provide universal transient barriers to protect analog signals from surges and transients.

6. Provide PLC that provides "bad" quality for each analog input. Provide system having selectable failure modes of 0% signal, 100% signal, or hold last value.

7. Scan rate of all analog inputs: Once per second average, with provisions for scanning at least 5% of the analog inputs at the rate of once per 0.1 second.

2.3 DATALINK

A. General

1. Provide hardware, software, and engineering for a fully functional datalink between the New PLCs i.e. New Wood Capacity Control Panel, Pump W1 Control Panel, Pump W2 Control Panel and OWNER’s Remote SCADA to allow for control and monitoring.

2. Interface directly with the OWNER’s SCADA vendor to clarify protocols, data addressing, data formats, and all other parameters required to design these data links.

3. Submit datalink database structure defining all database fields and the size, format, and acceptable entries for each field. Following review and approval by the ENGINEER, this database structure will not be modified during the remainder of the project without prior acceptance of the ENGINEER.

4. Ensure proper isolation between each PLC and the OWNER’s remote SCADA (Wonderware), so that a failure of PLC does not cause failure of the equipment upstream and downstream.

5. Provide data protocol that safeguards against false data transmission, allows for error detection, failure detection/recovery, as well as automatic switchover to the redundant network.

6. Provide datalink meeting the following requirements:

a. Pass all points required for complete remote control and monitoring.

b. Provide all points capable of being read from and written to in 1 second or less.

c. Verify LTE Cellular Modem Bandwidth limitations used to communicate with Owners Remote SCADA facility.

(1) Mitigate all cellular bandwidth issues using bandwidth mitigation techniques including signal strength optimization, bandwidth management, traffic prioritization, compression and optimization, content caching etc.

d. Include all software required for this datalink.

e. If redundant, fail over to the backup automatically upon primary datalink failure. Include alarming of the fail over.

f. Provide with the system all software tools and licenses required to modify the datalink, including database configuration. Fully document the software tools and provide the documentation to the OWNER.

B. Redundancy and Integrity

1. Ensure that no single failure of any system component (above the I/O level) or power source interrupts or disrupts any system function, nor any single system failure causes any controlled equipment to change status except as specifically described in this specification.

2. Ensure that a single PLC component failure does not cause loss of the interface link to the OWNER's remote SCADA.

3. Power all data highway interfaces from redundant power sources.

2.4 GRAPHICS AND DISPLAYS

A. Design, configure, and implement a complete and effective set of graphics and displays for the operator interface touch screen terminal unit. Provide graphic screens meeting the requirements of Section 40 90 50 - Process Control System Description, as well as requirements included herein.

B. Provide graphics and displays meeting the following requirements:

1. Graphics: Follow requirements of High Performance HMI standards.

2. Provide unambiguous and easily assimilated formats for displaying information on the operator graphics and displays. Ensure the approach to

the design of the displays starts with the user, and follows existing graphics.

3. Provide same operator interface for all control and monitoring functions. The location, layout, and orientation of data and objects on the operator graphics and displays must be consistent and logical such that the operator will instinctively know where on the display to find the needed information.

4. Provide standardized rules regarding color usage, operating status, picture area arrangement, data display, display programming, and symbols, defined and observed for all graphics and displays.

5. Provide graphic color usage as follows: **Contractor to coordinate with Owner and utilize the same color schema as used in the client owned and operated Canyon Lake and Bird Creek Pump Stations.**

6. Incorporate display hierarchy techniques to enable an operator to proceed from overviews to group/subsystem displays and back to obtain process detail.

7. Provide access to control, primarily from P&ID/process type graphics through pop-up faceplates. Develop pop-up faceplates for control of all devices, both analog and digital. Provide pop-up faceplates capable of being moved to different positions on the graphic.

8. Provide the capability to call up a minimum of four pop-ups at a time on each display.

9. Include pop-up faceplates, permissive sub display, and interlock displays in the contract price without being detailed in any display or graphic counts.

10. Provide permissive displays for applicable motors and valves, identifying all system interlocks. Develop the permissive displays either as a paged display associated with a given graphic or a pop-up display.

11. No logical functions may be performed in graphic and/or display files. Do not use script or other programming that suppresses or hides faults in a display such as “On script error resume”, in the development or issue of any display.

12. Each display must include alphanumeric and graphic symbols that may be configured to change color, shape, or blink, given different states of the process variables.

13. Group displays must allow operator under password protection to: change alarm limits and setpoints, to reconfigure control loop parameters and tuning constants, to develop time-based trending graphics using historical and real time data for all parameters monitored and/or controlled by the PLC without the need for system shutdown. Provide the operator the capability to use

"next page" and "previous page" buttons to scroll through display screens.

PART 3 EXECUTION

3.1 INSPECTION AND TESTING

A. General

1. Test all control and monitoring functions as described in Section 40 90 50 - Process Control System Description. Provide testing meeting requirements of Section 40 98 50 - Process Control System Factory Acceptance Testing, and Section 40 80 50 - Process Control System Commissioning.

B. Shop Testing

1. Factory Acceptance Test (FAT)

a. Provide a System Test Plan approved by the OWNER / ENGINEER prior to commencement of the system checkout and Factory Acceptance Test (FAT).

b. Provide system checkout including 100% I/O checkout, closed loop simulation of binary/modulating logic, and validation of all logic, displays, alarms, and reports.

c. Test all power systems and verify that the system common and chassis ground are isolated from each other on all cabinets.

d. Connect all inputs and outputs for soft simulation and functionality testing. Include the following in the simulation software:

(1) Simulation of 100% I/O

(2) Log and track all temporary logic changes.

e. Fully test the PLC side of the datalink (to OWNER’s remote SCADA). Include verification of range and alarm limits of all I/O, and graphic display checks for all data link testing. Use actual addresses and protocols in the testing.

f. Demonstrate all system reports; trend all points; demonstrate and verify all performance calculations.

g. Complete checkout services before arrival of OWNER / ENGINEER for the FAT.

h. Provide full time technical support during the FAT, including support personnel familiar with the project and be capable of fixing problems

identified during the FAT.

i. Ship the FAT closed loop simulation software to the OWNER, as soon after the FAT as practical, for use in training operators.

2. Site Acceptance Test (SAT)

a. Perform the Site Acceptance Test after the installation and commissioning of the PLC. Provide functions and characteristics included in the test the same as the factory checkout and acceptance tests, considering that the system will be connected to the process. Justify and correct any abnormality encountered in this test, at no additional cost to the OWNER.

b. Provide field support by qualified personnel to certify installation, verify cabling, grounding and power up the system.

c. Complete SAT on a processor/process area by process area basis.

d. Following SAT, ensure System meets the requirements of Commissioning in Section 40 80 50 - Process Control System Commissioning.

3.2 SCHEDULES

A. Reference drawings and the following table for list of PLCs to be supplied as part of the project. Data presented on the following table is for the convenience of the CONTRACTOR. Provide all PLCs required by the contract documents and including all components required for the operation of the equipment as described. Packaged system PLCs are not identified below:

PLC SCHEDULE

PLC Name	**Location**	**Comments**
PLC-WCCP	Wood Capacity Control Panel - Woods Pumping Station	Consisting of PLC and Cellular/LTE Gateway to communicate with Remote SCADA
PLC-W1	Pump W1 Control Panel	
PLC-W2	Pump W2 Control Panel	

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 40 95 13

PROCESS CONTROL SYSTEM PANEL ENCLOSURES AND EQUIPMENT

PART 1 GENERAL

1.1 SUMMARY

A. Section 40 95 13 includes technical requirements for fabrication, engineering, wiring, and installation of instrument panels and enclosures, and furnishing the panel mounted instruments and equipment. These include, but are not limited to the following:

1. Panel Construction

2. Panel Wiring

3. Panel Mounted Equipment

B. Related Work Specified in Other Sections Includes, but is Not Limited to the Following:

1. Section 01 33 00 - Submittals
2. Section 40 80 50 - Process Control System Commissioning
3. Section 40 90 00 - Process Control System General Requirements
4. Section 40 90 50 - Process Control System Description
5. Section 40 94 13 - Process Control Systems Computer and Network Hardware
6. Section 40 94 43 - Programmable Logic Controller Systems
7. Section 40 96 15 - Process Control System Input and Output List
8. Section 40 98 50 - Process Control System Factory Acceptance Testing

C. Panels provided by manufacturer as part of package control systems:

1. Certain control panels are provided by manufacturers of equipment specified under other Sections as part of a packaged control system. In general, provide those panels meeting the requirements of this specification section.

D. Provide all new control panels specified under this contract as indicated. This section is to provide guidelines to the electrical contractor for the design and workmanship on any new and/or existing panels to which the CONTRACTOR makes changes or modifications.

E. CONTRACTOR: Comply with the “Use of American Iron and Steel (UAIS)” requirements as contained in Section 436 of the Consolidated Appropriations Act, 2014, and described in Specification Section 00 45 49.

1.2 SUBMITTALS

A. General: Provide submittals as specified in Section 01 33 00 - Submittals, and as required in Section 40 90 00 - Process Control System General Requirements.

B. Include the following information in the submittal for this section:

1. Scaled drawings showing the location of mounted devices on face of panel, within panel, and all sides. Include a legend listing and identifying devices by their assigned tag numbers, nameplate inscriptions, service legends, and annunciator inscriptions. Include a legend listing all spec items and manufacturer's part number of each item installed.

2. Panel elementary diagrams. Include switched analog signals, panel power distribution, and ancillary devices such as relays, alarms, fuses, lights, fans, heaters, etc. Show circuits and components individually. Show panel terminal and wire identification numbers. Do not submit typical diagrams for multiple circuits.

3. Power requirement and heat dissipation summary for all panels. State required voltages, currents, and phase(s). State maximum heat dissipation in Btu/hr.

C. Action Submittals:

1. Product Data: Submit manufacturer's official and published product data, specifications, and installation recommendations for each item. Include in the product data terminal wiring details, specific features such as ranges and options, and manufacturing data. The submittal shall be book marked with all appropriate parts highlighted for each product.

2. Shop Drawings: Include the following information:

a. Bill of materials

b. Panel construction details and dimensions (front, internal)

c. Internal wiring diagrams, including wire type, size, and identification number. (Note wiring color schema should match color schema used at Bird Creek and Canyon Lake Pump Stations)

d. PLC card layout and wiring

e. Terminal block layout

f. Nameplate lists

g. Color schedules

h. Elementary control diagrams

i. Equipment weights

3. Provide loop diagrams conforming to ISA-S5.4 - Instrument Loop Diagrams.

D. Closeout Submittals: Provide submittals as required below.

1. As Built Drawings

2. Test Reports

1.3 QUALITY ASSURANCE

A. Comply with the applicable provision of the following codes and standards:

1. Underwriters Laboratory (UL)

a. UL50 Enclosures fore Electrical Equipment

b. UL508 Industrial Control Equipment

c. UL870 Wireways Auxiliary Gutters and Associated Fittings

2. Electrical Testing Laboratory (ETL)

3. National Electrical Code (NEC)

4. National Fire Protection Association (NFPA) 79, Electrical Standard for Industrial Machinery

5. International Society of Automation (ISA)

B. Provide all electrical materials and equipment new bearing the label of the Underwriters' Laboratory (UL), Inc., Factory Mutual (FM), or equivalent where standards have been established and label service regularly applies.

C. Provide all Process Control System Panels as part of Division 40, including PLC panels, complying with the requirements of UL-508A, NFPA 79, and NEC Article 409 - Industrial Control Panels.
G

D. Provide integrated process control systems. Assign complete responsibility for furnishing, coordination, assembly, and installation supervision of all equipment to one Systems Integrator regularly engaged in the manufacture, assembly, and production of systems of type specified. Provide complete, satisfactory, and trouble-free operating installation.

E. Provide like instruments from the same manufacturer. Minimize number of different manufacturers.

F. Provide safety and regulatory labels required by NEC, NFPA, and UL.

G. Tests and Inspection:

1. Test each panel in conjunction with factory acceptance test as described in Section 40 98 50 - Process Control System Factory Acceptance Testing.

1.4 MAINTENANCE

A. Provide the following spare parts:

1. One power supply of each type and size provided.

2. One surge suppressor for every 10 or fraction thereof

3. One installed terminal block, for every 10 or fraction thereof

4. Ten percent spare corrosion inhibitors, minimum of 1 of each size provided

5. One dozen fuses of each type used

6. One dozen relays of each type used

7. Two breakers of each size provided

8. One convertor module of each type used

9. One switch of each type used

10. One indicating light of each type used

11. One alarm buzzer of each type used

12. One signal isolator of each type used

13. One panel meter/indicator of each type used

14. One filter of each type used

15. One fan of each type used

16. One heater of each type used

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Provide panels and enclosures meeting the NEMA requirements for the type specified.

B. Fabricate panels, install instruments, and wire in the factory. Test wiring prior to shipment. Use numbered terminal blocks for external connections.

C. Provide instrument loop power supplies, mounting hardware, terminal blocks, control circuit breakers, and other items required for a fully operable panel.

D. Provide termination panels, if required. Include terminal blocks, interface hardware, wiring, and cabling necessary for a complete operational system.

E. Use panel fabrication techniques that allow for removal and maintenance of all equipment after installation.

F. Sizes shown are estimates. Provide panels and enclosures amply sized to house all equipment, instruments, front panel mounted devices, power supplies, power distribution panels, wiring, tubing and other components installed within.

G. For panels located inside control or electrical room areas, provide NEMA 12 rated panels unless specified otherwise.

H. For panels located in process areas or outdoors (except areas classified as hazardous locations), provide NEMA 4X rated panels unless specified otherwise. Provide all panels corrosion resistant.

I. For panels located inside Class 1 Division 1, or Class 1 Division 2 hazardous areas, provide NEMA 7 rated panels.

J. Provide lifting rings on panels in excess of 100 pounds.

K. Provide panels sized by the integrator based on the equipment provided. Minimum panel sizes are shown on the Drawings. Panels may be increased in size only upon approval from the ENGINEER based on substantiated request.

L. Panel Mounted Equipment

1. Unless otherwise specified, provide components to operate on 120 VAC single phase 60-Hertz power.

2. Provide 24VDC two-wire transmitter power supplies as required.

3. Provide signal isolators for each analog input and output signal to protect panel mounted equipment from electrical surges induced in field wiring.

4. Provide engraved laminated nameplates to identify each panel mounted component. Provide nameplates having black lettering on white background, with 3/16-inch minimum lettering height.

M. Provide enclosures with louvers, forced ventilation, or air conditioners as required to prevent temperature build-up to protect equipment with ambient temperatures of up to 105 degrees F. Except for enclosures mounted with their backs directly adjacent to a wall, place louvers in the rear of the enclosure, top and bottom. For enclosures mounted with their backs directly adjacent to a wall, place louvers on the sides.

N. Provide any inputs or outputs required for system diagnostics such as analog to digital converter check points, system alarms, cold junction compensation, cabinet temperature indications, and power supply voltage checks.

O. Where enclosures are mounted outside or in unheated areas, provide them with thermostatically controlled heaters that will maintain the inside temperature above 40 degrees F.

2.2 PANEL CONSTRUCTION

A. NEMA 12 Panels

1. Fabricate enclosures using Type 316 stainless steel, with stainless steel free of pitting and surface blemishes.

2. Continuously weld all exterior seams and grind smooth.

3. Provide stiffening members for strength and stiffness as required.

4. Provide panel flat within 1/16-inch over a 24-inch by 24-inch area.

5. Use pan type construction for doors, with door widths not exceeding 36-inches.

6. Mount doors with full length heavy duty piano hinge with stainless steel pin.

7. Provide oil resistant gasket completely around each door or opening.

8. Provide handle-operated, oil-tight, key-lockable three point stainless steel latches. Provide all project enclosures keyed alike.

9. Use stainless steel fasteners throughout.

10. Provide interior mounting panels and shelves constructed of minimum 12 gage steel.

11. Provide print pocket on door interior.

12. Provide enclosure mounting supports as required for floor, frame, or wall mount.

13. Provide all holes and cutouts for installation of conduit and equipment. Provide water tight conduit hubs. (Double locknuts are not acceptable.)

14. Completely clean all interior and exterior surfaces so they are free of dirt, corrosion and clear of any metal filings.

15. Stainless Steel Panels:

    a. Do not paint stainless steel enclosure exterior surface.

    b. Cover, sides, top, and bottom to have smooth #4 brushed finish.

16. Manufacturers:

    a. Hoffman Enclosures Co.

    b. Rittal Corporation

    c. Saginaw Control & Engineering

    d. Or approved equal

B. NEMA 4X Panels

1. Fabricate NEMA 4X enclosures from Type 316 stainless steel.

2. Provide non-corrodible metal hardware including hinge and cover clamps.

3. Do not paint stainless steel enclosure exterior surface.

4. Sandblast, roughen, or chemically etch stainless steel enclosures to reduce gloss, reflections, and glare.

5. Provide conduit knockouts prior to installation of equipment inside enclosure. Provide watertight conduit hubs (double locknuts are not acceptable). Top penetrations are not acceptable.

6. Provide handle-operated, oil-tight, key-lockable three-point stainless steel latches. Provide all project enclosures keyed alike.

7. Rolled lip around three sides of door and along top of enclosure opening.

8. Hasp and staple for padlocking.

9. Provide a clear plastic, gasketed lockable hinged door to encompass all non-NEMA 4 front of panel instruments.

10. Manufacturers:

    a. Hoffman Enclosures

    b. Rittal Corporation

    c. Saginaw Control & Engineering

    d. Or approved equal

C. Network Racks

1. Construct network racks to support rack mounted equipment including: network switches, servers and media converters. Reference Section 40 94 13 - Process Control System Computer and Network Hardware for network equipment requirements.

2. Provide network racks meeting or exceeding the following minimum requirements:

    a. Overall maximum dimensions of (78”) H x (23”) W x (42”) D

    b. Compatible with mounting on raised/false floor

    c. Minimum Internal 42 rack-unit, 19” mounting rack

    d. Constructed of 14-gauge, cold rolled steel

    e. Perforated, lockable, removable doors, with 80% openings for airflow: split rear door

    f. Adjustable mounting uprights, front and back, and have square holes for mounting server slide rails

    g. Provide all mounting hardware, including shelves, cable organizers, etc.

    h. Ventilating top with 550 CFM fan.

3. Manufacturers:

    a. APC AR 3100

    b. Or approved equal

2.3 PANEL GROUNDING

A. Provide 2 ground buses in each cabinet or panel, one for shield and cabinet grounding and one for signal grounding.

B. Provide grounding lugs for connection to the external grounding system.

C. Provide ground busbars, directly wired and connected to facility grounding system.

D. Provide DC ground bus (for analog cable shield termination) bonded to chassis ground.

E. Provide nickel-plated copper busbars, with current rating of 100 amperes.

F. Provide each busbar with at least twenty (20) screw clamp terminal blocks, each capable of accepting #10 AWG conductors.

G. Provide ground lug on each door and connect lug to the ground bus within panel.

2.4 PANEL WIRING

A. Terminate all wiring, to and from field devices, at panel terminal blocks, not on equipment terminals.

B. Do not terminate more than two wires at the same terminal. Wiring splices and wire nuts is not permitted within the enclosure.

C. Use flexible stranded copper wiring. Run wires in continuous lengths from terminal to terminal. Do not splice wires.

D. For analog signal wiring, use uniformly twisted shielded pairs not smaller than 16 AWG with a minimum of six twists per foot. Separate analog signal wiring at least six inches from power wiring. Provide continuous foil or metalized plastic shields with 100 percent coverage. Include a drain wire in continuous contact with the shield.

E. Use type THHN/THWN power wiring with insulation rated at 600 V. Use 14 AWG or larger for power wiring.

F. Segregate signal wiring from control and power wiring. Group wiring functionally and arrange neatly to facilitate tracing of circuits.

G. Use plastic wiring wraps to bundle wires, outside of wiring ducts. Securely fasten the bundles to the steel structure at intervals not exceeding 12 inches. Use Panduit, or equal wiring ducts and size to provide a minimum of 100% spare capacity.

H. Do not intermix signals within the same bundle or duct.

I. Use twisted unshielded wire for other DC signals and segregate from wire conducting AC signals.

J. Provide wire identification at each wire end. Utilize computer-generated, heat-shrink type wire markers.

K. Install all wiring in plastic wiring ducts, provided with snap-on covers. Size ducts to include at least 100% spare capacity. Restrain all wiring outside of ducts with plastic ties.

L. Group and wrap all wires passing a door hinge in protective wire harness. Provide abrasion protection for wire bundles passing through holes or across sheet metal edges.

M. Provide panel wiring of stranded copper with 600-volt rated thermoplastic insulation.

1. Power wiring: No. 14 AWG minimum

2. Control wiring: No. 16 AWG minimum

3. Electronic signal wiring: No. 16 twisted shielded pair minimum

4. Ethernet network wiring: Category 6 minimum

5. Other serial communication cables: As recommended by equipment manufacturer.

N. Provide wire color convention matching the wire color convention used at the client owned and operated Bird Creek and Canyon Lake Pump Stations. Coordinate with Owner to identify the specifics.

O. Physically separate AC wiring from DC wiring.

1. Where AC and DC wiring runs in parallel, provide at least 2-inch separation.

2. Where AC and DC wiring cross, cross at 90°.

P. Do not daisy-chain neutral wiring and grounding conductors at equipment terminals. Provide terminal blocks that accept jumper bridges.

Q. Protect network cables and fiber using cable management supports.

2.5 TERMINAL BLOCKS

A. Wire and terminate equipment in accordance with the latest standards of the National Electrical Code as well as state and local electrical codes.

B. Provide terminal blocks for field wiring and equipment wiring terminations. Provide unique identification at each terminal block.

1. Arrange terminal blocks in consecutively, based on standard alphanumeric order.

2. Group terminal blocks based on voltage level and function.

3. Color code foreign voltage terminal block identification to match wire insulation.

C. Provide at least 25% spare terminal blocks for each type used in each enclosure.

D. Provide high-density modular type terminal blocks suitable for mounting on standard DIN rails.

1. Material: Nylon

2. Termination type: tubular screw with serrated pressure plate

3. Current carrying parts (metal bodies): nickel or tin-plated copper

4. Ground terminal blocks: Dual color type, Green and Yellow

5. Maximum conductor size: No. 8 AWG stranded

6. Current rating: Up to 15 amperes at 250 VAC

7. Provide manufacturer jumper bridges, designed to fit on terminal blocks. Do not daisy-chain wiring.

E. Provide fused terminal blocks or DIN rail mounted circuit breakers for panel power distribution. Use for both 120 VAC and 24 VDC.

1. Provide disconnect lever and fuse-puller mechanism

2. Provide illuminated indication of blown fuse

3. Provide standard 1/4" by 1-1/4" fuses, sized to protect load

4. Provide DIN Rail breakers with trip indication and mechanical reset

F. Provide two-level type terminal blocks for PLC discrete input and outputs, with both levels of the feed-through types.

G. Provide three-level type terminal blocks for analog signal wiring, with top and center terminations of the feed-through types, and bottom termination grounded to isolated mounting railing, connected to the DC ground bus.

1. Provide factory assembled terminal blocks on a mounting channel and bolt the channel to the inside of the panel. Space terminal block strips no closer than 6 inches center to center.

2. Provide screw type 600 V terminals with pressure plate to accept wire size #14 AWG and smaller. Do not use miniature terminal blocks.

3. Provide a continuous marking strip with the terminals. Provide a separate terminal for terminating each shield wire.

4. Reserve one side of each terminal strip for field incoming conductors. Do not make common connections and jumpers required for internal wiring on the field side of the terminal. Terminate no more than two wires at any one terminal.

5. Provide a minimum of 25 percent spare terminals per terminal type, per panel.

H. Manufacturers:

1. Phoenix Contact

2. Allen Bradley

3. Or approved equal

2.6 PANEL MOUNTED EQUIPMENT

A. Provide panel heaters, vapor type corrosion inhibitors and breather drains for condensation and corrosion control inside panel. Provide panel heaters of the forced air types, complete with thermostatic control.

1. Manufacturers:

a. Cortec

b. Hoffman

c. Or approved equal

B. Provide one (1) UPS supply receptacle, 120 VAC, 20A duplex type.

C. Provide one (1) “service receptacle”, 120 VAC, 20A duplex, GFCI grounding type receptacle.

D. Provide one (1) 120 VAC 24” LED light fixture and protective plastic shield.

E. Provide one (1) 120 VAC, 20A, snap switch, to turn on the light, mounted in an outlet box with a cover and located so that it is easily accessible from access door.

F. Interposing Relays

1. Provide interposing relays to interface all PLC discrete outputs with field-mounted equipment.

2. Provide high density, DIN rail mounted type relays, with coils, contacts, and voltage ratings as required. Provide contacts rated 10 Amperes at 120 volts minimum. Provide relays having LED indicator to indicate coil status.

3. Provide DPDT relays for control of motor starters larger than NEMA size 1, rated 15 Amperes at 250 VAC.

G. Regulated Power Supplies

1. Provide regulated DC power supply as required for 2-wire analog loops. Size power supplies to include 100% spare capacity. Do not power more than three transmitter loops from the same power supply.

2. Provide power supplies as follows:

a. Input power: 120 VAC, 60 Hz.

b. Output power: Use 24VDC at 5 amps or greater to support existing/future devices

c. Output regulation: <1%

d. Operating temperature: 0 to 50° C

e. DIN Rail mountable.

3. Manufacturers:

a. Phoenix Contact

b. Action Instruments

c. Sola

d. Puls

e. Or approved equal

H. Uninterruptible Power Supply

1. Provide new panel mounted uninterruptable power supply (UPS).

2. Provide UPS to provide a minimum of 30 minutes of back power with all equipment in full operation. Submit calculations demonstrating the 30-minute capability. Provide UPS capable of providing power surge protection at all times including when not operating off the batteries. Provide UPS meeting lightning standard per ANSI/IEEE C62 41 Category A (3000 volt spike and 200 amp) and Category B (600 volt spike and 3000 amp). The UPS must reduce the spike to less than three volts on the output, for 200 to 1 spike attenuation. Provide UPS capable of providing computer grade sine-wave power with five percent or less total harmonic distortion. Input voltage: 120 VAC single phase. Provide UPS with no measurable break in the output during transfer from the normal AC line supply to the inverter battery supply or back to line.

3. UPS minimum overload capability: 125 percent for 10 minutes, 150 for 6 minutes and 110 percent indefinitely.

4. Provide the UPS with a relay interface card, and available alarms as dry contacts for wiring to the PLC.

5. Provide build in sealed, low maintenance, lead acid batteries, easily replaceable with standard tools.

6. Manufacturers:

    a. Eaton 9SX1500

    b. Or approved equal.

I. Control Devices and Pilot Lights

1. General: Provide heavy-duty type, 30.5MM, oil-tight, watertight, and corrosion resistant pushbuttons, selector switches, and indicating lights. Provide a legend plate at each device.

2. Contact block current rating: 10 amperes at 240 VAC.

3. Provide all pilot lights of the LED type, with LED color matching the lens cover color. Provide flashing lights where indicated.

4. Provide pilot light colors as follows: Contractor to coordinate with the Owner to utilize same color schema as client owned and operated Bird Creek and Canyon Lake Pump Station.

5. Manufacturers:

    a. Allen Bradley

b. Eaton

c. Schneider Square D

d. Or approved equal

J. Signal Isolators

1. Provide 4-wire type for use as a signal isolator, converter and/or repeater.

2. Input Signal: 4-20 mA DC, field configurable for other signal ranges.

3. Input Impedance: No greater than 50 ohms.

4. Isolation: 1000-volt RMS output from input, power and ground; fully floating

5. Output Signal: 4-20 mA DC into 800 ohms minimum.

6. Accuracy: +/- 0.1% of span

7. Power Supply: 120 VAC, 60 hertz or 24 VDC from UPS at DTC

8. Enclosure: designed for high density DIN rail mount

9. Isolators are not scheduled.

a. Provide isolators on all analog inputs to the PLC (unless the PLC is provided with isolated analog input modules).

b. Provide as shown and as necessary to eliminate ground loop problems when connecting instruments to other instrument loops.

10. Manufacturers:

a. Phoenix Contact

b. Action Instruments

c. Moore Industries

d. Or approved equal

K. Digital Panel Indicators

1. Type: Electronic, 3-1/2 Digit LED, 0.60-inch high display

2. Input Impedance: no greater than 250 ohms.

3. Power Source: 110 VAC, 60 hertz

4. Input Signal: 4-20 mA DC

5. Input Dampening: Adjustable

6. Enclosure: 1/8 DIN, general purpose for indoor flush panel mount. Provide indicators for outdoor panels having a NEMA 4X bezel rating or mounted behind a weatherproof gasketed door assembly.

7. Accuracy: +/- 0.05 percent of span +/- 1 count

8. Decimal Point: Selectable via DIP switches or keypad.

9. Input Connections: Compression type screw terminals

10. Range Selection: DIP switches, multi-turn potentiometers, or keypad.

11. Manufacturers:

    a. Precision Digital

    b. Red Lion

    c. Or approved equal

2.7 ENCLOSURE OPTIONS

A. Louvers

1. Include washable aluminum air filters with louvers used for ventilation

2. Provide 1 can of filter spray adhesive for every enclosure.

B. Heaters for Condensation Control

1. Provide thermostatically controlled, fan driven heaters for all outdoor enclosures for condensation control unless otherwise specified

2. Meet the following requirements:

    a. Power: 115 VAC, 60 Hz

    b. Rating: 100 Watts for panels smaller than 24 in by 48 in

3. Provide thermostats that sense air temperature in the panel and are adjustable from 40 to 80 degrees F.

4. Mount heaters near the bottom center of the enclosure. Do not mount electronic components closer than 6 inches to the heater.

5. Manufacturers:

    a. Hoffman Design Aire Electric Heater

    b. Hammond

    c. Or approved equal.

C. Corrosion Inhibitors.

1. Provide enclosures with vapor phase protective corrosion inhibitors

2. Provide adequate corrosion inhibiting devices, tape, or emitters for the individual panel volume

3. Activate the inhibitor upon delivery to the site. Do not store panels with inhibitors inactive. If necessary, cover panels to reduce ventilation and prolong inhibitor life.

4. Manufacturers:

    a. Hoffman A-HCI-5E or -10E

    b. Or approved equal

D. Air Conditioning Unit

1. For panels located outdoors or in non-conditioned space, provide panel mounted air conditioning unit. Air conditioning unit to be supplied for operation on 120 VAC, single phase, 60 Hz, powered from a circuit breaker within the control panel.

2. Provide an adjustable internal panel thermostat for control of Air Conditioner to activate on high temperatures inside panel.

3. Provide air conditioning units having the following features:

    a. Maximum current draw: 6A at 120 VAC

    b. Corrosion resistant

    c. Stainless steel enclosure

    d. Maintain NEMA rating on installed panel

4. Manufacturers:

a. Hoffman/Pentair

b. Or approved equal.

2.8 SOURCE QUALITY CONTROL

A. Tests and Inspection

1. Test each panel in conjunction with factory acceptance test as described in Section 40 90 00 - Process Control System General Requirements.

PART 3 EXECUTION

3.1 PREPARATION

A. Sequence enclosure installation as follows:

1. Prior to installation, remove enclosure door, internal panels, and equipment from enclosures.

2. Install enclosures and conduits, and pull field wiring into enclosures.

3. Seal all wire entries with non-setting silicon compound to prevent moisture and insects from entering enclosure.

4. Cover enclosure installation thoroughly with heavy-duty plastic sheet to protect against moisture, paint splatter, and dirt. Cover until 120-volt power is available, and enclosure is ready to receive internal panel.

5. Terminate field wiring on terminal blocks.

6. Energize panel heater and keep enclosure door closed when no work is being performed in enclosure. (Do not energize any other equipment prior to field wiring termination check.)

7. Check accuracy of field wiring termination. Thoroughly test for continuity.

8. Energize panel mounted equipment only after all wiring has been thoroughly checked and tested.

9. Energize panel heater to prevent condensation inside the panel.

3.2 ERECTION, INSTALLATION, AND APPLICATION

A. Do not install control panels or enclosures directly against concrete walls. Provide stainless steel channels between wall and enclosure. Mount enclosure to stainless steel channels.

B. Install enclosures and panels level and plumb. Touch up all nicks, scratches, etc. with materials recommended by enclosure manufacturer.

C. Vacuum and clean all panel interior surfaces prior to system commissioning.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspection

1. Demonstrate that each enclosure and each panel mounted equipment:

   a. Has not been damaged during transportation or installation

   b. Has been properly installed

   c. Has no mechanical defects

   d. Is in proper alignment

   e. Has been properly wired and connected

3.4 DEMONSTRATION

A. Test all control function as described in Division 1 and Section 40 90 00 - Process Control System General Requirements, and Section 40 98 50 - Process Control System Factory Testing. In addition, perform the following:

1. Calibrate all process variable indications

2. Adjust all alarm setpoints

3. Tune all control function to achieve optimum and stable control

3.5 SCHEDULES

Reference Contract Drawings and the following table for list of control panels and network racks. Data presented on the following table is for the convenience of the CONTRACTOR. Provide all control panels and network racks of size and type required by the contract documents and including all components required for the operation of the equipment as described.

CONTROL PANEL SCHEDULE

Panel	Qty	Location	Panel Type	NEMA Rating	Comments
Wood Capacity Control Panel (WCCP)	1	Woods Pumping Station	Free-Standing	12	Provided by CONTRACTOR
W1 Pump Control Panel (PCP-W1)	1	Woods Pumping Station	Free-Standing	12	Provided by CONTRACTOR
W2 Pump Control Panel (PCP-W2)	1	Woods Pumping Station	Free-Standing	12	Provided by CONTRACTOR

A. Provide other control panels for packaged equipment control systems which meet the general requirements of this Section.

END OF SECTION

SECTION 40 96 15

PROCESS CONTROL SYSTEM INPUT/OUTPUT LIST

PART 1 GENERAL

1.1 DESCRIPTION

A. Section 40 96 15 specifies the input/output (I/O) point list, which follows this Section and requirements for configuring the control system database.

B. Related Work Specified in Other Sections Includes, but is Not Limited to the Following:

1. Section 01 33 00 - Submittals
2. Section 40 80 50 - Process Control System Commissioning
3. Section 40 90 00 - Process Control System General Requirements
4. Section 40 90 50 - Process Control System Description
5. Section 40 94 43 - Programmable Logic Controller Systems
6. Section 40 98 50 - Process Control System Factory Acceptance Testing

1.2 SUBMITTALS

A. General: Provide all submittals as specified herein, and as specified in Section 01 33 00 - Submittals.

B. Action Submittals:

1. For each I/O attribute listed in the I/O list that cannot be used exactly as listed, submit an explanation of the reason for the deviation and propose a method to modify the I/O list information. Do not proceed with any configuration until a method of resolving deviations is accepted by the ENGINEER.

2. Include the control system I/O database information in the PLC specific submittals for Programmable Logic Controller Systems Hardware.

3. CONTRACTOR: Supplement and complete the information provided in the drawings and attached tables, including identification of all soft I/O for digital communication networks including Ethernet I/P. Include in the listing the node address and addresses within the device. Coordinate the addresses so that node and segment addresses are unique within the Process Control System.

C. Closeout Submittals: Provide submittals as required below.

1. Section 01 78 90 - Contract Closeout.

2. Complete I/O List

1.3 I/O POINT LIST DESCRIPTION

A. The I/O list contains the information necessary to configure the PLC I/O interface hardware and to indicate range conversion or signal functions.

B. INDEX: Indicates a sequential number used to reference the I/O (0001 through 9999)

C. SERVICE DESCRIPTION: an alphanumeric character string up to 40 positions in length. Points described as SPARE denote pre-wired I/O.

D. I/O TYPE:

1. AI: Analog Input
2. AO: Analog Output
3. DI: Discrete Input
4. DO: Discrete Output
5. RTD: RTD Temperature Input

E. P&ID: Piping and Instrumentation diagram where the I/O point can be referenced to.

F. EQUIPMENT: Indicates the type of equipment associated with the I/O point (VFD, Pump, MOV, PIT, etc.).

G. EQUIPMENT DESCRIPTION: Indicates the description of the type of equipment associated with the I/O point (Variable Frequency Drive, Vertical Turbine Pump, Motor-Operated Valve, Level Indicator, etc.).

H. FROM: Indicates origination of the I/O point (VFD, Pump, MOV, PIT, PLC, etc.).

I. TO: Indicates destination of the I/O point (VFD, Pump, MOV, PIT, PLC, etc.).

J. COMMENTS – Comments, if required.

1. “SOFT (ETHERNET I/P)” is used to designate those I/O points that are transferred via ethernet connection from equipment and PLC.

2. “HARDWIRE” is used to designate those I/O points that are transferred via hardwired connection from equipment and PLC.

K. HMI/PLC TAGNAME: Indicates the designated programming tag for the I/O point. By Integrator. Note: Use the same naming conventions as client owned and operated Bird Creek & Canyon Lake Pump Stations.

L. ETHERNET/IP ADDRESS: Indicates the IP address associated with the I/O point (for soft I/Os). By Integrator.

M. RACK: Indicates the PLC Rack number associated with the I/O point (for hardwired I/Os). By Integrator.

N. SLOT: Indicates the PLC I/O card slot number associated with the I/O point (for hardwired I/Os). By Integrator.

O. POINT: Indicates the PLC I/O card channel number associated with the I/O point (for hardwired I/Os). By Integrator.

PART 2 PRODUCTS

2.1 GENERAL

A. Provide a complete single I/O point list that includes all analog, digital, and control output signals in a single list. Start a new page for each associated PLC. Sort list according to the following criteria in descending priority: P&ID, PLC, I/O TAGNAME. After final sorting, generate INDEX number column starting from 0001 through as needed. The I/O lists included in this document is not considered complete lists. Use only for reference.

B. Provide a list that includes all information not included in the I/O list described above, but that is developed internal to the PLCs, including diagnostic alarms for communications failure, I/O signal failure, and all internal PLC alarms.

C. Submit for review preliminary copies of the I/O point list during the shop drawing review phase. For final O&M documentation, provide five printed copies and two electronic copies in Microsoft Excel spreadsheet format for each list required.

PART 3 EXECUTION

3.1 GENERAL

A. Provide I/O address information to the RESIDENT PROJECT REPRESENTATIVE for each I/O point. Use slot and point designations.

1. Slot refers to the location of a field control module on a DIN mounting rail or chassis.

2. Point refers to the point location or address for the I/O point on the designated field control module/card.

B. Provide prewired I/O for points identified as SPARE in the description.

3.2 I/O CONFIGURATION

A. Implement the control system database fields in a consistent manner by using the following procedures:

1. Use abbreviations and acronyms already established in the Contract Documents. In particular, use the information in the I/O Point List.

2. Use only abbreviation or acronym for a word or group of words, respectively.

3. Use the same subject and word order within data fields.

4. Use the same term (either phrase, description, word or acronym) to denote the same meaning. Do not use multiple terms for a single meaning.

5. Use the point names, descriptions, logic state descriptions, ranges and units of measurement exactly the same wherever the point is referenced.

6. Show point names and descriptions for all point references on documentation.

7. Maintain lists of acronyms and abbreviations used.

3.3 I/O HARDWARE CONFIGURATION

A. Partition the I/O among cards within an I/O enclosure to provide control loop integrity.

1. Place all inputs of the same I/O type associated with a device (e.g. pump, blower, clarifier, or other piece of equipment) on the same card.

2. Place all inputs of the same I/O type for devices arranged in process trains (e.g. a pump, its inlet valve and its outlet valve) on the same card or adjacent cards if more than one card is required to accommodate the points.

3. Place all outputs of the same I/O type associated with a device or group of devices in a process train on the same card or adjacent cards if more than one card is required to accommodate the points.

4. Where the preceding requirements specified in this paragraph would cause more than 20 percent spare points on a card, points for a device or process train may be split between two consecutive cards.

5. Make unused terminals resulting from partitioning the I/O into pre-wired spares. Provide pre-wired spare points with all cabling and termination internal to the PLC as done for other I/O points.

3.4 POINT DATA FIELDS

A. I/O point data fields may be subject to review and modification by the ENGINEER during the Shop Drawing review phase. Incorporate changes directed by the ENGINEER completely into the entire system, at no increase in contract price, subject to the following limitations:

1. Limit the total number of modifications to 35 percent of the total number of I/O points.

2. Each unique change will count as one modification. For example, modifying the description, range, and engineering unit on an analog input counts as three modifications.

3. Analog input alarm limit definition does not count as a modification.

3.5 INPUT/OUTPUT LIST

A. The project Input/Output list included herein indicates all minimum required I/O for the project, including all hardwired I/O as well as soft I/O to be communicated between processors and Ethernet protocols, and is not be considered a complete list, and is for use as reference material. Furnish availability of all I/O at the OWNER's SCADA system.

B. The I/O list does not include all details that must be coordinated during project implementation, such as final node addresses and registers for all I/O. However, columns have been provided in the I/O list attached to facilitate inclusion of this information as the project installation progresses. SYSTEM INTEGRATOR is responsible for including additional hardwired or soft I/O as required for the PLC and PCS to function as described in Section 40 90 50 - Process Control System Description.

C. All Analog Points are required to have Trends and Records created on the Historian.

D. CONTRACTOR: Follow the OWNER-approved format included herein. The attached I/O list can be provided to the CONTRACTOR in electronic form (Microsoft Excel) upon request.

E. CONTRACTOR: Submit the required tag database submittals for each PLC, as described under Sections 40 94 43 - Programmable Logic Controller Systems, in the format attached, in both hardcopy and electronic form (Microsoft Excel).

F. Include in each submittal all information coordinated with equipment vendors and suppliers for the systems integration work including, but not limited to:

1. Alarm settings and class

2. Terminal block information

3. Power source

4. PLC term no.

5. Final PLC register location

G. Additionally, for soft I/O communicated over Ethernet, include in the submittal similar information coordinated with all equipment vendors and suppliers. For soft I/O include, but not be limited to:

1. Alarm settings and class

2. Communication segment tag

3. Node address on segment coordinated with all vendors and suppliers with equipment on that segment.

4. Final PLC register location.

3.6 SCHEDULES

A. See attached schedules for I/O list format.

END OF SECTION

INDEX	I/O TYPE	SERVICE DESCRIPTION	P&ID	EQUIPMENT DESCRIPTION	FROM	TO	CONNECTION	COMMENTS	HMI/PLC TAGNAME	ETHERNET/IP ADDRESS	RACK	SLOT	POINT
0001	DI	PUMP W1 SUCTION VALVE OPEN (S7)	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0002	DI	PUMP W1 DISCHARGE VALVE OPEN (D7)	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0003	DI	PUMP W1 DISCHARGE VALVE CLOSED (D7)	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0004	DI	PUMP W1 LOCAL MODE	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0005	DI	PUMP W1 REMOTE MODE	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0006	DI	PUMP W1 READY	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0007	DI	PUMP W1 LOCKOUT	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0008	DI	PUMP W1 PLC FAULT ALARM	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0009	DI	PUMP W1 VFD FAULT ALARM	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0010	DI	PANEL PCP-W1 POWER FAILURE ALARM	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0011	DO	PUMP W1 START	N03	Pump W1 Control Panel	PLC WCCP	PCP-W1	Soft (Ethernet/IP)	N/A					
0012	DO	PUMP W1 STOP	N03	Pump W1 Control Panel	PLC WCCP	PCP-W1	Soft (Ethernet/IP)	N/A					
0013	DO	PUMP W1 EMERGENCY STOP	N03	Pump W1 Control Panel	PLC WCCP	PCP-W1	Soft (Ethernet/IP)	N/A					
0014	AO	PUMP W1 SPEED COMMAND	N03	Pump W1 Control Panel	PLC WCCP	PCP-W1	Soft (Ethernet/IP)	N/A					
0015	AI	PUMP W1 SPEED FEEDBACK	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0016	DI	LINE VALVE L5 OPEN	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0017	DI	LINE VALVE L5 CLOSED	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0018	AI	PUMP W1 THRUST BEARING VIBRATION	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0019	AI	PUMP W1 SUCTION MANIFOLD BEARING VIBRATION	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0020	AI	PUMP W1 OUTBOARD BEARING VIBRATION X AXIS	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0021	AI	PUMP W1 OUTBOARD BEARING VIBRATION Y AXIS	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0022	AI	PUMP W1 PHASE A WINDING 1 TEMPERATURE	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0023	AI	PUMP W1 PHASE A WINDING 2 TEMPERATURE	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0024	AI	PUMP W1 PHASE B WINDING 1 TEMPERATURE	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0025	AI	PUMP W1 PHASE B WINDING 2 TEMPERATURE	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0026	AI	PUMP W1 PHASE C WINDING 1 TEMPERATURE	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0027	AI	PUMP W1 PHASE C WINDING 2 TEMPERATURE	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0028	AI	PUMP W1 MOTOR BEARING 1 TEMPERATURE	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0029	AI	PUMP W1 MOTOR BEARING 2 TEMPERATURE	N03	Pump W1 Control Panel	PCP-W1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0030	DI	PUMP W2 SUCTION VALVE OPEN (S8)	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0031	DI	PUMP W2 DISCHARGE VALVE OPEN (D8)	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0032	DI	PUMP W2 DISCHARGE VALVE CLOSED (D8)	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0033	DI	PUMP W2 LOCAL MODE	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0034	DI	PUMP W2 REMOTE MODE	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0035	DI	PUMP W2 READY	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0036	DI	PUMP W2 LOCKOUT	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0037	DI	PUMP W2 PLC FAULT ALARM	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0038	DI	PUMP W2 VFD FAULT ALARM	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0039	DI	PANEL PCP-W2 POWER FAILURE ALARM	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0040	DO	PUMP W2 START	N03	Pump W2 Control Panel	PLC WCCP	PCP-W2	Soft (Ethernet/IP)	N/A					
0041	DO	PUMP W2 STOP	N03	Pump W2 Control Panel	PLC WCCP	PCP-W2	Soft (Ethernet/IP)	N/A					
0042	DO	PUMP EMERGENCY STOP	N03	Pump W2 Control Panel	PLC WCCP	PCP-W2	Soft (Ethernet/IP)	N/A					
0043	AO	PUMP W2 SPEED COMMAND	N03	Pump W2 Control Panel	PLC WCCP	PCP-W2	Soft (Ethernet/IP)	N/A					
0044	AI	PUMP W2 SPEED FEEDBACK	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0045	DI	LINE VALVE L4 OPEN	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0046	DI	LINE VALVE L4 CLOSED	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0047	AI	PUMP W2 THRUST BEARING VIBRATION	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0048	AI	PUMP W2 SUCTION MANIFOLD BEARING VIBRATION	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0049	AI	PUMP W2 OUTBOARD BEARING VIBRATION X AXIS	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0050	AI	PUMP W2 OUTBOARD BEARING VIBRATION Y AXIS	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0051	AI	PUMP W2 PHASE A WINDING 1 TEMPERATURE	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0052	AI	PUMP W2 PHASE A WINDING 2 TEMPERATURE	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0053	AI	PUMP W2 PHASE B WINDING 1 TEMPERATURE	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0054	AI	PUMP W2 PHASE B WINDING 2 TEMPERATURE	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0055	AI	PUMP W2 PHASE C WINDING 1 TEMPERATURE	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0056	AI	PUMP W2 PHASE C WINDING 2 TEMPERATURE	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0057	AI	PUMP W2 MOTOR BEARING 1 TEMPERATURE	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0058	AI	PUMP W2 MOTOR BEARING 2 TEMPERATURE	N03	Pump W2 Control Panel	PCP-W2	PLC WCCP	Soft (Ethernet/IP)	N/A					
0059	DI	LINE VALVE L4 OPEN	N03	Line Valve L4 MOV	MOV-L4	PCP-W2	Hardwired	N/A					
0060	DI	LINE VALVE L4 CLOSED	N03	Line Valve L4 MOV	MOV-L4	PCP-W2	Hardwired	N/A					
0061	DO	LINE VALVE L4 OPEN COMMAND	N03	Line Valve L4 MOV	MOV-L4	PCP-W2	Hardwired	N/A					
0062	DO	LINE VALVE L4 CLOSE COMMAND	N03	Line Valve L4 MOV	MOV-L4	PCP-W2	Hardwired	N/A					
0063	DI	LINE VALVE L5 OPEN	N03	Line Valve L5 MOV	MOV-L5	PCP-W1	Hardwired	N/A					
0064	DI	LINE VALVE L5 CLOSED	N03	Line Valve L5 MOV	MOV-L5	PCP-W1	Hardwired	N/A					
0065	DO	LINE VALVE L5 OPEN COMMAND	N03	Line Valve L5 MOV	MOV-L5	PCP-W1	Hardwired	N/A					
0066	DO	LINE VALVE L5 CLOSE COMMAND	N03	Line Valve L5 MOV	MOV-L5	PCP-W1	Hardwired	N/A					
0067	AI	PUMP STATION SUCTION SURGE TANK LEVEL	N03	Level Transmitter	LIT-201	PLC WCCP	Hardwired	N/A					
0068	AI	PUMP STATION DISCHARGE TANK LEVEL	N03	Level Transmitter	LIT-202	PLC WCCP	Hardwired	N/A					
0069	DI	60-INCH SUCTION CROSSOVER VALVE OPEN (S9)	N03	Valve Limit Switch S9	ZS-S9	PLC WCCP	Hardwired	N/A					
0070	DI	72-INCH SUCTION CROSSOVER VALVE OPEN (S10)	N03	Valve Limit Switch S10	ZS-S10	PLC WCCP	Hardwired	N/A					
0071	DI	60-INCH DISCHARGE CROSSOVER VALVE OPEN (D9)	N03	Valve Limit Switch D9	ZS-D9	PLC WCCP	Hardwired	N/A					
0072	DI	72-INCH DISCHARGE CROSSOVER VALVE OPEN (D10)	N03	Valve Limit Switch D10	ZS-D10	PLC WCCP	Hardwired	N/A					

INDEX	I/O TYPE	SERVICE DESCRIPTION	P&ID	EQUIPMENT DESCRIPTION	FROM	TO	CONNECTION	COMMENTS	HMI/PLC TAGNAME	ETHERNET/IP ADDRESS	RACK	SLOT	POINT
0073	DI	FUEL GAS LOW PRESSURE	N03	Generator Control Panel	GCP	PLC WCCP	Hardwired	N/A					
0074	DI	GENERATOR FAILURE	N03	Generator Control Panel	GCP	PLC WCCP	Hardwired	N/A					
0075	DI	EMERGENCY BATTERIES - LOW VOLTAGE	N03	Generator Control Panel	GCP	PLC WCCP	Hardwired	N/A					
0076	DI	MAIN POWER FAILURE	N03	ATS	ATS	PLC WCCP	Hardwired	N/A					
0077	DI	EMERGENCY POSITION	N03	ATS	ATS	PLC WCCP	Hardwired	N/A					
0078	DI	NORMAL POSITION	N03	ATS	ATS	PLC WCCP	Hardwired	N/A					
0079	DI	EXHAUST FAN FAILURE ALARM	N03	TCP	TCP	PLC WCCP	Hardwired	N/A					
0080	DI	SMOKE DETECTION ALARM EAF-1/EAF-3	N03	TCP	TCP	PLC WCCP	Hardwired	N/A					
0081	DI	SMOKE DETECTION ALARM EAF-2	N03	TCP	TCP	PLC WCCP	Hardwired	N/A					
0082	DI	COMPRESSED AIR LOW PRESSURE	N03	AIR COMPRESSOR		PLC WCCP	Hardwired	N/A					
0083	DI	COMPRESSED AIR HIGH WATER IN RECEIVER		AIR COMPRESSOR		PLC WCCP	Hardwired	N/A					
0084	DI	PUMP W1 VFD RUNNING STATUS	N03	PUMP W1 VFD	VFD-W1	PCP-W1	Hardwired	N/A					
0085	DI	PUMP W1 VFD ENABLE RUN STATUS	N03	PUMP W1 VFD	VFD-W1	PCP-W1	Hardwired	N/A					
0086	DI	PUMP W1 VFD FAULT	N03	PUMP W1 VFD	VFD-W1	PCP-W1	Hardwired	N/A					
0087	DI	PUMP W1 MOTOR TEMPERATURE HIGH-HIGH TRIP	N03	TE-101	RTD	PCP-W1	Hardwired	N/A					
0088	DO	PUMP W1 MOTOR TEMPERATURE HIGH-HIGH TRIP	N03	PCP-W1	PCP-W1	VFD-W1	Hardwired	N/A					
0089	DO	PUMP W1 VIBRATION HIGH-HIGH TRIP	N03	PCP-W1	PCP-W1	VFD-W1	Hardwired	N/A					
0090	DO	PUMP W1 START COMMAND	N03	PCP-W1	PCP-W1	VFD-W1	Hardwired	N/A					
0091	DO	PUMP W1 STOP COMMAND	N03	PCP-W1	PCP-W1	VFD-W1	Hardwired	N/A					
0092	AI	PUMP W1 SPEED FEEDBACK	N03	Pump W1 Control Panel	PCP-W1	VFD-W1	Hardwired	N/A					
0093	AO	PUMP W1 SPEED COMMAND	N03	Pump W1 Control Panel	PCP-W1	VFD-W1	Hardwired	N/A					
0094	DI	PUMP W1 DISCHARGE VALVE OPEN (D7)	N03	Motor Operated Valve	MOV-D7	PLC W1	Hardwired	N/A					
0095	DI	PUMP W1 DISCHARGE VALVE CLOSED (D7)	N03	Motor Operated Valve	MOV-D7	PLC W1	Hardwired	N/A					
0096	DI	PUMP W1 SUCTION VALVE OPEN (S7)	N03	Valve Limit Switch D7	ZS-D7	PLC W1	Hardwired	N/A					
0097	DI	PUMP W2 VFD RUNNING STATUS	N03	PUMP W2 VFD	VFD-W2	PLC W2	Hardwired	N/A					
0098	DI	PUMP W2 VFD ENABLE RUN STATUS	N03	PUMP W2 VFD	VFD-W2	PLC W2	Hardwired	N/A					
0099	DI	PUMP W2 VFD FAULT	N03	PUMP W2 VFD	VFD-W2	PLC W2	Hardwired	N/A					
0100	DI	PUMP W2 VFD TEMPERATURE HIGH-HIGH TRIP	N03	PCP-W2	PCP-W2	VFD-W2	Hardwired	N/A					
0101	DO	PUMP W2 VIBRATION HIGH-HIGH TRIP	N03	PCP-W2	PCP-W2	VFD-W2	Hardwired	N/A					
0102	DO	PUMP W2 START COMMAND	N03	PCP-W2	PCP-W2	VFD-W2	Hardwired	N/A					
0103	DO	PUMP W2 STOP COMMAND	N03	PCP-W2	PCP-W2	VFD-W2	Hardwired	N/A					
0104	AI	PUMP W2 SPEED FEEDBACK	N03	Pump W2 Control Panel	PCP-W2	VFD-W2	Hardwired	N/A					
0105	AO	PUMP W2 SPEED COMMAND	N03	Pump W2 Control Panel	PCP-W2	VFD-W2	Hardwired	N/A					
0106	DI	PUMP W2 DISCHARGE VALVE OPEN (D8)	N03	Motor Operated Valve	MOV-D8	PLC W2	Hardwired	N/A					
0107	DI	PUMP W2 DISCHARGE VALVE CLOSED (D8)	N03	Motor Operated Valve	MOV-D8	PLC W2	Hardwired	N/A					
0108	DI	PUMP W2 SUCTION VALVE OPEN (S8)	N03	Valve Limit Switch D8	ZS-D8	PLC W2	Hardwired	N/A					
0109	AI	UTILITY POWER PHASE A AMPS	N03	Microprocessor Monitoring System	MMSD SWBD-1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0110	AI	UTILITY POWER PHASE B AMPS	N03	Microprocessor Monitoring System	MMSD SWBD-1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0111	AI	UTILITY POWER PHASE C AMPS	N03	Microprocessor Monitoring System	MMSD SWBD-1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0112	AI	UTILITY POWER AVERAGE AMPS	N03	Microprocessor Monitoring System	MMSD SWBD-1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0113	AI	UTILITY POWER A-B VOLTS	N03	Microprocessor Monitoring System	MMSD SWBD-1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0114	AI	UTILITY POWER B-C VOLTS	N03	Microprocessor Monitoring System	MMSD SWBD-1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0115	AI	UTILITY POWER A-C VOLTS	N03	Microprocessor Monitoring System	MMSD SWBD-1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0116	AI	UTILITY POWER A-N	N03	Microprocessor Monitoring System	MMSD SWBD-1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0117	AI	UTILITY POWER B-N	N03	Microprocessor Monitoring System	MMSD SWBD-1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0118	AI	UTILITY POWER C-N	N03	Microprocessor Monitoring System	MMSD SWBD-1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0119	AI	UTILITY POWER 3-PHASE WATTS	N03	Microprocessor Monitoring System	MMSD SWBD-1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0120	AI	UTILITY POWER 3-PHASE VARS	N03	Microprocessor Monitoring System	MMSD SWBD-1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0121	AI	UTILITY POWER POWER FACTOR	N03	Microprocessor Monitoring System	MMSD SWBD-1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0122	AI	UTILITY POWER FREQUENCY	N03	Microprocessor Monitoring System	MMSD SWBD-1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0123	AI	UTILITY POWER WATT DEMAND	N03	Microprocessor Monitoring System	MMSD SWBD-1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0124	AI	UTILITY POWER WATT-HOURS	N03	Microprocessor Monitoring System	MMSD SWBD-1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0125	AI	UTILITY TOTAL HARMONIC DISTORTION PHASE A	N03	Microprocessor Monitoring System	MMSD SWBD-1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0126	AI	UTILITY TOTAL HARMONIC DISTORTION PHASE B	N03	Microprocessor Monitoring System	MMSD SWBD-1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0127	AI	UTILITY TOTAL HARMONIC DISTORTION PHASE C	N03	Microprocessor Monitoring System	MMSD SWBD-1	PLC WCCP	Soft (Ethernet/IP)	N/A					
0128	AI	AVERAGE 3-PHASE TOTAL HARMONIC DISTORTION	N03	Microprocessor Monitoring System	MMSD SWBD-1	PLC WCCP	Soft (Ethernet/IP)	N/A					

SECTION 40 98 00

PROCESS CONTROL SYSTEM TRAINING

PART 1 GENERAL

1.1 REQUIREMENTS AND RESPONSIBILITIES

Section 40 98 00 specifies training requirements for the Process Control System (PCS), including operation, hardware, software, instrumentation, and any equipment affected by the modifications performed as part of the TUMA Raw Water Pump Station Facility Assessment project.

A. CONTRACTOR: Provide all labor, materials, equipment, and incidentals as shown, specified, and required to perform and coordinate all required training at times acceptable to OWNER and ENGINEER.

B. CONTRACTOR: Retain the services of the SYSTEM INTEGRATOR to provide operation and maintenance training for all Control System components and systems, including instrumentation as specified herein, and identified in other sections.

C. CONTRACTOR: Provide on-site training by an authorized representative of the equipment manufacturer, fully knowledgeable in the operation and maintenance of the equipment and certified by the manufacturer as a trainer of that specific equipment, for equipment not manufactured by the CONTRACTOR.

D. CONTRACTOR: Conduct all training in the normal eight-hour working shift (day, evenings, or midnights) until conclusion of the training course. Assign a full time instructor for training at the SUPPLIER's facility. Ensure instructor does not perform other duties throughout the period of each scheduled course. Schedule the training courses to meet the working requirements for each shift. Schedule the training classes during day, evening, and midnight shifts to allow three shift training, if applicable.

E. The requirements of this specification supplement the requirements of Section 01 79 00 - Training.

F. Related Work Specified in Other Sections Includes, but is Not Limited to the Following:

1. Section 01 33 00 - Submittals
2. Section 01 79 00 - Training
3. Section 26 05 00 - Basic Electrical Material and Methods
4. Section 40 80 50 - Process Control System Commissioning
5. Section 40 90 00 - Process Control System General Requirements
6. Section 40 90 50 - Process Control System Description
7. Section 40 94 13 - Process Control Systems Computer and Network

Hardware

8. Section 40 94 43 - Programmable Logic Controller Systems
9. Section 40 95 13 - Process Control System Panel Enclosure and Equipment
10. Section 40 96 15 - Process Control System IO List
11. Section 40 98 50 - Process Control System Factory Acceptance Testing

1.2 SUBMITTALS

A. General: Provide all submittals as specified herein, and as specified in Section 01 33 00 - Submittals.

B. Action Submittals:

1. Provide training plan, with a minimum of 30 days of prior notice, for training conforming to the requirements of Division 01. Include in the plan course outlines for each control system, equipment, instrumentation, and coordinated schedules for training to be provided at the SYSTEM INTEGRATOR's or SUPPLIER's facilities. Scheduled training to allow OWNER personnel to receive the training in a timely manner in accordance with the project and equipment startup schedule.

2. Identify which systems are covered by each of the training courses, and identify common topics and specialty topics unique to a system or a course.

3. Provide Lesson Plans, including course outline, for each class for review by OWNER/ ENGINEER.

4. Provide copies of training materials for each class for OWNER / ENGINEER's review a minimum of eight weeks before the scheduled class, and provide the final training materials two weeks before the scheduled class.

5. Provide instructor/trainer qualifications and experience records.

1.3 ON-SITE TRAINING

A. Provide training for all aspects of the process control system, and is not limited to instruments, software, computers, and hardware. The generic requirements for training are provided below. Prepare and replicate training specifically for all elements of the process control system.

B. The OWNER may record and/or videotape on-site training sessions at its option.

C. The ENGINEER may monitor any training course.

D. Generic Training Requirements:

1. Provide on-site operation and maintenance training by SYSTEM INTEGRATOR or SUPPLIER and the equipment manufacturer

representatives prior to placing the equipment in continuous operation, conforming to the requirements of Section 01 79 00 - Training. Provide the services of equipment manufacturer's representatives for a minimum of eight hours for each type of instrument provided.

2. Provide training to accomplish the following:

   a. Provide instruction covering use and operation of the equipment to perform the intended functions.

   b. Provide instruction covering procedures for routine, preventive and troubleshooting maintenance, including equipment calibration.

   c. Explain procedures for placing the equipment in and out of operation and explain necessary actions and precautions to be taken regarding the overall facility monitoring and control system.

   d. Provide all instructions necessary to operate and utilize all system components.

   e. Provide all instruction necessary to monitor and control the system processes from the designated control panel.

   f. Explain procedures for control of the system during scheduled or unscheduled shutdown and the subsequent start-up.

   g. Provide instructions for regular maintenance and administration operations.

   h. Different phases of the training may be grouped for presentation by different personnel. Submit schedule and instructors for approval.

E. Include the following training subjects:

1. An overview of each new major piece of equipment in the system (e.g., new controller, new input/output (I/O) module, new communication module, new instrument, etc.), and how each interacts with the process.

2. An overview of the control system with a discussion showing how the hardware and software react and influence the operation of the controlled processes.

3. A unit block diagram showing how and what information flows within the system and what is done by each of the functional units.

4. Specific calibration and tuning requirements for each type of new instrument being supplied.

5. Troubleshooting instructions and techniques particular to each new instrument application.

6. Instruction in the use of any special tools necessary for maintenance and calibration.

F. Provide instruction from instructor highly experienced in practical system applications similar to the specified installation, as well as in teaching the selected curriculum. Furnish the resumes of those on the training staff, who will be instructing the plant operating personnel, for review and approval by OWNER/ENGINEER.

G. For training conducted on-site, include the costs for the instructor's travel, meals, and lodging. For any additional time required for travel, include the cost for instructor per diem expenses. Include all course fees and course material costs.

H. Procedures:

1. The training procedures are the complete responsibility of the CONTRACTOR. Furnish formal classroom instruction in small classes (15 students maximum). Encourage trainees to freely ask questions during the instruction periods.

2. Hold classes at the facility designated by the OWNER/ ENGINEER using the actual equipment installed.

3. Hold classes as many times per day as necessary to accommodate the different shifts at the facilities.

I. Materials:

1. Provide comprehensive text material to supplement classroom lectures and to provide material for self-study. Permit personnel who have attended training courses to retain text materials for future reference.

J. Training following two months of regular system operations:

1. SYSTEM INTEGRATOR or SUPPLIER: Provide operation and maintenance covering all system equipment provided.

2. Provide training of the same format, content, and duration as the training described above. Provide additional emphasis or retraining for areas of weakness.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 TRAINING

A. Provide the specified minimum instructor hours/number of sessions of training in accordance with Section 01 79 00 - Training.

B. SYSTEM INTEGRATOR: Supplement the table below to schedule the timing and duration of the training to verify completion of training prior to Facility Startup, testing, and commissioning.

Content	**Duration (hours per course)**	**Operator (seats)**	**Responsibility**
Onsite Process Control System	20	5	SYSTEM INTEGRATOR
SCADA/HMI/OIT	20	5	SYSTEM INTEGRATOR
Vendor Training (Maintenance & Programming)	50	5	SYSTEM INTEGRATOR
Total instruction hours	**90**	**15**	

END OF SECTION

(NO TEXT FOR THIS PAGE)

SECTION 40 98 50

PROCESS CONTROL SYSTEM FACTORY ACCEPTANCE TESTING

PART 1 GENERAL

1.1 SUMMARY

A. Section 40 98 50 specifies technical requirements for fabrication, engineering, wiring, and factory testing of Process Control System (PCS) components and functions installed as part of TUMA Raw Water Pump Station Facility Assessment project.

B. The OWNER and ENGINEER will witness test all equipment covered by this Specification Section at any time during manufacturing, assembling, and/or testing.

C. CONTRACTOR: Provide the OWNER and ENGINEER copies of the factory test plan and of the factory test results.

D. CONTRACTOR: Provide the OWNER and ENGINEER sets of complete factory test procedures. These factory test results, and the test procedures will be reviewed and accepted by the OWNER/ENGINEER prior to scheduling the testing date.

E. CONTRACTOR: Provide the OWNER, ENGINEER, the factory testing date in writing. Provide a minimum of two weeks advance notice prior to the factory testing.

F. CONTRACTOR is responsible for scheduling the factory acceptance test.

G. Schedule the IT Network and Communication factory witness test to be completed in one trip, within 8 nominal hours per day.

H. Schedule the Software factory witness test to be completed in parallel with each hardware factory test, completed within 8 nominal hours per day.

I. CONTRACTOR: Schedule all testing between the hours of 7 AM and 7 PM, Monday-Friday, unless previously approved by the OWNER/ENGINEER. Do not schedule testing on City of Tulsa, Oklahoma holidays, or federal holidays.

J. Related Work Specified in Other Sections Includes, But is Not Limited to the Following:

1. Section 01 33 00 - Submittals
2. Section 40 80 50 - Process Control System Commissioning
3. Section 40 90 00 - Process Control System General Requirements
4. Section 40 90 50 - Process Control System Description

5. Section 40 94 13 - Process Control Systems Computer and Network Hardware
6. Section 40 94 43 - Programmable Logic Controller Systems
7. Section 40 95 13 - Process Control System Panel Enclosure and Equipment
8. Section 40 96 15 - Process Control System IO List
9. Section 40 98 00 - Process Control System Training

K. Process Control System Factory Acceptance Testing provided by manufacturer as part of packaged control systems:

1. Certain control panels are provided by manufacturers of equipment specified under other Sections as part of a packaged system. In general, test those panels according to the requirements of the manufacturer and this specification section.

1.2 SUBMITTALS

A. General: Provide all submittals as specified herein, and as specified in Section 01 33 00 - Submittals.

B. Action Submittals:

1. Submit data on the following as required in Section 40 90 00 - Process Control System General Requirements:

a. Test Plan

b. Test Forms

c. Test Sequence

C. Information Submittals:

1. Submit data on the following as required in Section 40 90 00 - Process Control System General Requirements:

a. Test Schedule

b. Testing Tools

D. Closeout Submittals:

1. Submit data on the following as required in Section 40 90 00 - Process Control System General Requirements:

a. Test results: Provide copies of the certified factory test results.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 QUALITY CONTROL

A. Tests and Inspection

1. Demonstrate for each enclosure and each panel mounted equipment:

a. All installed equipment is terminated and securely mounted

b. All wiring is labeled

c. All equipment is labeled

d. All enclosures are labeled

e. Wiring diagram is installed in cabinet.

3.2 DEMONSTRATION

A. Factory Tests

1. SYSTEM INTEGRATOR: Perform the factory acceptance test, and include hardware and software test verification of all control panels included under the scope of this project, including all network components and associated interfaces.

2. Replicate and simulate the control system network to demonstrate network communication between PLC systems, package control systems, instruments, process control equipment, and all other interfacing devices.

3. Complete system programming prior to each factory test.

B. Factory Tests: Perform the following tests:

1. In-Factory Inspection and PLC I/O Testing (See Paragraphs D & E)

2. Graphical Interface and Software Testing (See Paragraph F)

3. Communication Failure Testing (See Paragraph G)

4. Power Failure/System Restart Testing (See Paragraph H)

C. Test Preparation

1. In-Factory Testing Aids and Equipment:

a. Provide the following documents:

(1) One copy of submittals applicable to equipment to be tested

(2) One copy of Drawings and Specifications, with Addenda and Change Orders

(3) One master copy of test procedure

(4) Complete inventory of equipment to be tested including make, model, and serial number; identify firmware revision

b. Provide the following support facilities:

(1) Desk with keylock or lockable room with table for OWNER and ENGINEER's use

(2) Meeting room

(3) Reproduction facilities for copying test information

2. Meet following criteria prior to start of test:

a. Complete submittals and resolve disputes, if any

b. ENGINEER's review of test procedure

c. Include all processors, network interfaces, I/O cards, and HMI computer in testing

d. Set test date agreeable to each party

3. Schedule:

a. Limit testing to 8 hours of testing to 10 hours maximum on location days

b. Meet each morning to review day's test schedule

c. Meet each evening to review day's test results and to review or revise next day's test schedule

d. At end of test, meet to review list of deficiencies. ENGINEER will indicate those items which must be corrected prior to shipment

e. Confirm in writing, locations, times, and dates of test 2 weeks before tests

D. In-Factory Inspection and I/O Testing

1. Process Control System PLCs are required to pass in-factory inspection and testing prior to shipment to job site

2. Perform In-Factory inspection and testing at site of panel fabrication, witnessed by OWNER and ENGINEER.

3. In-Factory Inspection:

a. Verify the following in accordance with approved submittals:

(1) Panel dimensions

(2) Equipment layout

(3) Wiring

(4) Wire and terminal identification

b. Verify proper access to equipment for maintenance.

c. Verify proper access to field wire termination points.

d. Inspect for neatness of wiring and wire harness construction.

E. In-Factory Testing and Demonstration

1. Demonstrate proper wiring and fabrication of Process Control System PLC:

a. Perform initial in-house hardware configuration to assure system is ready to demonstrate prior to arrival of OWNER and ENGINEER

b. After successful initial in-house hardware configuration, notify ENGINEER of test date at least one week in advance.

2. Install Designer-configured PLC programming software, provided as part of the project, to permit the following:

a. Diagnostic test of PLC processor to assure proper run mode operation.

b. Diagnostic test of remote I/O to assure proper operation.

c. Inspection of PLC data table to allow viewing of discrete input on/off status.

d. Inspection of PLC data table to view register contents when inputs are tested at 0, 4, 12, and 20 mA DC.

e. Forcing of all digital outputs

f. Generation of 4, 12, and 20 mA DC signals for all analog outputs

3. Test as follows:

a. Verify equipment and manuals against inventory lists.

b. Run hardware diagnostics.

c. Testing of all input and output (I/O) signals at terminal strip used for field terminations:

(1) Test change of state for all discrete inputs

(2) Test analog inputs at 0, 4, 12, and 20 mA DC

(3) Manipulate PLC data table or use forces to test response of all discrete output signals.

(4) Manipulate PLC data table to test response of all analog output signals at 4, 12, and 20 mA DC.

4. Correct any deficiencies discovered prior to shipment to jobsite.

F. Graphical Interface and Software Testing

1. Demonstrate proper graphical programming for all screens associated with the project:

a. Furnish Color Standards meeting the high-performance HMI standards and as follows:

(1) White: On

(2) Grey: Off

(3) Yellow: Fault Condition (Warning)

(4) Red: High Priority (Emergency)

(5) Black: Static Text

(6) Blue: Dynamic Text

(7) Green: Set Points

b. Navigation between equipment screens, overview screens, alarm screens

G. Communication Failure Testing

1. Demonstrate communication failure alarm when a network connection is lost:

a. Disconnect each data highway.

b. Verify communication alarms and failure modes.

H. Power Failure / System Restart Testing

1. Remove and then reconnect main power to system. Re-boot system and demonstrate start-up services and sequence for use by Operator.

I. Testing of Connection with other PLC systems

1. Demonstrate connection of between PLCs

2. Verify communication gateway to and from PLCs

3. Verify program and point mapping.

J. Documentation

1. Prepare in-factory inspection and testing sign-off document. Include the following in the document, as a minimum:

a. Project description and number

b. Company name for PLC SUPPLIER, OWNER, and ENGINEER

c. Section labeled “In-Factory Inspection”, with listing of items to be inspected as described above

(1) For each item, include area for initials of PLC SUPPLIER’s, OWNER’S, and ENGINEER’s representative indicating passing of inspection

(2) Include area for handwritten notes of any corrections required

END OF SECTION

SECTION 43 21 17

PUMP REFURBISHMENT

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for replacing existing engine drives and refurbishing existing pumps. The work includes the replacement of two engine drives with direct drive electric motors, new variable frequency drives, and all other associated Work as shown or specified for a complete and operable system. The work also includes the refurbishment of two existing pumps. Refurbishment includes removal, preparation for shipment, shipment, refurbishment, reinstallation, and startup testing and commissioning of the pumps.

1. Pump refurbishment includes the following items:

a. Complete pump teardown, inspection/analysis, and reassembly
b. Rehabilitation of the shaft
c. Rehabilitation of the bearings
d. Rehabilitation of tube nut assembly
e. Rehabilitation of the coatings
f. Replacement of the impeller, if required
g. Replacement of the bell suction, if required

B. Work Sequence Requirements: Coordinate the pump drives replacements and pump refurbishment work with the Authority and perform work within the time periods specified in Section 01 11 00-Summary of Work.

C. Related Work Specified in Other Sections Include:

1. Section 01 11 00 – Summary of Work
2. Section 02 41 00 – Demolition
3. Section 09 96 00 –High Performance Coatings
4. Section 26 05 80 – Electric Motors
5. Section 26 69 23 – Adjustable Frequency Drives

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. AWWA E101 - Vertical Turbine Pumps - Line Shaft and Submersible Types

2. ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, 800

3. ASTM A 48 - Specification for Grey Iron Castings

4. ASTMA A743 - Specification for Castings, Corrosion Resistant

5. AWWA C 207 - Steel Pipe Flanges and Waterworks Service, Sizes 4 Inch Through 144 Inch (100 mm Through 3,600 mm)

6. Hydraulic Institute Standards.

1.3 SYSTEM DESCRIPTION

A. General: Provide refurbished pumps of the vertical turbine type, driven by a horizontal electric motor, with an above floor discharge. Mount the motor in place of the existing engine to be removed and modify the concrete pad per Contract Drawings.

1. Design the pumping equipment for installation in the spaces as shown, without appreciable revision to the piping, structure and foundation arrangement.

2. Design the pumping equipment for complete disassembly from above the pump mounting floor and with the lifting equipment shown.

3. Design pumping units in accordance with AWWA E101 Standard for Vertical Turbine Pumps, except as otherwise specified.

B. Pumped Fluid: Design the pumping units to pump nonpotable water.

C. Starting and Stopping: Provide pumping equipment capable of starting and stopping against a closed discharge valve.

D. Operating Conditions: Design the pumps to operate vortex free at the capacities and heads and over the range of operating conditions specified without cavitation, undue noise and vibration. Furnish pumps in accordance with the following requirements:

Rating Data	Unit
Capacity at rating point, gpm	35,800
Total head at rating point, feet	31
Pump speed, rpm	556
Motor horsepower	400

E. Natural Frequencies: Provide the pump, (suction barrel) and drive as installed with no natural frequencies occurring within 25 percent of any exciting frequency for the specified speeds. Exciting frequencies are periodic forces that may occur as the result of unbalance

(one times rotation), misalignment (two times rotational), vane pass (multiples of vane numbers), etc.

F. Reverse Speed: Design the pumping unit, including drive, to be capable of running safely at reverse runaway or provide the drive with a nonreverse ratchet.

1.4 SUBMITTALS

A. General: Include all submittals, including the following, as specified in Division 1.

B. Shop Drawings: Submit shop drawings, including arrangement and erection drawings of the equipment and equipment operating characteristics. Include the following:

1. Motor support plate drawings.

2. Motor equipment pad and anchor bolt drawings

3. Motor drawings and performance characteristics.

4. Flexible coupling drawings and rating data.

5. Pump refurbisher inspection report.

6. Submit a certificate of compliance and compatibility for the pumps, motors, adjustable frequency drives, controls, and control panels.

C. Operation and Maintenance: Submit pumping equipment operation and maintenance manuals.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver, store, and handle all products and materials as specified in Division 1.

1.6 SPARE PARTS AND TOOLS

A. General: Furnish the following spare parts:

1. One set of bearings

2. One set of gaskets and "O" rings

3. One set of wearing rings

4. One set of motor bearings for each new motor

Note: One set means all those items necessary for a complete pumping unit.

B. Identification: Plainly tag and mark spare parts for identification and reordering, and properly box spare parts.

C. Special Tools: Furnish a complete set of special wrenches and other special tools required for the removal, dismantling, reassembling and maintaining the pumping units. Provide tools of forged steel, case hardened, and full finished. Furnish special tools in a metal tool case with a handle and provisions for padlocking.

D. Lifting Devices: Provide lifting lugs or any special lifting devices necessary for pumping unit installation, removal and dismantling.

PART 2 PRODUCTS

2.1 EQUIPMENT SUPPLIER

A. Obtain the variable frequency drive and motor from either the motor or variable frequency drive manufacturer who is to be responsible for:

1. Furnishing the variable frequency drives, motors, controls and control panels and all appurtenant equipment specified.

2. All coordination of the characteristics of the equipment, furnished, including the exchange of pertinent data between manufacturers of equipment, prior to shop drawing submittal.

3. Acquisition and submittal of a certificate from each of the manufacturers of the motors, variable frequency drives, controls and control panels that states that the equipment furnished by the manufacturer is compatible with the equipment items furnished by the other manufacturers.

4. Sound power level performance.

B. Provide all motors produced by single manufacturer and all variable frequency drives produced by a single manufacturer.

2.2 MANUFACTURERS

A. Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted.

1. Pump Refurbishment

a. Ruhrpumpen

(1) Contact: Jamin Baker, (918) 624-2370

2. Motors

a. TECO-Westinghouse Motor Company
b. U.S. Motors
c. Nidec Motor Corporation

2.3 PUMP REFURBISHMENTS

A. Dismantling and Inspection:

1. Each pump shall be disassembled into its basic components for cleaning and inspection. Basic components include such items as suction bowl, impeller, diffuser, discharge head, shaft, stuffing box and other components bolted together. Match mark the flanges of each component prior to disassembly to permit reassembly with the components in the same relative position as originally assembled.

2. All pump parts shall be cleaned prior to inspection. The cleaning shall remove dirt, grit, grease and rust scale. All internal surfaces of the basic pump components shall be glass bead blast cleaned to remove rust scale.

3. Each component shall be inspected for wear, corrosion and other damage. Sleeve bearing bores, bearing journal diameters and male-female fits shall be measured with a micrometer. Shaft run-out shall be checked with a dial indicator.

4. A PDF copy (hard copies to be supplied if required by Owner) of an inspection report for each pump shall be submitted to the Engineer. Each report shall show the results of the inspections and measurements and photographs of component part defects and shall indicate which component parts are suitable for reuse. Component parts that are suitable for reuse and are specified to be replaced by new parts, shall be returned to the Authority. Components parts not suitable for reuse shall be properly disposed of by the refurbisher.

B. Refurbishments:

1. Replace the pump impellers.

a. Replacement impellers shall be dynamically balanced.

b. Replacement impellers shall be constructed geometrically identical to the original impellers in order to provide the same pump performance characteristics and

mechanical integrity. The impeller shall be a one piece casting of ASTM A 743 Grade CA6NM stainless steel.

c. Replacement impellers shall have vanes equally spaced and with uniformly rounded inlet edges and water passages with smooth contours.

2. Replace the suction bells. Replacement suction bells shall be one-piece casting of ASTM A 743 Grade CA6NM stainless steel.

3. Blast clean and coat the internal surfaces (wetted) of the discharge bowls. Coat with Belzona 1341 Supermetalglide. Clean and coat in accordance with coating manufacturer's instructions.

4. Replace the pump shafts. Replacement pump shafts shall be constructed of 416 stainless steel. The shafts shall be accurately machined and polished and shall be of the same size and design as the original equipment.

5. Replace the bowl, tail and stuffing box bearings. The replacement bearings shall be constructed of leaded bronze. The bearings shall be of the sleeve type, accurately machined, polished and grooved and shall be of the same design and size as the original equipment.

6. Replace the pump thrust bearing. Provide new anti-friction bearings of the same size and type as the original equipment.

7. All grease fittings, gaskets, "O" rings and seals shall be replaced.

8. Any shaft keys, bolts, nuts, studs and other fasteners that are damaged by corrosion shall be replaced with keys and fasteners of the same size, design and material as the original.

9. Each stuffing box shall be properly packaged with suitable soft, graphite impregnated, nonasbestos packing material.

C. Painting: Shop paint pumps in accordance with the requirements of Section 09 96 00.

D. Shop Assembly: Shop assemble pumps prior to shipment. Reassemble components the same relative position as received, align match marks on component flanges.

2.4 MOTORS

A. General: Provide drive motors with a voltage rating at 460 volts, 3 phase, 60 hertz, meeting the requirements of Section 26 05 80.

B. Reverse Rotation Ratchets: Provide reverse rotation ratchets to protect the motor from reverse runaway speed.

C. Thrust Bearing: Equip each motor with a suitable thrust bearing for the loads imposed by the axial thrust of the pump and the weight of the rotating element. Design the thrust bearing to operate without any external means of cooling.

2.5 MOTOR MOUNTING

A. General: Provide each motor with a steel mounting plate, stainless steel mounting bolts, washers, nuts, shims and all appurtenances necessary for a complete installation.

B. Mounting Plate: Provide a mounting plate designed to support the new motor from the new concrete equipment pad and with the motor and pump shaft in alignment. Fabricate from steel plate. The mounting plate shall have a neat and finished appearance, free of sharp edges and gouges. The mounting plate shall extend not less than I-inch beyond the overall length and width of the mounting of the motor. Provide center hole or cutout to facilitate installing grout. The mounting surface shall be machined to a 63RMS micro inch finish and a maximum flatness tolerance of .0005 inch per lineal foot. Furnish each pedestal shop primed and field painted in accordance with the requirements of Section 9900 “Painting”. Submit the motor mounting plate design for approval before beginning the modifications.

2.6 FLEXIBLE COUPLINGS

A. Provide new flexible couplings to connect the new motors to the pump shafts.

B. Provide couplings rated to transmit the maximum pump load torque with a 1.5 service factor and suitable for pump drive service. The couplings’ torsional characteristics shall be as required to preclude detrimental torsional vibrations in the motor and pump rotating components. A torsional natural frequency analysis of motor and pump system shall be performed by the pump manufacturer. Provide drive coupling, motor and pump rotating assembly mass elastic data and other information required by the pump manufacturer to perform a torsional natural frequency analysis of motor and pump system. The pump manufacturer shall review the analysis results. Any changes in the drive coupling or rotating assembly required to alleviate any diverse torsional response shall be provided at no additional cost.

C. Provide flexible grid, piloted couplings for the motor and pumps and a piloted floating shaft designed to span the distance between the motor and pump shafts. Provide a Type T50 as manufactured by the Falk Corporation.

D. Fit and key the half couplings to the existing pump and new motor shafts. Do not exceed .002 inches maximum clearance fit for the coupling diameter and key width. Furnish fully finished keys constructed of AISI 1018 cold drawn steel.

E. Following the coupling manufacturer's installation instructions. Heat the half coupling hubs as required to ease assembly.

2.7 COUPLING GUARDS

A. Furnish and install coupling guards for each drive unit.

B. The coupling guards shall cover all rotating parts between the engines and driven equipment and shall be designed in accordance with OSHA requirements.

C. Each guard enclosure shall be fabricated sheet steel, supported from the station floor and designed to be removable. The guard shall have a neat and finished appearance, free of sharp edges and corners.

D. The guards shall be shop painted in accordance with the requirements of Section 09 96 00 "High Performance Coatings".

E. All bolts, nuts and washer shall be stainless steel.

2.8 CONTROLS AND OPERATION

A. Control equipment shall be supplied by the Contractor in accordance with Section 40 90 50.

B. Programmable logic controllers shall be provided by the Contractor in accordance with Section 40 94 43.

PART 3 EXECUTION

3.1 INSTALLATION

A. General: Remove, refurbish and reinstall pumps and install the new motors, in accordance with constraints specified in Section 01 11 00.

B. Site Inspection: Before work is started, the contractor shall inspect the existing equipment affected by the work. Care shall be taken to observe and record any existing equipment defects.

C. Install new work in accordance with the approved submittals and pump manufacturer's recommendations.

D. Pump manufacturer's trained representative to remove and install new pump replacement parts.

3.2 PUMP REMOVAL AND REINSTALLATION

A. Dismantling, Removal and Shipping

1. Disconnect all mechanical and electrical services affected by the work.

2. Dismantle all connections and attachments to Pumps W1 and W2 and their accessories to permit removal.

3. Match mark the flanges of each pump component prior to removal in order to facilitate pump reassembly with the components in the same relative position as installed.

4. Remove Pumps W1 and W2 from their operating positions.

5. Disassemble Pumps W1 and W2 as required to permit removal from the station.

6. Properly prepare pumps for shipment to prevent damage during shipment. Obtain and follow the manufacturer's special instructions where applicable.

7. Ship Pumps W1 and W2 to the manufacturer's repair facility.

B. Return Shipment and Reinstallation

1. Prepare Pumps W1 and W2 for shipment from the manufacturer's repair facility in the same manner as described in Subsection 3.2.A.5.

2. Ship Pumps W1 and W2 from the manufacturer's repair facility to the pump station.

3. Reinstall Pumps W1 and W2 into their original operating position.

4. Where field assembly of Pumps W1 and W2 is necessary, obtain and follow the manufacturer's instructions.

5. Reassemble all connections and attachments to Pumps W1 and W2.

6. Install all new accessories.

7. Reconnect all mechanical and electrical services.

8. Restore the equipment to its full and proper operating condition.

3.3 MOTOR INSTALLATION

A. Motor Mounting Plate Installation and Grouting: Install mounting plates as follows:

1. Install leveling wedges or jack-screws to support the mounting plate at each anchor bolt. Provide approximately 1-1/2 to 2 inches grout allowance between mounting plate and concrete pad and provide approximately 1/8 inch shim allowance between motor foot and mounting plate as shown.

2. Check alignment to pump shaft.

3. Adjust leveling wedges or jack-screws to level the mounting plate. Tighten the foundation bolts evenly but not too firmly. Level the mounting plate to within .001 inches per foot.

4. Fill grout space with non-shrink grout as specified in Section 03 60 00.

5. Fully tighten the anchor bolts after grout has cured.

B. Coupling Installation: Install new flexible couplings and shaft keys on the pump and motor shafts. Follow the manufacturer's installation instructions. Heat half-coupling hubs as required to ease assembly. Sledging or hammering of the hubs is not permitted.

C. Motor Installation: Install new motor into its operating position and assemble all connections and attachments.

D. Motor and Pump Alignment: Perform motor and pump shaft alignment using laser alignment equipment. Use personnel who are experienced in machinery alignment. Align the shafts as follows:

1. Align motor and pump shafts after the grout has cured.

2. Align shafts to obtain .0035 inches maximum parallel offset and .007 inches maximum angular misalignment.

3. Use stainless steel shims with an area equal to the motor's load bearing surface and with "U" shaped slots to fit around the bolts.

4. Verify the motor soft foot condition does not exceed the maximum soft foot tolerance. Use the following procedure:

   a. Check that all mounting bolts are tight before proceeding.

   b. Set a dial indicator on the foot being checked.

   c. Zero the dial indicator on the foot being checked.

   d. Loosen the mounting bolt on the foot being checked and observe the indicator defection. A maximum deflection of .002 inches is permitted.

   e. Retighten the mounting bolt and repeat this procedure for all feet.

   f. Inspect each bolt for clearance relative to its bolt hole. Correct any bolt and bolt hole binding or interference.

   g. Correct any soft foot condition that exceeds the .002 inch limit. Verify the pump and motor alignment after making any corrections.

   h. Perform soft foot and bolt clearance inspection in the presence of the ENGINEER.

5. Re-check the alignment after the unit has been operated. Record the final alignment values in the presence of the ENGINEER.

3.4 PAINTING

A. Field Painting: Paint the motor mounting plate and coupling guard in accordance with the requirements of Section 09 96 00 “High Performance Coatings”. Submit color samples for approval.

3.5 FIELD QUALITY CONTROL

A. Manufacturer’s Field Services: Furnish the services of the motor, variable frequency drive and pump manufacturer to provide proper installation of the equipment, inspect the completed installation, make any necessary adjustments,

participate in startup and field testing of the equipment, and place the equipment in trouble-free operation as specified in Division 1.

B. Tests: After installation of each motor, variable frequency drive, refurbished pump and all appurtenances, subject the units to a field running test, as specified in Division 1, under actual operating conditions. Perform field tests int eh presence of, and as directed by, the Owner and Engineer.

1. Demonstrate that under all conditions of operation each unit:
   a. Has not been damaged by transportation or installation.
   b. Has been properly installed.
   c. Has no mechanical defects.
   d. has been connected properly.
   e. Is free of overheating oof any parts.
   f. Is free of overloading of any parts.

2. Test the pumping units to demonstrate that the pumps and control system operate as specified. Promptly correct any defects in the equipment or failure to meet the requirements of the specifications. Pumps shall run satisfactorily, without fault, for 100 hours under normal operating conditions. Any failure during the test will result in resetting the 100 hour test requirement duration.

END OF SECTION