

Contract Documents

For

BROADVIEW AQUIFER STORAGE AND RECOVERY PROJECT

Wells Equipping and Site Improvements

Specification No. 23-04

Bids will be received until 3:00 p.m., October 11, 2023 and publicly opened on October 11, 2023 at 3:00 p.m. at Westlands Water District Office, 3130 North Fresno Street, Fresno, California 93703

INVITATION FOR BIDS FOR BROADVIEW AQUIFER STORAGE AND RECOVERY PROJECT

Wells Equipping and Site Improvements

SPECIFICATION NO. 23-04

Board of Directors

Jeff Fortune, President Jim Anderson, Vice-President Kevin Assemi William Bourdeau Frank Coelho, Jr. Ernie Costamanga Justin Diener Donald Ross Franson III Jeremy Hughes

District Staff

Allison Febbo, General Manager Jose L. Gutierrez, Chief Operating Officer

TABL	E OF	CONTENTS
------	------	-----------------

	Page
Notice Inviting Bids	NIB-1
Instructions to Bidders	IB-1
B - 1 Form of Bid and Signature	IB-1
B - 2 Preparation and Submission of the Bid	IB-1
B - 3 Consideration of Bids	IB-1
B - 4 Qualifications	IB-1
B - 5 Bid Security	IB-1
B – 6 DIR Registration and Prevailing Wages	IB-2
B - 7 Local Conditions	IB-2
B - 8 Execution of Contract	IB-2
B - 9 Bonds	IB-3
B - 10 Liability	IB-3
B - 11 Insurance	IB-3
B - 12 Interpretation of Bid Documents	IB-4
B - 13 Addenda	IB-4
B - 14 Subcontracts	IB-4
B - 15 Schedule	IB-4
Bid Form	P-1
Qualifications	P-3
Designation of Subcontractors	P-4
Bidding Schedule	P-5
Noncollusion Declaration	ND-1
Contract Agreement	CA-1
General Conditions	GC-1
Article 1 Definitions	GC-3
Article 2 Contract Documents	GC-4
Article 3 Indemnification and Insurance	GC-6
Article 4 Permits, Licenses, Ordinances, and Regulations	GC-8

Article 5 Drawings and Specifications	GC-8
Article 6 Subcontractors	GC-9
Article 7 State Requirements Regarding Wages, Hours, and Equal Opportunity	GC-10
Article 8 Supervision and Labor	GC-12
Article 9 Inspection and Testing	GC-13
Article 10 Protection of Workers, Public, and Property	GC-14
Article 11 Submittals and Materials	GC-17
Article 12 Payments	GC-19
Article 13 [Reserved]	GC-21
Article 14 Delays and Extensions of Time	GC-21
Article 15 Changes to the Work	GC-23
Article 16 [Reserved]	GC-25
Article 17 Rejection and Replacement of Work and Materials	GC-25
Article 18 District's Right to Terminate the Contract	GC-26
Article 19 Preservation and Cleaning	GC-27
Article 20 Completion, Inspection and Occupancy by District	GC-27
Article 21 Contract Closeout	GC-28
Article 22 Guarantees	GC-29
Article 23 Claim Requirements	GC-29
Article 24 Additional Provisions	GC-34
Division 01 Specifications	
01200 Measurement and Payment	01200-1
01330 Submittals	01330-1
Technical Specifications	
Section XX	XXXXX-1

Figures

Vicinity Map	F-1
Location Map	F-2

WESTLANDS WATER DISTRICT

NOTICE INVITING BIDS

BROADVIEW AQUIFER STORAGE AND RECOVERY PROJECT, 23-04

Notice is hereby given that:

A-1. Sealed bids for the well equipping and construction of site improvements for one aquifer storage and recovery (ASR) wells that will accept an injection flowrate of up to approximately 1,500 gallons per minute ("Project"), including all other work in accordance with the District's Specification No. 23-04, will be received by Westlands Water District by electronic submittal until 3:00 p.m., Pacific Daylight Savings Time, October 11, 2023. The submitted bids will be publicly opened and read live, either in person or online via video conferencing on October 11, 2023, 3:00 p.m., Pacific Daylight Savings Time. The selection of the bid opening venue will be made no later than one week prior to the bid submission deadline. Those prospective bidders that attended the entirety of the pre-bid meeting will be notified via email and notice will be posted on the District's website as soon as a venue is selected. The link and instructions to attend an online bid opening will be provided one week prior to the conference. Bidders are encouraged to test their Internet viewing capability in advance of bid will be considered unless it is received prior to the bidding deadline.

A-2. The District reserves the right, after opening bids, to reject all bids, which may or may not include rebidding the work, and to waive any immaterial irregularity in any bid. With the Engineer's recommendation, the General Manager may award the Contract to the lowest responsive, responsible Bidder. Bids will be compared on the basis of the Engineer's estimate of the quantities of the several items of work shown in the Bidding Schedules.

A-3. Bidders are required to attend a mandatory pre-bid conference with District personnel to familiarize themselves with existing conditions and clarify any Specification details. Bidders are to meet at Westlands Water District Tranquillity Field Office, 32650 W. Adams Ave, Tranquillity, CA 93668 at 10:00am on September 27, 2023, and from there, bidders will be escorted to the job site. Attendance for the duration of the meeting and site visit is mandatory, and each Bidder shall be required to sign in at the pre-bid conference and to certify on its Bid Documents that the Bidder attended the entirety of the conference. Failure to attend the pre-bid conference waives the right to submit a bid.

A-4. Bids shall be submitted in a sealed envelope addressed to the District and labeled with the name and address of the Bidder and the name of the Project. No bid will be accepted which is not on the bid form included in the Bid Documents. No bid will be accepted from a bidder who is not licensed in accordance with the California Contractors License Law (California Business and Professions Code Sections 7000 *et seq.*). The successful Bidder will be required to possess a current and valid California Contractor's License of the following class: C-57. No bid will be accepted from a Bidder who is not registered with the Department of Industrial Relations (DIR) as required by Labor Code section 1725.5.

A-5. Each bid must be accompanied by Bid Security in the amount of not less than <u>Ten Percent</u> (10%) of the Total Bid Amount, in the form of a certified check, a cashier's check, a bidder's bond issued by a corporate surety acceptable to the District, or cash, as a guaranty that the Bidder will, if an award is made to it in accordance with the terms of its bid, promptly secure the required insurance, payment bond, and performance bond, and execute an Agreement in the required form. A bid may be withdrawn prior to bid opening, but a Bidder may not withdraw its bid for a period of 45 days after the date and time set for the opening thereof without forfeiting its Bid Security.

A-6. The Project is a public works project within the requirements of Division 2, Part 7, Chapter 1 of the California Labor Code, and, as a result, the Contractor must pay prevailing wages under Labor Code Section 1771. In accordance with the provisions of Sections 1770 through 1773.5 of the California Labor Code, the Director of DIR has determined the general prevailing rates of wages and employer payments for workmen needed to perform the Contract. Said rates are on file at the District Office, are incorporated herein by reference, and will be made available to any interested party on request.

A-7. Pursuant to Public Contract Code section 22300, securities may be substituted for any money to be withheld by the District from the Contractor to ensure performance under the Contract. At the request and expense of the Contractor, eligible securities equivalent to the amount to be withheld shall be deposited with the District Treasurer or a state or federally chartered bank as the escrow agent. Such securities shall be delivered to the Contractor only upon satisfactory completion of the Contract. The Contractor shall be the beneficial owner of any securities substituted for moneys withheld and shall receive any interest thereon.

A-8. The Bid Documents shall consist of this Notice Inviting Bids, together with the Instructions to Bidders, Bid, Bidding Schedule(s), Agreement, Specifications, and the Drawings listed therein, and any addenda that may be issued by the District prior to the time set for the opening of bids.

Dated: 09/15/2023

WESTLANDS WATER DISTRICT

By

Jose L. Gutierrez, P.E. Chief Operating Officer

INSTRUCTIONS TO BIDDERS

B-1 FORM OF BID AND SIGNATURE. The bid shall be submitted on the attached form and shall be enclosed in a sealed envelope plainly marked with the name and address of the Bidder and "Proposal for," followed by the name of the Project and the date of opening bids. The Bid Security shall be enclosed in the same envelope with the bid.

If the bid is made by an individual, it shall be signed by the Bidder; if it is made by a partnership or limited liability company, it shall be signed in the firm's name by a member of the firm with authority to bind the Bidder; and if it is made by a corporation or joint venture, it shall be signed by its duly authorized officer. Bids will be considered from licensed contractors who are registered with the Department of Industrial Relations (DIR) under Labor Code section 1725.5 only, and the Bidder shall give its license number and classification and DIR registration number in the place provided therefor in the bid form.

- B-2 **PREPARATION AND SUBMISSION OF THE BID**. Blank spaces in the bid form shall be properly completed. The bid form must not be changed or made conditional. Alterations by erasure or interlineation must be initialed by the Bidder. Alternative bids will not be considered unless specifically provided for. A Bidder may withdraw its bid before the hour fixed for opening bids, without prejudice to resubmitting a bid, by submitting a written request to the Supervisor of Procurement and Fleet Services for its withdrawal. No bid may be withdrawn after the hour fixed for opening bids without forfeiture of the Bid Security, except in accordance with Public Contract Code sections 5100 *et seq.*. No bid received after the time named, or at any place other than the place stated in the Notice Inviting Bids, will be considered. Telephone, email, or faxed bids or modifications will not be accepted. Bidders shall prepare bids at their own expense. Westlands will not reimburse any costs associated with submittal of any bid.
- B 3 **CONSIDERATION OF BIDS**. The bid opening and tabulation will be conducted live either in person or online via a group meeting software. The selection of the bid opening venue will be made no later than one week prior to the bid submission deadline. Those prospective bidders that attended the entirety of the pre-bid meeting will be notified via email and notice will be posted on the District's website as soon as a venue is selected. The link and instructions to attend an online bid opening will be provided one week prior to the conference. All bids will be opened and declared publicly. Bidders, their representative, and others interested are invited to be present at the opening. Participation in the bid opening is not mandatory as the successful bidder will be notified independently. The meeting link will be provided to bidders having uploaded timely bids. Additionally, the link to bid opening access notice will be posted to the public on the District website under the notices section (wwd.ca.gov/news-andreports/notices/). All interested parties are encouraged to test their Internet viewing capability in advance as the District assumes no responsibility for connectivity or other technical viewing problems during the bid opening, and inability to view the bid opening will not serve as grounds for protest.

The District may evaluate a Bidder's and its subcontractors' quality, fitness, capacity, and experience to satisfactorily perform the work, as well as their trustworthiness, prior to selecting the lowest responsible Bidder, and may reject a bid if the Bidder is found not to be responsible following the hearing required by law. The District will reject any bid not accompanied by the required Bid Security or otherwise materially deviating from the requirements of the Bid Documents. The District reserves the right either to waive any immaterial irregularity in a bid or to reject a bid containing such a deviation. The District may reject all bids upon a finding that such rejection is necessary and in the best interest of the District.

The Bidder shall state in figures the unit prices and extended prices, or the lump sum price, for which it proposes to supply the labor, materials, supplies, or machinery, and perform the work required by the Specifications. If the unit price and extended price for any item are not

consistent, then the unit price will control, and the extended price will be corrected to conform thereto. The sum of the extended bid items shall control over the stated bid amount, and if the sum of the extended bid items does not equal the stated bid amount, then the District shall correct the bid amount. Where unit prices are called for, modifications to the extended price will not modify the unit price.

- B 4 **QUALIFICATIONS**. See pages P-3 and P-4 of the Bid Form
- B 5 **BID SECURITY**. Each Bidder shall submit with its bid a certified check or cashier's check made payable to Westlands Water District, or a bidder's bond issued by a corporate surety satisfactory to the District, in the amount of at least ten percent (10%) of the total bid amount ("Bid Security"), as a guaranty that the Bidder will, if an award is made to it in accordance with the terms of its bid, promptly execute an Agreement in the required form, obtain the required performance and payment bonds, and satisfy the insurance requirements set forth herein. If a Bidder to whom an award is made fails to do so within the time stated in paragraph B-8 hereof, then the Bid Security shall be used to compensate the District for the difference in price between the low bidder's bid price and the price at which the Contract is awarded, as well as all other expenses of the District, including without limitation attorneys' fees and any necessary acceleration costs due to the delay, incurred as a result of the Bidder's failure(s). The Bid Security of all other bidders, including the Contractor, will be returned after the Agreement is executed and required bonds and insurance have been provided.
- B-6 **DIR REGISTRATION AND PREVAILING WAGES**. The Project is a public works project within the requirements of Division 2, Part 7, Chapter 1 of the California Labor Code. As such, the Bidder and all subcontractors are required to be registered pursuant to Labor Code section 1725.5 at the time of bidding. Failure of the Bidder to be registered at the time of bidding shall render the bid non-responsive and unavailable for award. A subcontractor who is unregistered at the time of bidding will not be permitted to work on the Project. If any subcontractor required to be listed in the bid is unregistered, the Contractor will be required to substitute that subcontractor with a registered Subcontractor at no additional cost to the District. Bidders shall provide the DIR registration numbers for all listed subcontractors within 24 hours of bid opening and registration numbers of all subcontractors who are not required to be listed not later than 24 hours before they are to start work on the Project.

This project is a "public work," as that term is defined by Labor Code Section 1720, so is subject to prevailing wages under Labor Code Section 1771. Contractor and its subcontractors shall fully comply with all the provisions of the California Labor Code governing the performance of public works contracts including, but not limited to, payment of prevailing wages, limitations on time worked, compliance with apprentice requirements, maintenance of payroll records, posting of wages at the job site, and prohibitions against discrimination. Copies of such prevailing rate of per diem wages are available upon request at Westlands' office, 3130 93703-6056 Fresno Street, Fresno, CA the Internet N. or on at http://www.dir.ca.gov/OPRL/PWD. This Project is subject to compliance monitoring and enforcement by the California Department of Industrial Relations.

B - 7 **LOCAL CONDITIONS**. By submitting a bid, the Bidder represents that it has reviewed the Specifications, Drawings, and other Contract Documents; has adequately inspected the Project site; and has reviewed local conditions, uncertainty of weather, and all other contingencies sufficient to allow the Bidder to bid. The District assumes no responsibility with respect to the sufficiency or accuracy of borings or of the log of test borings or other preliminary investigations or of the interpretation thereof, and does not guaranty, expressly or impliedly, that the conditions indicated are representative of those existing throughout the Project. If provided, test borings, soils studies and/or any other report of subsurface conditions are included only for the convenience of bidders, and shall not be construed as a waiver of the requirement for bidders to satisfy themselves through their own investigations as to the conditions to be encountered. The quantities of work or material stated in the unit price items of the Bidding Schedules are given only as a basis for the comparison of bids, and the District

does not expressly or by implication agree that the actual amount of work or material will correspond therewith. Contractor shall have no claim for damages or loss of profits or otherwise because of any difference between the quantities of work actually done and material furnished and those stated in said unit price items of the Bidding Schedules.

- B 8 EXECUTION OF CONTRACT. A Bidder to whom the award is made shall execute a written Contract with the District on the form of Agreement attached hereto, satisfy the insurance requirements set forth herein, and furnish bonds as required in the following paragraph, all within 10 days from the date of the District's Notice of Intent to award the Contract, or such later time allowed by the District. If a Bidder to whom award is made fails or refuses to enter into the Contract or to conform to any of the requirements stated herein, then the Bidder forfeits its Bid Security, and the District may award the Contract to the next lowest responsible bidder. A corporation to which an award is made will be required, before the Contract is finally executed, to furnish evidence of its corporate existence, of its right to do business in California, and of the authority of the officer signing the Contract and bonds for the corporation to so sign.
- B-9 **BONDS.** A Bidder to whom the Contract is awarded shall within the time mentioned in the preceding paragraph furnish the following bonds issued in a form and by a corporate surety acceptable to the District: a) a performance bond conditioned upon the faithful performance by the bidder of all covenants and stipulations in the Contract and b) in accordance with the provisions of Civil Code sections 9550 *et seq.*, a payment bond. Each bond shall be in an amount not less than 100 percent of the estimated aggregate payments to be made under the Contract. All bonds shall be furnished by the Bidder to whom the Contract has been awarded at its own cost and expense.
- B 10 LIABILITY. Contractor will be responsible for completing the work in accordance with the Contract and will be responsible for any and all injury or damage arising out of its or its subcontractors' performance of the work, except for injury or damage caused by the active or sole negligence or willful misconduct of the District. The Contractor shall assume the defense of, indemnify, and hold harmless the District, its officers, officials, directors, employees, and agents, from and against any loss, liability, expense, claims, costs, including attorneys' fees, suits, and damages therefor, excluding indemnification for injury or damage caused by the active or sole negligence or willful misconduct of the District.
- B 11 INSURANCE. After notice of intent to award the Contract, the Contractor shall promptly obtain, at its own expense, all required insurance and shall submit a completed insurance coverage verification form for review and approval by the District. The insurance requirements must be met within the period allowed for Contract execution. Approval of the insurance coverage by the District does not relieve the Contractor or subcontractors from liability under paragraph B-10. The Contract will not be executed by the District, and the Contractor shall not begin work, until such insurance has been approved by the District. The Contractor shall not allow any subcontractor to begin work on its subcontract until all similar insurance required of the subcontractor has been obtained.
- B 12 INTERPRETATION OF BID DOCUMENTS. Should a bidder find discrepancies in, or omissions from, the Bid Documents, or should it be in doubt as to their meaning, it shall at once notify the Engineer in writing. Should it be found that clarification is required, a written Addendum will be sent to all bidders. Any such issue which is not raised with the Engineer at least two (2) days prior to the bid deadline shall be waived, and the District will not consider any challenge based on the contents, structure, or terms of the Bid Documents after the bid deadline. The District shall be bound only by written responses to questions contained in an addendum. Oral responses or email responses shall not be binding on the District.
- B 13 **ADDENDA.** Any Addenda supplementing the Bid Documents and issued prior to the time set for the opening of bids shall form a part of the documents furnished the Bidder for the preparation of its bid. The Bidder must acknowledge all addenda in the bid.

The District reserves the right to postpone the date for presentation and opening of bids and will provide notice of any such postponement in an addendum to each prospective Bidder.

B - 17 **SUBCONTRACTS.** In accordance with the requirements of Public Contract Code sections 4100 *et seq.*, the bid shall list the name, location of the place of business, the California contractor license number, and public works contractor registration number issued pursuant to Section 1725.5 of the Labor Code of each subcontractor who will perform work or labor, render service, or specially fabricate and install a portion of the work in excess of one-half of one percent of the total amount of the bid. The Bidder shall specify the portion of the work which will be performed by each subcontractor. Only one subcontractor shall be listed for each portion of the work. If a Bidder fails to list a subcontractor for a portion of work in excess of one-half of one same portion of work, the Bidder represents that it is fully qualified to perform that portion itself, and that the Contractor shall perform that portion itself. A listed subcontractor must be used to perform the work for which it was listed and shall not be substituted except as permitted by law.

B - 18 SCHEDULE. Work Schedule is as follows:

The project is scheduled to occur between October 16, 2023 through January 30, 2023 ("Construction Window"), taking into consideration the proposed schedule submitted during the bidding process. The Contractor will have 110 days during the Construction Window and after the designated construction start date, identified in the Notice to Proceed to complete all the work described in the Contract Documents. The Contractor shall submit with the sealed bid a general schedule consisting of an estimated time to complete each milestone, and a requested start date based on the Contractor's anticipated availability. A final proposed schedule shall be submitted by the Contractor within ten (10) days after receipt of the Notice to Proceed, as provided in the contract. The proposed final schedule must include, but not limited to, in detail, the steps and time needed for site preparation, fencing and security, well pump and pedestal completion, shade structure, piping and mechanical, electrical and instrumentation, integration with engine, and final testing. This schedule will need to be coordinated with the District to ensure proper notification and scheduling of the lateral shutdown, and the final schedule shall be subject to District input and approval.

(THIS PAGE LET BLANK INTENTIONALLY)

BID FORM

BID FOR: Broadview Aquifer Storage and Recovery Project, 23-04

TO: Supervisor of Procurement & Fleet Services Westlands Water District 3130 N. Fresno Street P.O. Box 6056 Fresno, CA 93703

DIR Registration #_____ Expiration date: _____

To Whom It May Concern:

On behalf of Bidder, the undersigned hereby represents that Bidder's authorized representative attended the full duration of the pre-bid conference (if mandatory); that Bidder has read the Bid Documents and agrees to all the stipulations contained therein; that it has carefully examined the site of the work, the form of Agreement approved by the District, the Specifications and Drawings therein referred to, and other information regarding the project made available to bidders, and it proposes and agrees that, if its bid is accepted, it will contract in the form so approved to furnish and provide all labor, materials, supervision, transportation, tools, equipment, services and other facilities necessary and required for the expeditious complete the same within the time stipulated therein; and that it will accept in full payment therefor, the prices named in the Bidding Schedule.

Enclosed herewith is Bid Security in an amount not less than ten percent (10%) of the bid amount, made payable to the District as a guarantee that Bidder will enter into the Agreement and will furnish specified insurance and bonds. Bidder agrees that, upon receipt of written notice of the Intent to Award the Contract to Bidder based on this bid, it will execute the Agreement, secure the required insurance, and furnish the required bonds, all within 10 days from the date of receipt of the Notice, or within such additional time as may be allowed by the District; and that failure or refusal to do so within said time will forfeit the Bid Security. If Bidder timely executes the Agreement, secures the required insurance, and furnishes the required bonds, then the District shall return the Bid Security within three days thereafter, and the bid bond, if furnished, shall become void.

Surety(ies) that have agreed to provide payment and performance bonds:

The Bidder has investigated and is satisfied as to the conditions (including but not limited to, subsurface conditions to be encountered), the character, quality, and quantities of work to be performed and materials to be furnished, the difficulties to be encountered, and the requirements of the Bid Documents.

Bidder has notified the District of any discrepancies, ambiguities, inconsistencies, errors or omissions in the Bidding Documents, Contract Documents, applicable law or requirements, and/or of any doubt about the meaning of any of the Contract Documents. Bidder has contacted the District before bid date to verify that it has received any clarifying addenda, and acknowledges receipt of the following addenda:

(Include All Addenda Received)

NO.	DATE	
NO	DATE	
NO.	DATE	

The undersigned has the authority to bind Bidder to these representations and agreements, and does so under penalty of perjury of the laws of the State of California by the signature below.

NOTE: If Bidder is a corporation, the legal name of the corporation shall be set forth below; if Bidder is a partnership, limited liability company, or joint venture, the true name of the firm shall be set forth below.

NAME OF BIDDER: _____

BIDDER'S ADDRESS:

(Signed)

(Print Name)

(Title)

(Date)

Bidder is a (check one):

- □ Individual
- □ Partnership
- □ Limited Liability Company
- □ Corporation
- □ Joint Venture

BIDDER'S QUALIFICATIONS

The Bidder shall have no less than five (5) years of local (Central Valley of California) experience completing large wells (12" discharge producing 2,000 gpm or larger) and associated control valves, sand media filters, instrumentation, and controls. The Bidder must possess a valid and current Class A California Contractor's license.

The Bidder shall provide the following information and responses with the bid proposal:

- 1) A brief company history, business type, number of employees, and ownership. (attach to Bid Form)
- 2) Proposed project team including name, title, project role, years of experience, and contact information for the project manager(s) and all proposed project supervisors and drillers. (attach to Bid Form)
- 3) Health and safety program:
 - a) Does your company have a health and safety training program? <u>Yes</u> <u>or No</u>
 - b) Does your company have written health and safety procedures? <u>Yes</u> <u>or No</u>
 - c) Does your company have a medical surveillance and substance abuse program? <u>Yes or No</u>
 - d) Has your company had any work-related fatalities in the last three years? <u>Yes or</u> <u>No</u>
 - e) What is the frequency of job site safety meetings?
 - f) Provide the following information regarding your company's safety organization and safety performance.

Name of Company's Safety Officer(s):		
Safety Certifications		
Certification Name	Issuing Agency	Expiration

Provide Worker's Compensation Insurance Experience Modification Rate (EMR), Total Recordable Frequency Rate (TRFR) for incidents, and Total Number of Recorded Manhours (MH) for the last 3 years.

Year									
Legal Name of Company	EM R	TRF R	MH	EM R	TRF R	MH	EM R	TRF R	MH

- 4) A statement of availability and a start date for project. (attach to Bid Form)
- 5) A list of project-specific experience for three (3) similar projects (attach to Bid Form):
 - a) Project Name:
 - Well Discharge Diameter and Flow: b)
 - c) Location:
 - Owner and Owner Contact Name: d)
 - Contract Value: e)
 - f) Scope of Work (site description, project materials, production capacity, etc.)
 - Month/Year Completed: g) h)
 - Project Duration:

BIDDER'S REFERENCES

The following contracts have been completed in the last five years for the persons, firm or authority indicated, and to whom reference is made. Public works projects involving similar work are preferred. (Name three contracts.)

1. Project Name:						
Year(s):	Contract Amount: \$					
D Prime Contrac	t \Box Subcontract (subcontract amount)					
Project Owner:	Name Address					
Project Contact: _	Name	Position				
-	Phone Number	Email				
Project Description	Project Description (type of work):					
2. Project Name:						
Year(s):	Contract Amount: \$					
□ Prime Contrac	t \Box Subcontract (subcontract amount)					
Project Owner:	Name Address					
Project Contact: _	Name	Position				
-	Phone Number	Email				
Project Description	n (type of work):					

 Prime Contract Subcontract (subcontract amount) Project Owner: Name Address 	\$
Project Owner:Address	
Project Contact:	Positior
Phone Number	Email
Project Description (type of work):	

DESIGNATION OF SUBCONTRACTORS

LIST OF SUBCONTRACTORS FOR _____

(BIDDER)

PROJECT:

Pursuant to the provisions of Sections 4100 to 4114 inclusive, of the California Public Contract Code, the above-named Bidder hereby designates below the names, portion of work, contractor license numbers, locations of the place of business, and DIR registration number of each subcontractor. Please check one of the boxes and sign below:

We are not using any Subcontractors.

_____ All of our Subcontractors are performing at least 1/2 of 1% of the Work listed below, including additive alternates, if any.

PORTION OF WORK	SUBCONTRACTOR NAME	LICENSE NUMBER	SUBCONTRACTOR ADDRESS	DIR REGISTRATION NUMBER

Signed:

BIDDING SCHEDULE

Bidder's Name:

PROJECT: Broadview Aquifer Storage and Recovery Project, 23-04

NOTE: NOTE: The work associated with this Bid Schedule shall be based on the Contractor performing all work in accordance with the Bid Documents, General Conditions, Technical Specifications and Figures, and includes all costs to perform the complete Project work. Bid items 1 through 31 include all work set forth under the contract. Bid prices shall include everything necessary for the completion of the work including, but not limited to, providing the materials, equipment, tools, plant and other facilities, and the management, superintendence, labor and services. Bid prices shall include allowance for federal, state and local taxes.

Abbreviations used in the Bidding Schedule are defined as follows:

LF -- linear feet EA -- each LS -- lump sum SF - square feet CY - cubic yard

Bid Schedule for Broadview ASR Well Completion and Site Improvements

Item No.	Work or Material	Estimated Quantity	Unit Price	Extended Amount
1.	Project Mobilization/ Demobilization	1 LS		
2.	Final Site Cleanup	1 LS		
3.	AB Surface Pads (5" thk.)	5,500 SF		
4.	Compaction for New Road	27,000 SF		
5.	Earthwork and Grading	320 CY		
6.	Filters and Chemicals Conc. Pads	340 SF		
7.	6' + Barbed Wire Fencing (optional)	440 LF		
8.	Barbed Wire Gate (optional)	1 EA		
9.	Bar Vehicle Gate (optional)	1 EA		
10.	8 Tank Ag Sand Media Filter System	1 LS		
11.	Yard Piping and Valves	1 LS		
12.	Well Pump and Pedestal	1 LS		
13.	10" Well Pump Column	500 LF		

14.	Well Pump Intake - PVC	500 LF					
15.	2.5" Well Injection Layflat Tubing	1,000 LF					
16.	Chemical Storage and Injection Systems	1 LS					
17.	1000 Gallon Diesel Nurse Tank	1 LS					
18.	Shade Structure	1 LS					
19.	PV Array	1 LS					
20.	Batteries	1 LS					
21.	Battery Inverter / Charge Controller	1 LS					
22.	Lighting Panelboards	1 LS					
23.	Cathodic Corrosion Protection System	1 LS					
24.	Other Electrical	1 LS					
25.	PLC	1 LS					
26.	Instrumentation	1 LS					
27.	Cameras and NVR	1 LS					
28.	PLC Programming	1 LS					
29.	SCADA Programming	1 LS					
30.	Startup and Testing	1 LS					
31.	Other Misc. Site Items	1 LS					
TOT	TOTAL BID AMOUNT (in numbers): \$						
101	TOTAL BID AMOUNT (in words):						

A) Where lump sump (LS) prices are in the Bidding Schedule, they shall include all labor, materials, and equipment necessary to produce a complete and finished job.

B) When no specific item is listed in the Bidding Schedule for work required, the cost of such work shall be included in the price bid for the time which most appropriately covers the work.

NONCOLLUSION DECLARATION

STATE OF SS. County of

Noncollusion Declaration to be Executed by Bidder and Submitted with Bid.

I, _____, declare that I am _____(Title) of ______, the party making the foregoing bid. The bid is not made in the interest of, or on behalf of, any undisclosed person, partnership, company, association, organization, or corporation. The bid is genuine and not collusive or sham. The bidder has not directly or indirectly induced or solicited any other bidder to put in a false or sham bid. The bidder has not directly or indirectly colluded, conspired, connived, or agreed with any bidder or anyone else to put in a sham bid, or to refrain from bidding. The bidder has not in any manner, directly or indirectly, sought by agreement, communication, or conference with anyone to fix the bid price of the bidder or any other bidder, or to fix any overhead, profit, or cost element of the bid price, or of that of any other bidder. All statements contained in the bid are true. The bidder has not, directly or indirectly, submitted his or her bid price or any breakdown thereof, or the contents thereof, or divulged information or data relative thereto, to any corporation, partnership, company, association, organization, bid depository, or to any member or agent thereof to effectuate a collusive or sham bid, and has not paid, and will not pay, any person for such purpose.

Any person executing this declaration on behalf of a bidder that is a corporation, partnership, joint venture, limited liability company, limited liability partnership, or any other entity, hereby represents that he or she has full power to execute, and does execute, this declaration on behalf of the bidder.

	I declare	unde	r pena	lty of	perjury unde	er th	e laws of th	he Sta	te of California tha	t the foregoing is	s tr	ue
and	correct	and	that	this	declaration	is	executed	on		[date)	at
	[city],						[state].					

By: ____ (Signature)

Print:

THIS PAGE LEFT BLANK INTENTIONALLY

Table of Contents Technical Specifications Broadview Aquifer Storage and Recovery Project Aquifer Storage and Recovery Wells

Division 1 – General Requirements

- 01000 Summary of Work
- 01060 Safety and Health
- 01075 Price and Payment Procedures
- 01200 Project Meetings
- 01300 Schedule and Submittals
- 01355 Construction Waste Management
- 01400 Quality Control
- 01500 Contractors Utilities
- 01560 Environmental Controls
- 01605 Shipment Protection and Storage
- 01660 Equipment and System Performance and Operational Testing
- 01662 Commissioning
- 01664 Training
- 01700 Project Closeout
- 01720 Record Drawings
- 01730 Operating and Maintenance Information
- 01802 Stormwater Pollution Prevention
- 01900 Seismic Anchorage and Bracing Requirements
- 01999 Reference Forms

Division 13 - Special

13110 Pre-Engineered Metal Structures

Division 16 - Electrical

- 16000 General Requirements for Electrical Work
- 16030 Electrical Acceptance Testing
- 16110 Raceways, Boxes, and Supports
- 16120 600 V Conductors, Wire, and Cable
- 16175 Miscellaneous Electrical Devices
- 16450 Grounding System
- 16470 Lighting and Power Distribution Panelboards
- 16617 PV Batter Backup System

Division 17 – Process Integration

- 17000 General Requirements for Instrumentation and Control
- 17030 Process Instrumentation and Control Testing
- 17110 Instrument and Control Panels
- 17140 Miscellaneous Instrument Valves and Fittings
- 17200 Instrument Index
- 17212-A Flow Measurement
- 17212-B Level Measurement
- 17212-C Pressure Measurement
- 17212-D Process Liquid Analytical Measurement
- 17310 Programmable Logic Controllers
- 17315 Process Control System Development and Programming
- 17710 SCADA Radio Communication System
- 17715 Security Surveillance System
- 17800 Network and Communication Equipment
- 17900 Process Control Descriptions

SECTION 01000

SUMMARY OF WORK

PART 1 GENERAL

- A. The work covered under this contract will be performed at the WWD property located at Township 13 Range 14, approximately 4 miles southwest of Firebaugh with the southeast corner at approximately latitude 36 degrees 47'34" N, longitude 120 degrees 28'37" W as shown in the Drawings and described in the Specifications. The project site is located in a remote agricultural area. The site is 0.9 miles south of Shields Avenue and 3.1 miles north of Belmont Avenue.
- B. The site had been used for irrigated agriculture until about 10 years ago, after which it has been fallowed. The site is periodically disked to keep it in a condition for future agricultural use.

1.02 DESCRIPTION OF OWNER'S PROJECT AND WORK UNDER THIS CONTRACT

- A. The overall project will consist of the equipping of one aquifer storage and recovery (ASR) well, each with a design injection rate of up to 1,500 gallons per minute (gpm) and a design production rate of up to 2,500-gpm for irrigation. The Contract consists of the supply and installation of all equipment necessary for the proper operation of the well system.
- B. The Contractor shall be responsible for the supply, construction and installation of the following list of items/activities. This partial list of items/activities is not intended to describe the complete extent of the Contract requirement outlined by these Drawings and Specifications. The Contractor shall make an independent determination of all project requirements and include all associated costs in their bid. The facility to be constructed under this contract will include, but not be limited to, the following components:
 - 1. 2,500-gpm vertical turbine pump for existing groundwater well
 - 2. Wellhead piping
 - 3. Piping and adapters for injection through layflat tubing down well annular space
 - 4. Site work including grading and paving
 - 5. Chemical feed system and associated appurtenances
 - 6. Aggregate pad for diesel well pump engine and fuel tank
 - 7. Site yard piping
 - 8. Electrical equipment
 - a. Panelboards
 - b. PLC
 - c. PV Battery control power system
 - d. Radio communication
 - e. Instrumentation
 - f. Control panels
 - g. Site lighting and cameras
 - 9. PLC and OIS Programming

- 10. SCADA screen development and programming
- 11. Radio path survey and radio antenna
- 12. Coordination with rental diesel engine supplier
- 13. Site fencing and entrance gates
- 14. Connection to irrigation distribution system
- 15. Permitting acquisition as required by the County of Fresno
- 16. System startup and testing

1.03 LOCATION

A. Work is to be performed on property owned by WWD located at Township 13 Range 14, approximately 4 miles southwest of Firebaugh with the southeast corner at approximately latitude 36 degrees 47'34" N, longitude 120 degrees 28'37" W. The site is 0.9 miles south of Shields Avenue and 3.1 miles north of Belmont Avenue.

1.04 OWNER FURNISHED PRODUCTS

A. Owner will contract with rental diesel engine supplier to provide engine and connect fuel system and diesel-related controls.

1.05 CONTRACTOR USE OF SITE (AND PREMISES)

- A. Utility outages and shutdown: The connection piping to the existing irrigation distribution system shall be coordinated with the OWNER a minimum of one week in advance.
- B. Site security: The CONTRACTOR shall be responsible for providing all fencing required to continuously maintain a secure site during construction.
- C. Site access during construction: Access to the site during construction will be from West Shaw Avenue.
- D. Staging area: The CONTRACTOR may stage equipment and materials at the site and nearby fallowed field.

1.06 CHANGE PROCEDURES

A. The Engineer may issue to the CONTRACTOR a Proposal Request which includes a detailed description of a proposed change with supplementary or revised drawings and specifications, a change in Contract Times for executing the change and the period of time during which the requested price will be considered valid. The CONTRACTOR will prepare and submit an estimate within 15 working days. The estimate shall contain a detailed breakdown of the labor, equipment, material, subcontract, equipment rental, contingencies, overhead, and profit costs associated with the requested change. The estimate shall also include any requested adjustments to Contract Times including the window of time the OWNER has to render a decision on the matter.

1.07 DEFINED TERMS

A. Terms used in these Specifications which are defined in the General Conditions of the Contract Documents shall have the meanings assigned to them in the General Conditions.

1.08 ABBREVIATIONS

A. Where any of the following abbreviations are used in the Contract Documents, they shall have the meaning set forth opposite each.

AASHTO	American Association of State Highway and Transportation Officials		
ACI	American Concrete Institute		
IEEE	Institute of Electrical and Electronics Engineers, Inc.		
AISC	American Institute of Steel Construction		
ANS	American National Standard		
ANSI	American National Standards Institute		
API	American Petroleum Institute		
ASCE	American Society of Civil Engineers		
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers		
ASME	American Society of Mechanical Engineers		
ASTM	American Society for Testing and Materials		
AWWA	American Water Works Association		
CS	Commercial Standard		
IPS	Iron Pipe Size		
NEC	National Electrical Code; Latest Edition		
NEMA	National Electrical Manufacturers Association		
NFPA	National Fire Protection Association		
AWG	American or Brown and Sharpe Wire Gage		
NPT	National Pipe Thread		
UL	Underwriters' Laboratories		

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 FIELD SURVEY WORK

- A. Utilizing OWNER's reference points, the CONTRACTOR shall establish the initial control base line and all control bench marks to be utilized throughout the project. Base line shall be set in accordance with all lines, dimensions, reference points, and elevations given in the Contract Drawings.
- B. Should the CONTRACTOR detect a discrepancy between the information as presented in the Contract Drawings and any existing survey gridwork, bench marks, structures, etc., the CONTRACTOR shall notify the ENGINEER immediately. New construction shall not commence until accurate control base lines and bench marks have been established.
- C. The CONTRACTOR shall, throughout the course of the project, set all additional stakes which are needed for offset stakes, reference points, slope stakes, pavement and grade stakes, stakes for structures, storm drains, utilities, fence, culverts, or other structures,

supplementary bench marks, and any other horizontal or vertical controls necessary to secure a correct layout and construction of the work. Stakes for line and grade for storm drains, etc., shall be set at twenty-five (25) foot maximum intervals. Base lines shall be staked in such manner as to clearly define them for the project.

- D. It shall be the CONTRACTOR's responsibility that the finished work conform to the lines, grades, elevations and dimensions called for in the Contract Documents. The Work shall be subject to checking by the ENGINEER, but any inspection or checking of CONTRACTOR's layout by the ENGINEER and the acceptance of all or part of it shall not relieve the CONTRACTOR of his responsibility to secure the proper dimensions, grades, elevations and locations on the several parts of the Work. The CONTRACTOR shall exercise care in the preservation of stakes, monuments and bench marks and shall have them reset at his expense when they are lost or displaced.
- E. Prior to the commencement of any Work activity, the CONTRACTOR shall survey and layout the Work to be performed and advise the ENGINEER of any conflicts, obstructions, concerns, etc. which will prevent completion of such work in accordance with the requirements of the Contract Documents. If the CONTRACTOR fails to conduct such survey and layout or if the survey and layout fails to identify a conflict, obstruction, etc., which it reasonably should have, and a conflict, obstruction, concern, etc., is discovered, the CONTRACTOR shall bear the cost of any standby time for labor and/or equipment which occurs pending the ENGINEER's direction and the cost of rework of any Work installed which is affected by the conflict, obstruction, etc.
- F. Where the dimensions and locations of existing structures are of importance in the installation or connection of any part of the Work, the CONTRACTOR shall verify such dimensions and locations in the field before the fabrication of any material or equipment which is dependent on the correctness of such information.

3.02 COORDINATION AND MEETINGS

- A. The CONTRACTOR will be required to coordinate his work, to phase the construction operations, and provide, install and maintain any temporary connections necessary to prevent interference to operation of OWNER's facilities. Any construction work requiring the shut-down of facilities must be scheduled and performed only at such times as shall be authorized by the ENGINEER. Such work must be completed during the specific periods authorized by the OWNER. It may be necessary that work will be performed during several shut-down periods and/or during periods of premium time payment to accomplish the desired construction. All costs to perform the CONTRACTOR's work, including premium time payments, shall be borne by the CONTRACTOR and are included in the Contract price.
- B. In addition to the above, the CONTRACTOR shall:
 - 1. Coordinate scheduling, submittals, and work of the various sections of specifications to assure efficient and orderly sequence of installation of interdependent construction elements, with provisions for accommodating items installed later.
 - 2. Verify the utility requirement characteristics of operating equipment are compatible with building utilities. Coordinate work of various sections having interdependent responsibilities for installing, connecting to, and placing in service, such equipment.
 - 3. Coordinate space requirements and installation of mechanical and electrical work which are indicated diagrammatically on drawings. Follow routing shown for pipes,

ducts, and conduit, as closely as practicable; place runs parallel with line of building. Utilize spaces efficiently to maximize accessibility for other installations, for maintenance, and for repairs.

- 4. In finished areas except as otherwise indicated, conceal pipes, ducts, and wiring within the construction. Coordinate locations of fixtures and outlets with finish elements.
- Coordinate completion and cleanup of Work of separate sections in preparation for substantial completion and for portions of Work designated for OWNERs partial occupancy.
- 6. After OWNER occupancy of premises, coordinate access to site for correction of defective Work and Work not in accordance with Contract Documents, to minimize disruption of OWNER's activities.

3.03 FUNDING REQUIREMENTS

- A. The project is funded in part by a Proposition 1 Grant. The CONTRACTOR is required to comply with the following requirements associated with the grant:
 - 1. Should a potential archaeological or historical resource be discovered during construction, all work in the area of the find shall cease until a qualified archaeologist has evaluated the situation and made recommendations regarding preservation of the resource, and the State has determined what actions shall be taken to protect and preserve the resource.
 - 2. Contractor shall post a sign at the intersection of Verner Avenue and Panorama Drive near the existing site sign. The sign shall conform to the project signage guidance included in Attachment 1, will include the Department of Water Resources color logo, and the following disclosure statement: "Funding for this project has been provided in full or in part form the Water Quality, Supply, and Infrastructure Improvement Act of 2014 and through an agreement with the State Department of Water Resources."
 - 3. The State has the right to inspect the project at any and all reasonable times. The Contractor shall accommodate any and all visits by the State.

This page intentionally left blank.

SECTION 01060

SAFETY AND HEALTH

PART 1 GENERAL

1.01 GENERAL

A. The CONTRACTOR certifies that he is experienced and qualified to anticipate and meet the safety and health requirements of this Project. The CONTRACTOR shall require his personnel to observe proper hygienic precautions. The CONTRACTOR shall take measures to assure his personnel observe proper safety precautions when working.

1.02 SAFETY AND HEALTH REGULATIONS

- A. The CONTRACTOR shall comply with Safety and Health Regulations for Construction, promulgated by the Secretary of Labor under Section 107 of the Contract Work Hours and Safety Standards Act, as set forth in Title 29, C.F.R. Copies of these regulations may be obtained from Labor Building, 14th and Constitution Avenue N.W., Washington, DC 20013.
- B. The CONTRACTOR shall also comply with the provisions of the Federal Occupational Safety and Health Act as amended, California Code of Regulations, and California Health and Safety Code.

This page intentionally left blank.

SECTION 01075 PRICE AND PAYMENT PROCEDURES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Applications for payment.
- B. Change procedures.
- C. Defect assessment.
- D. Unit prices.
- E. Alternates.

1.02 APPLICATIONS FOR PAYMENT

- A. In general, progress payments shall be submitted monthly in a format acceptable to the ENGINEER. The progress payment request shall be based on the approved schedule of values as required under Section 01300, Article 1.01C, and should provide the percentage of completion, total dollar value completed, dollar value completed prior to the current payment, and the amount requested for this progress payment for each line item contained in the schedule of values. Progress payment requests for material and/or equipment suitably stored but not yet incorporated into the work shall be accompanied by a copy of the appropriate manufacturers invoice, shipping order, bill of lading, etc. and the progress payment amount shall be the direct cost to the CONTRACTOR, or subcontractor, for such material and/or equipment. Payment will not be made to the CONTRACTOR if, upon inspection by the ENGINEER, it is determined that the material and/or equipment does not conform to the requirements of the Contract Documents including proper storage, receipt of approved shop drawings, receipt of any special guarantees, Bonds, insurance coverage, any evidence of damage or imperfections, etc.
- B. Submit updated construction schedule with each Application for Payment.
- C. Payment Period: Submit at one-month intervals, including work completed through the end of the month.
- D. Upon approval of invoice from the ENGINEER, submit invoice to

Westlands Water District Attn: David Vang 3130 North Fresno Street Fresno, CA 93703

- E. Substantiating Data: When ENGINEER requires substantiating information, submit data justifying dollar amounts in question. Include the following with Application for Payment:
 - 1. Partial release of liens from major subcontractors and vendors.
 - 2. Construction progress schedules, revised and current.

3. Estimate of future value of work completed, with projected total value of work completed by the end of each month through the end of the project.

1.03 CHANGE PROCEDURES

- A. Maintain detailed records of work done on a Cost of Work basis. Provide full information required for evaluation of proposed changes, and to substantiate costs of changes in the Work.
- B. Document each quotation for a change in cost or time with sufficient data to allow evaluation of the quotation.
- C. On request, provide additional data to support computations:
 - 1. Quantities of products, labor, and equipment.
 - 2. Taxes, insurance and bonds.
 - 3. Overhead and profit.
 - 4. Justification for any change in Contract Time.
 - 5. Credit for deletions from Contract, similarly documented.
- D. Support each claim for additional costs, and for work done on a Cost of Work basis, with additional information:
 - 1. Origin and date of claim.
 - 2. Dates and times work was performed, and by whom.
 - 3. Time records and wage rates paid.
 - 4. Invoices and receipts for products, equipment, and subcontracts, similarly documented.
- E. The ENGINEER will advise of minor changes in the Work not involving adjustment to Contract Sum/Price of Contract Time by issuing supplemental instructions on a Field Order.
- F. The ENGINEER may issue a Proposal Request including a detailed description of proposed change with supplementary or revised drawings and specifications, a change in Contract Time for executing the change. CONTRACTOR will prepare and submit estimate within 10 days.
- G. CONTRACTOR may propose changes by submitting a request for change to ENGINEER, describing proposed change and its full effect on the Work. Include a statement describing reason for the change, and effect on Contract Sum/Price and Contract Time with full documentation and a statement describing effect on Work by separate or other Contractors.
- H. Stipulated Sum/Price Change Order: Based on Proposal Request and CONTRACTOR'S fixed price quotation or CONTRACTOR'S request for Change Order as approved by ENGINEER.
- I. Unit Price Change Order: For contract unit prices and quantities, the Change Order will be executed on fixed unit price basis. For unit costs or quantities of units of work which are not pre-determined, execute Work under Work Directive Change. Changes in Contract Sum/Price or Contract Time will be computed as specified for Time and Material Change Order.
- J. Work Directive Change: ENGINEER may issue directive instructing CONTRACTOR to proceed with change in the Work, for subsequent inclusion in a Change Order. Document will describe changes in the Work, and designate method of determining any change in Contract Sum/Price or Contract Time. Promptly execute change.
- K. Time and Material Change Order: Submit itemized account and supporting data after completion of change, within time limits indicated in Conditions of the Contract. ENGINEER will determine change allowable in Contract Sum/Price and Contract Time as provided in Contract Documents.
- L. Maintain detailed records of work done on Time and Material basis. Provide full information required for evaluation of proposed changes, and to substantiate costs for changes in the Work.
- M. Document each quotation for change in cost or time with sufficient data to allow evaluation of quotation.
- N. Execution of Change Orders: ENGINEER will issue Change Orders for signatures of parties as provided in Conditions of the Contract.
- 0. Correlation of CONTRACTOR Submittals:
 - 1. Promptly revise Application for Payment forms to record each authorized Change Order as separate line item and adjust Contract Sum/Price.
 - 2. Promptly revise progress schedules to reflect change in Contract Time, revise subschedules to adjust times for other items of work affected by the change, and resubmit.
 - 3. Promptly enter changes in Project Record Documents.

1.04 DEFECT ASSESSMENT

- A. Replace the Work, or portions of the Work, not conforming to specified requirements in accordance with the General Conditions.
- B. Non-Payment for Rejected Products: Payment will not be made for rejected products for any of the following:
 - 1. Products wasted or disposed of in a manner that is not acceptable.
 - 2. Products determined as unacceptable before or after placement.
 - 3. Products not completely unloaded from transporting vehicle.
 - 4. Products placed beyond lines and levels of required Work.
 - 5. Products remaining on hand after completion of the Work.
 - 6. Loading, hauling, and disposing of rejected products.

1.05 UNIT PRICES

- A. Authority: Measurement methods are delineated in individual specification sections.
- B. Measurement methods delineated in individual specification sections complement criteria of this section. In event of conflict, requirements of individual specification section govern.

- C. Take measurements and compute quantities. ENGINEER will verify measurements and quantities.
- D. Unit Quantities: Quantities and measurements indicated in Bid Form are for contract purposes only. Quantities and measurements supplied or placed in the Work shall determine payment. Actual quantities provided shall determine payment.
 - 1. When actual Work requires more or fewer quantities than those quantities indicated, provide required quantities at unit sum/prices contracted.
 - 2. When actual Work requires 25 percent or greater change in quantity than those quantities indicated, OWNER or CONTRACTOR may claim for Contract Price adjustment.
- E. Payment Includes: Full compensation for required labor, products, tools, equipment, plant and facilities, transportation, services and incidentals; erection, application or installation of item of the Work; overhead and profit.
- F. Final payment for Work governed by unit prices will be made on basis of actual measurements and quantities accepted by ENGINEER multiplied by unit sum/price for Work incorporated in or made necessary by the Work.
- G. All work specified in DIVISION 1 GENERAL REQUIREMENTS shall be considered incidental to and included in the appropriate Unit Prices stated in the Bid Form.
- H. Measurement of Quantities:
 - 1. Weigh Scales: Inspected, tested and certified by applicable state Weights and Measures department within past year.
 - 2. Platform Scales: Of sufficient size and capacity to accommodate conveying vehicle.
 - 3. Metering Devices: Inspected, tested and certified by applicable State department within past year.
 - 4. Measurement by Weight: Concrete reinforcing steel, rolled or formed steel or other metal shapes will be measured by handbook weights. Welded assemblies will be measured by handbook or scale weight.
 - 5. Measurement by Volume: Measured by cubic dimension using mean length, width and height or thickness.
 - 6. Measurement by Area: Measured by square dimension using mean length and width or radius.
 - 7. Linear Measurement: Measured by linear dimension, at item centerline or mean chord.
 - 8. Stipulated Sum/Price Measurement: Items measured by weight, volume, area, or linear means or combination, as appropriate, as completed item or unit of the Work.

1.06 ALTERNATES

- A. Alternates quoted on Bid Forms will be reviewed and accepted or rejected at OWNER'S option in accordance with article 9 of Instructions to Bidders. Accepted Alternates will be identified in OWNER-CONTRACTOR Agreement.
- B. Coordinate related work and modify surrounding work.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

PROJECT MEETINGS

1.01 PRECONSTRUCTION CONFERENCE

A. The ENGINEER will schedule and conduct one preconstruction conference prior to the commencement of any work at the site, to which all interested agencies and utility companies will be invited to discuss their interests and requirements relating to the project. CONTRACTOR and all subcontractor representatives shall attend.

1.02 CONSTRUCTION PERIOD MEETINGS

- A. Construction period meetings will be conducted at weekly intervals or at some other frequency if approved by the CONTRACTOR and ENGINEER. These meetings shall be attended by the ENGINEER and the CONTRACTOR's Project Manager and any others that are invited by these people.
- B. The agenda of these project meetings will include reports on construction progress, the status of submittal reviews, the status of information requests, and any general business. The meetings will be conducted by the ENGINEER. The ENGINEER shall keep minutes of the proceedings. The minutes shall be typed and distributed to all attendees within 48 hours of each meeting.

SCHEDULE AND SUBMITTALS

PART 1 GENERAL

1.01 BEFORE STARTING WORK

- A. Preliminary Progress Schedule
 - 1. In accordance with Section 2.05 of the General Conditions, the CONTRACTOR shall prepare and submit to the ENGINEER for approval, a preliminary construction progress schedule. This submittal is to be made within ten (10) days from the effective date of Agreement. The method of schedule preparation required is generally referred to as the Critical Path Method (CPM).
 - 2. The schedule shall include, as a minimum, the following separate activities:
 - a. Physical construction (includes mobilization, demobilization, setup time, lags, etc.).
 - b. Issuance by CONTRACTOR of purchase orders for material and equipment and submittal of shop drawings and samples to the ENGINEER.
 - c. Review by ENGINEER for each submittal of samples and shop drawings. Unless otherwise approved by the ENGINEER, allow a minimum of fifteen (15) working days for ENGINEER to review each submittal.
 - d. Fabrication time for materials and equipment.
 - e. Delivery of materials and equipment.
 - f. Installation of materials and equipment.
 - g. Testing, start-up and training for individual pieces of equipment or entire systems as appropriate
 - h. Winter affected activities.
 - i. Outages or interruptions of OWNER's facilities required to perform work.
 - j. Demolition or removal work under this Contract.
 - 3. Activity durations shall represent the best estimate of elapsed time considering the scope of the Work involved in the activity and the resources planned for accomplishing the activity expressed in working days.
 - 4. Activity descriptions shall clearly define the scope of work associated with each activity. If activity descriptions contained in the schedule are not sufficient to describe the work, a supplemental narrative description is to be provided.
 - 5. The construction work shall be detailed to an extent that progress can be readily monitored on a weekly basis. In general, the construction work shall be detailed such that no construction activity shall have a duration greater than fifteen (15) work days.
 - 6. Each activity shall be coded by the CONTRACTOR as necessary for proper and efficient utilization of the schedule. As a minimum, each activity shall be coded by:
 - a. Activity type (ie., submittal, ENGINEER's review, delivery, construction, etc.).
 - b. Responsibility (ie., CONTRACTOR, subcontractor A, subcontractor B, OWNER, ENGINEER, etc.).
 - c. Area (ie., Building A, Building B, sitework, etc.).

- 7. The above schedule development requirements are a minimum and the CONTRACTOR shall develop the schedule as necessary to properly control and manage the project.
- 8. All equipment provided as equal shall be approved by the District prior to the purchase or supply of the proposed equipment.
- B. Shop Drawings and Samples Submittal Schedule
 - The preliminary progress schedule shall contain activities in the network representing submittal and review of shop drawings and material samples. The shop drawing and sample submittal schedule required per Paragraph 2.6 of the General Conditions shall be developed by sorting these activities from the progress schedule. The schedule shall be presented in a report format containing the following information:
 - a. activity number
 - b. activity description (including reference to the appropriate specification section)
 - c. early and late start dates
 - d. early and late finish dates
 - e. total and free float
 - f. successor activities
- C. Schedule of Values
 - 1. The CONTRACTOR shall submit to the ENGINEER a schedule of values representing a detailed subdivision of the lump sum Contract amount. This subdivision, when approved by the ENGINEER, will become the basis for computing the CONTRACTOR's monthly progress payments. If practical, the schedule of values shall be developed by assigning a cost value to the appropriate activities contained in the preliminary progress schedule. If activities, or other line items, in the schedule of values contain costs associated with material, labor or subcontracts these costs are to be identified separately by listing the activity multiple times and identifying material, labor and subcontract with a suffix M, L and S respectively. Cost values for activities representing materials/equipment only shall be assigned to the activity representing delivery of such material/equipment to the job site.
 - 2. In addition to the cost of material, labor and subcontracts, the following costs are to be identified separately in the schedule of values accompanied by such supporting documentation as required by the ENGINEER to substantiate the amounts listed.
 - a. Mobilization To include CONTRACTOR's actual cost to setup temporary facilities at the job site.
 - b. Bonds, Insurance To reflect premiums paid, or to be paid, for Bonds and insurance required to be provided per the Contract Documents. Additional insurance coverage or bonds purchased by the CONTRACTOR at his option shall be considered general overhead and apportioned to construction activity costs.
 - c. Job Site Overhead To reflect the cost of maintaining the temporary facilities at the job site including the cost of direct field supervision. This value, when approved, will be paid to the CONTRACTOR in equal monthly increments based on the number of months between mobilization and final completion.
 - d. Demobilization To reflect the cost of removing the temporary facilities and final site cleanup.
 - e. Permits To include fees required for any permits which CONTRACTOR is required to obtain including inspection fees associated with such permits.

- 3. The cost of home office overhead, profit, financing, contingencies, etc. are to be apportioned to the construction activities in the schedule of values based on the percentage that each construction activity cost represents when compared to the subtotal of all construction activity costs. This subtotal is excluding mobilization, demobilization, job site overhead, permits, home office overhead, profit, financing, contingencies, etc. The total of all items in the schedule of values shall equal the Contract Price.
- D. Cash Flow Schedule
 - 1. Accompanying the CPM Schedule required above, the CONTRACTOR shall also submit to the ENGINEER, for approval, a Cash Flow Schedule. The Cash Flow Schedule shall show the amounts of money by months which will be required to reimburse the CONTRACTOR for Work performed during each month of the Contract Times. The sum of all the monthly cash requirements shall equal the Contract Price. The monthly cash requirements shall be proportioned based on the CPM Schedule. The initial cash flow schedule shall depict monthly cash requirements based on the early start dates of the CPM Schedule. The approved cash flow schedule will be developed by the ENGINEER and will reflect the CONTRACTOR's schedule performance as of the date of approval. This process of approving cash flow schedules will occur with each required schedule update.
 - 2. The approved Cash Flow Schedule will be used by the OWNER to program funds for progress payments to the CONTRACTOR. Monthly payments will be made to the CONTRACTOR in accordance with the Contract Agreement, but at no time will the aggregate amount of payments exceed the accumulated amount of payments for the same period of the approved Cash Flow Schedule.
- E. Preconstruction Video Taping
 - 1. Prior to mobilization at the site, the CONTRACTOR shall furnish to the ENGINEER a video recording of all planned construction areas, material storage areas, areas adjacent to these areas, including but not limited to, streets, driveways, sidewalks, curbs, ditches, fencing, railing, visible utilities, retaining structures and adjacent building structures. The purpose of the video is to document existing 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.
 - 2. The tapes shall be high quality, color and in an electronic format. Temporary lighting shall be provided as necessary to properly tape areas where natural lighting is insufficient (indoors, shadows, etc.). The tapes shall include an audio soundtrack to provide the following information:
 - a. Detailed description of location being viewed referenced to Contract Drawings (ie. station no., building designation, pipeline route etc.).
 - b. Direction (N, S, E, W, looking up, looking down, etc.) of camera view.
 - c. Date, time, temperature, environmental conditions at time of recording.
 - 3. Any areas not readily visible by recording methods shall be described in detail. Unless otherwise approved by ENGINEER, recording shall not be performed during inclement weather or when the ground is covered partially or totally with snow, ice, leaves, etc.

1.02 FINALIZING SCHEDULES

- A. The CONTRACTOR shall be prepared to present and discuss at the preconstruction meeting, the schedules submitted in accordance with this specification. Unless additional information is required to be submitted by the CONTRACTOR, the ENGINEER will, within 15 working days of the preconstruction conference, provide comments to the CONTRACTOR. The CONTRACTOR shall then resubmit the affected schedules addressing the ENGINEER's comments.
- B. Approval of the final schedules by the ENGINEER is advisory only and shall not relieve the CONTRACTOR of responsibility for accomplishing the work within the Contract Times. Omissions and errors in the approved CPM schedule shall not excuse performance less than that required by the Contract. Approval by the ENGINEER in no way makes the ENGINEER an insurer of the success of those schedules or liable for time or cost overruns flowing from shortcomings in such schedules.

1.03 REQUIREMENTS FOR CONFORMING WITH SCHEDULE

A. If, in the opinion of the ENGINEER, the CONTRACTOR falls behind the progress schedule, the CONTRACTOR shall take such steps as will be necessary to improve his progress, and ENGINEER may require CONTRACTOR to increase the number of shifts and/or overtime operations, days of work, and/or the amount of construction planned, and to submit for approval such supplementary schedule or schedules as may be deemed necessary to demonstrate the manner in which the agreed rate of progress will be regained, all without additional cost to the OWNER. An updated cash flow schedule will be required in this occurrence and will be provided with the supplementary schedules referenced above.

1.04 UPDATING SCHEDULES

- A. The CONTRACTOR shall submit to the ENGINEER monthly updates of the schedules required per this specification section. Progress and shop drawing schedule updates shall reflect the progress to date by providing actual start dates for activities started, actual finish dates for completed activities, and identifying out of sequence work, schedule logic changes and any circumstances or events impacting the current schedule. The updates shall also contain the CONTRACTOR's best estimate of the remaining duration for activities not complete as of the date of the update. All graphic presentations, reports and electronic files required per the initial submittal of these schedules shall be provided with each update.
- B. The schedule of values and cash flow schedules shall be updated to reflect any changes.

1.05 ADJUSTMENT OF PROGRESS SCHEDULE AND CONTRACT TIMES

- A. If the CONTRACTOR desires to make changes in his method of operating which affect the approved progress schedule, he shall notify the ENGINEER in writing stating what changes are proposed and the reason for the change. If the ENGINEER approves these changes, the CONTRACTOR shall revise and submit for approval, without additional cost to the OWNER, all of the affected portions of the schedule.
- B. Shop drawings and samples which are not approved on the first submittal or within the schedule time shall be immediately rescheduled, as well as any work which fails to pass specified tests or has been rejected.

- C. The Contract Times will be adjusted only for causes specified in the General Conditions. In the event the CONTRACTOR requests an adjustment of the Contract times, he shall furnish such justification and supporting evidence as the ENGINEER may deem necessary for a determination as to whether the CONTRACTOR is entitled to an adjustment of Contract Times under the provisions of the General Conditions. The ENGINEER will, after receipt of such justification and supporting evidence, make findings of fact and will advise the CONTRACTOR in writing thereof. If the ENGINEER finds that the CONTRACTOR is entitled to any adjustment of the Contract Times the ENGINEER's determination as to the total number of days adjustment shall be based upon the currently approved progress schedule and on all data relevant to the adjustment. The CONTRACTOR acknowledges and agrees that actual delays in activities which, according to the progress schedule, do not affect the Contract completion date shown by the critical path in the network will not be the basis for an adjustment of Contract Times.
- D. From time to time it may be necessary for the progress schedule and/or Contract Times to be adjusted by the OWNER to reflect the effects of job conditions, weather, technical difficulties, strikes, unavoidable delays on the part of the OWNER, and other unforeseeable conditions which may indicate schedule and/or Contract Times adjustments. Under such conditions, the ENGINEER shall direct the CONTRACTOR to reschedule the work and/or Contract Time to reflect the changed conditions, and the CONTRACTOR shall revise his schedule accordingly. No additional compensation shall be made to the CONTRACTOR for such changes except as provided in the General Conditions. Unless otherwise directed, the CONTRACTOR shall take all possible actions to minimize any extension to the Contract Times and any additional cost to the OWNER.

1.06 SHOP DRAWINGS

- A. The CONTRACTOR shall promptly supply to the ENGINEER for approval, shop drawings with details and schedules for all items contained in the list of required Shop Drawings included at the end of this Section, or for other items as may be required by the ENGINEER.
- B. Each submittal shall have the job name on it and the appropriate specification section or contract drawing reference.
- C. Shop drawings shall be numbered with the OWNER'S file number _____XX Rev. _____ Detailed procedures for numbering will be outlined at the pre-construction meeting.
- D. Each copy of the submittals made to the OWNER for approval shall be prepared by the CONTRACTOR and shall have an identifying title stamp as follows:

Westlands Water District	
Broadview ASR Project	
Specification Section	

Specification Section _____

Shop Drawing No. ____- Rev. _____

E. As required by the General Conditions, each copy of the submittals shall also be stamped with the CONTRACTOR's approval indicating that the shop drawing has been reviewed for conformance to the Contract Documents and has been coordinated with all other work and/or trades. The CONTRACTOR shall identify and bring to the attention of the ENGINEER any deviations to the Contract Documents contained in the submittal. For shop drawings being resubmitted the CONTRACTOR shall identify and bring to the attention of the ENGINEER any revisions other than those originally requested by the ENGINEER.

F. Submittals smaller than $8\frac{1}{2}x11$ shall not be accepted for review.

1.07 CATEGORIES OF SUBMITTALS

- A. GENERAL:
 - 1. Submittals fall into two general categories; submittals for review and comment, and submittals which are primarily for information only. Submittals which are for information only are generally specified as <u>PRODUCT DATA</u> in Part 2 of applicable specification sections.
 - 2. At the beginning of work, the CONTRACTOR will furnish a list of those submittals specified in the Specifications, which are to be reviewed for comment by the ENGINEER. The list of submittals shall include designation between submittals for review and comment and product data (submittals) for information only.
- B. SUBMITTALS (PRODUCT DATA) FOR INFORMATION ONLY:
 - 1. Where specified, the CONTRACTOR shall furnish submittals (product data) to the ENGINEER for information only. Submittal requirements for operation and maintenance manuals, which are included in this category, are specified in Section 01730.
- C. SUBMITTALS FOR REVIEW AND COMMENT:
 - 1. All submittals, except where specified to be submitted as product data for information only, shall be submitted by the CONTRACTOR to the ENGINEER for review and comment.

1.08 SUBMITTAL REVIEW

- A. All submittals will be returned to the CONTRACTOR following review by the ENGINEER stamped with one of the following classifications:
 - 1. "No Exceptions Taken" There are no notations or comments on the submittal and, in our opinion, the submittal meets the requirements of the Contract Documents and the CONTRACTOR may release the equipment for production.
 - 2. "Make Corrections Noted" Notations have been made on the submittals to insure conformance with the Contract Documents. The CONTRACTOR may release the equipment for production in accordance with the notations.
 - 3. "Not Approved" The submittal does not meet the requirements of the Contract Documents. The CONTRACTOR must submit the specified product.
 - 4. "Revise and Resubmit" When the material submitted is incorrect or insufficient to review properly and it is necessary to see the complete package again.
 - 5. "Resubmit Record Copy" Used with the review action "Approved As Noted". The resubmittal shall incorporate notations.
- B. Where a submittal indicates a departure from the Contract which the ENGINEER deems to be a minor adjustment in the interest of the OWNER not involving a change in Contract Price or extension of Contract Times, the ENGINEER may approve the submittal but the approval will contain, in substance, the following notation:

- C. "The modification indicated on the attached submittal is approved in the interest of the OWNER to effect an improvement for the Project and is accepted with the understanding that it does not involve any change in the Contract Price or Times; that it is subject generally to all Contract stipulations and covenants; and that it is without prejudice to any and all rights of the OWNER under the Contract Bonds."
- D. It is emphasized that the ENGINEER's approval of CONTRACTOR's submitted data is for general conformance to the Contract Drawings and Specifications, but subject to the detailed requirements of Drawings and Specifications. Although the ENGINEER may check submitted data in more or less detail, such checking is an effort to discover errors and omissions in CONTRACTOR's drawings and to assist the CONTRACTOR in coordinating and expediting his work, and shall in no way relieve the CONTRACTOR of his responsibility to ENGINEER the details of the Work in such manner that the purpose and intent of the Contract will be achieved, nor shall such detail check by the ENGINEER be construed as placing on the ENGINEER, any responsibility for the accuracy, and for proper fit, functioning and performance of any phase of the Work included under this Contract.

1.09 SAMPLES

- A. When required by the ENGINEER or where noted in other Sections of these Specifications, samples or materials shall be submitted for approval.
- B. Submit samples to illustrate functional and aesthetic characteristics of the product, with integral parts and attachment devices. Coordinate sample submittals for interfacing work.
- C. Submit samples of finishes from the full range of manufacturer's standard colors, textures, and patterns for ENGINEER's selection.
- D. Include identification on each sample, with full project information.
- E. Submit the number or samples specified in individual specification sections; one of which will be retained by ENGINEER.
- F. Reviewed samples which may be used in the Work are indicated in individual specification sections.

1.10 PROGRESS PAYMENTS

A. Progress payments shall be made in accordance with Section 01075.

1.11 CONTRACTOR'S DAILY REPORTS

- A. If requested by the ENGINEER or the Resident Project Representative, the CONTRACTOR shall prepare and submit daily reports containing the following information:
 - 1. The number of craftsmen and hours worked of each subcontractor,
 - 2. the number of hours worked by each trade,
 - 3. the number of hours worked of each type of equipment,
 - 4. a description of work activities performed,
 - 5. a description of any material or equipment deliveries,
 - 6. description of obstructions encountered,

- 7. temperature and weather conditions.
- B. The daily reports shall be submitted on a daily basis, by the end of the next business day.
- C. Information provided on the daily report shall not constitute notice of delay or any other notice required by the Contract Documents. Notice shall be as required therein.

1.12 REQUEST FOR SUBSTITUTION

- A. Requests for substitution of specified equipment shall be in writing and shall be accompanied with sufficient information to permit the ENGINEER to identify the nature and scope of the request. Information to be provided along with the request for substitution shall include:
 - 1. All submittal information required for the specified equipment, including all deviations from the specified requirements necessitated by the proposed substitution.
 - 2. Materials of construction, including material specifications and references.
 - 3. Performance data, including performance curves and guaranteed power consumption, over the range of specified operating conditions.
 - 4. Dimensional drawings, showing required access and clearances, including any changes to the work required to accommodate the proposed substitution.
 - 5. Where controls are a part of the proposed substitution, piping, process and instrumentation drawings (P&IDs), produced in the project format and with project-specific symbols, along with control descriptions.
 - 6. Where controls specified in the project manual require modification to accommodate the proposed substitution, piping, process and instrumentation drawings (P&IDs), produced in project format and with project-specific symbols, with all required modifications clearly highlighted.
 - 7. Information and performance characteristics for all system components and ancillary devices to be furnished as a part of the proposed substitution.
 - 8. Reproducible contract drawings, marked up to illustrate the alterations to all structural, architectural, mechanical, electrical and HVAC systems required to accommodate the proposed substitution.
 - 9. A list of installations of the proposed substitution indicating application, location, owner and date of first use.

1.13 SUBMITTAL COMPLETENESS

A. Submittals which do not have all the information required to be submitted, including deviations, are not acceptable and will be returned without review.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 TRANSMITTAL PROCEDURE

- A. GENERAL:
 - 1. Unless otherwise specified, submittals regarding material and equipment shall be accompanied by a Transmittal Form. Submittals for operation and maintenance

manuals. A separate form shall be used for each specific item, class of material, equipment, and items specified in separate, discrete sections, for which the submittal is required. Submittal documents common to more than one piece of equipment shall be identified with all the appropriate equipment numbers. Submittals for various items shall be made with a single form when the items taken together constitute a manufacturer's package or are so functionally related that expediency indicates checking or review of the group or package as a whole.

2. A unique number, sequentially assigned, shall be noted on the transmittal form accompanying each item submitted. Original submittal numbers shall have the following format: "XXX"; where "XXX" is the sequential number assigned by the Contractor. Resubmittals shall have the following format: "XXX-Y"; where "XXX" is the originally assigned submittal number and "Y" is a sequential letter assigned for resubmittals, i.e., A, B, or C being the 1st, 2nd, and 3rd resubmittals, respectively. Submittal 25B, for example, is the second resubmittal of submittal 25.

3.02 REVIEW PROCEDURE

- A. GENERAL:
 - 1. Submittals are specified for those features and characteristics of materials, equipment, and methods of operation which can be selected based on the CONTRACTOR's judgment of their conformance to the specified requirements. Other features and characteristics are specified in a manner which enables the CONTRACTOR to determine acceptable options without submittals. The review procedure is based on the CONTRACTOR's guarantee that all features and characteristics not requiring submittals conform as specified. Review shall not extend to means, methods, techniques, sequences or procedures of construction, or to verifying quantities, dimensions, weights or gages, or fabrication processes (except where specifically indicated or required by the project manual) or to safety precautions or programs incident thereto. Review of a separate item, as such, will not indicate approval of the assembly in which the item functions.
 - 2. Submittals shall be reviewed by ENGINEER and returned to CONTRACTOR within 20 Working days and graded in accordance with Section 01300 paragraph 1.07.
 - 3. When the contract documents require a submittal, the CONTRACTOR shall submit the specified information as follows:
 - a. Four copies of all submitted information plus one reproducible original of all information shall be transmitted with submittals for review and comment.
 - b. Unless otherwise specified, 4 copies of all submitted information shall be transmitted with submittals (Product Data) for information only.

CONSTRUCTION WASTE MANAGEMENT

PART 1 GENERAL

1.01 GENERAL

- A. Contractor shall provide construction waste management services and appurtenant work in accordance with the Contract Documents.
- B. Waste Management Collection: Within Project boundary lines, the Contractor shall furnish professional recycle/reuse waste management collection services as required for the proper separation, temporary on-site storage, measurement, documentation, record keeping, removal from the Project Site and final disposal as specified in the contract documents and as required by the California Building Code (CBC) and/or local ordinance.
 - 1. Construction Waste Diversion: Establish a construction waste management plan or meet local ordinance, whichever is more stringent.
 - 2. Construction Waste Management Plan: Submit plan per this section to Authority Having Jurisdiction (AHJ).
 - 3. Provide documentation of the waste management plan that meets the requirements of the CBC.
- C. Recycle and/or salvage for reuse a minimum of non-hazardous construction and demolition debris to meet local ordinance requirements.
 - 1. Exceptions:
 - a. Excavated soil and land clearing debris.
 - b. Alternative waste reduction methods developed by working with local agencies if diversion or recycle facilities capable of compliance with this item do not exist.
 - 2. Verification of Compliance: A copy of the completed waste management report shall be provided to the AHJ.
- D. Excavated Soil and Land Clearing Debris: 100% of trees, stumps, rocks and associated vegetation and soils resulting primarily from land clearing shall be reused or recycled.
- E. Contamination: Contractor shall prevent contamination of recycled/salvaged materials.
- F. Reuse or Recycling Facilities or Agent Tags: Contractor shall collect and retain all reuse/recycling facilities or agent tags that reflect the weight of the hauled material. These units of measure must be consistent on every tag from every reuse/recycling facility or agency.

1.02 REFERENCES:

A. 2019 California Green Building Standards Code

1.03 CONTRACTOR SUBMITTALS:

- A. Submittals: Furnish submittals in accordance with Section 01300.
 - 1. Construction Waste Management Plan: Contractor's Construction Waste Management Plan shall be submitted to the Owner's Representative at least 30 days prior to the start of Work.

- 2. Construction Waste Management Plan shall include, but is not limited to:
 - a. Project Identification Information including Contractor's contact information.
 - b. Demonstration of compliance with applicable Federal, State and local ordinances and regulations for disposal, recycling and waste management processes.
 - c. An inventory of the types and quantities of materials and availability of recycling facilities that will be managed for the purposes of Waste Management Plan achieving goals.
 - d. An inventory of the types and quantities of materials that will be reused, recycled or taken to a landfill. Materials taken to landfill shall be provided with explanation as to why they are not recycled or reused.
 - e. Procedures that will be implemented to locate, identify, separate and measure materials managed.
 - f. Description of reuse/recycling facilities or agent. Include name and type of facility accepting the recovered waste materials, type of materials, location, phone number and copy of license for each facility.
 - g. Description of landfill facilities or agent. Include name and type of facility accepting the waste materials, type of materials, location, phone number and copy of license for each facility.
 - h. Site plan showing the location of collection area for recyclables.
 - i. If materials will be donated or sold during on-site auctions, describe the process and identify organizations that may receive the materials.
- 3. Status Reports: With each application for progress payment, Contractor shall submit to the Owner's Representative an updated and current hardcopy of the following:
 - a. Calculations for determining quantities shall be submitted by weight or by volume but shall be consistent throughout for all materials. Indicate a zero if there is no quantity to report for a type of material.
 - b. With each status report submit copies of manifests, weight tickets, receipts and invoices that identify the Project and waste material. These documents shall be from recyclers or disposal site operators that can legally accept the materials for the purpose of reuse/recycling/disposal.
 - c. Each status report shall indicate project title and number, progress payment number, name of company completing the report and compiling backup documentation, the printed name, signature and phone number of person completing the form, the beginning and ending dates of the period covered on the report and date the report is completed.

PART 2 PRODUCTS: (NOT USED)

PART 3 EXECUTION

3.01 COLLECTION

- A. On-site Separation of Materials:
 - 1. Contractor shall designate a specific area for separation of materials for recycling and salvage. Recycling and waste bin areas are to be kept clean and clearly marked in order to avoid contamination of materials.
 - 2. Contractor shall provide necessary containers and storage areas to facilitate effective waste management. Change-out full containers for empty ones, as demand requires.

Provide designated collection and storage areas as required by reuse/recycling facilities or agent.

- 3. If contamination chemically combines with the material so that it cannot be cleaned, do not deposit into recycle containers. Dispose of the contaminated materials in accordance with the requirements of the AHJ.
- B. Disposal: Contractor shall be responsible for transporting and disposing of materials that cannot be source-separated or recycled to a transfer station or disposal facility that can accept the materials in accordance with the requirements of the authority having jurisdiction. Arrange for collection by or delivery to the appropriate recycling or reuse facility.
 - 1. Do not burn, bury or otherwise dispose of solid waste on the project job site.

SECTION 01400 OUALITY CONTROL

PART 1 GENERAL

1.01 DESCRIPTION

A. This Section specifies administrative and procedural requirements for quality control services, field inspections and field testing for this project. Contractor is responsible for the quality assurance and quality control of their respective work. Civil and structural quality control is discussed herein. Equipment and system performance testing is specified in Section 01660.

1.02 **DEFINITIONS**

- A. Quality Control System (QCS): The quality control, assurance, and inspection system established and carried out to ensure compliance with the Plans and Specifications.
- B. QCS Supervisor: That person in responsible charge of the work occurring, as designated by the Contractor in the QCS Plan.
- C. QCS Inspector: Responsible, certified personnel inspecting the various constructs at specified milestones and during the project overall and designated by the Construction Manager, the Contractor's person responsible for the overall performance of the project. The Special Inspector is part of the QCS Inspector team.
- D. Factory Test: Tests made on various materials, products and component parts prior to shipment to the job site.
- E. Field Tests: Tests and analyses made at or in the vicinity of the job site in connection with the actual construction.
- F. Certified Inspection Report: Reports signed by approved inspectors attesting that the items inspected meet the specification requirements other than any exceptions included in the report
- G. Certificate of Compliance: Certificate from the manufacturer of the material or equipment identifying said manufacturer, product and referenced standard, and shall be signed by a designated officer of the manufacturer.
- H. Standard Compliance: Condition whereby specified materials or equipment must conform to the standards of organizations such as the American National Standard Institute (ANSI), American Society for Testing and Materials (ASTM), Underwriters Laboratories (UL) or similar organization.
- I. Quality Assurance: The day-to-day, in-process supervisory observations of work and materials conducted by the CONTRACTOR to assure that the proper methods and materials are being used and installed by tradesmen.
- J. Source Quality Control: The in-process testing and inspections conducted by the QCS Inspector(s) to verify that the materials, equipment, workmanship and shop

manufactured constructs are in compliance with the Contract Documents, applicable Codes and standards.

K. Field Quality Control: The testing and inspections conducted by the QCS Inspector(s) in the field during and at the completion of each construct to verify that the in-process and completed construction is in compliance with the Contract Documents, applicable Codes and standards.

1.03 REFERENCES

- A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
- B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization, or if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

Reference	Title
ASTM C102	Practice for Laboratories Engaged in the Testing of Building Sealants.
ASTM C802	Practice for Conducting an Inter-Laboratory Test Program to Determine the Precision of Test Methods for Construction.
ASTM C1093	Practice for Accreditation of Testing Agencies for Unit Masonry.
ASTM D3740	Practice for Evaluation of Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction.
ASTM D4561	Practice for Quality Control Systems for an Inspection and testing Agency for Bituminous Paving Materials.
ASTM E329	Practice for Use in the Evaluation of Inspection and Testing Agencies as Used in Construction.
CBC	2019 California Building Code

1.04 CONTRACTOR'S RESPONSIBILITIES

- A. CONTRACTOR shall be responsible for the following items during the performance of construction activities:
 - 1. Monitor quality assurance over suppliers, manufacturers, products, services, site conditions, and workmanship, to produce work of specified quality.
 - 2. Coordinate with, schedule specified inspections by, and provide normal and customary assistance to the QCS Inspectors.
 - 3. Comply fully with manufacturers' instructions, including each step in sequence.

- 4. Should manufacturers' instructions conflict with Contract Documents, request clarification before proceeding from ENGINEER.
- 5. Comply with specified standards as a minimum quality for the work except when more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.
- 6. Perform work by persons qualified to produce workmanship of specified quality.

1.05 QUALITY CONTROL SYSTEM SUPERVISOR

- A. The Contractor shall appoint a qualified operations specialist as Quality Control System (QCS) Supervisor to manage, coordinate, and supervise the CONTRACTOR's quality assurance program. The QCS Supervisor shall have at least 5 years of total experience and experience on at least five separate projects, in managing the startup commissioning of mechanical, electrical, instrumentation, and piping systems for similar water supply projects. The quality assurance program shall include:
 - 1. A testing plan setting forth the sequence in which all testing work required under this project manual will be implemented.
 - 2. A documentation program to record the results of all equipment and system tests.
 - 3. An installed performance testing program for all mechanical, electrical, and instrumentation equipment and systems installed under this contract.

1.06 REGULATORY REQUIREMENTS

- A. GENERAL
 - 1. Comply with all Federal, State, and local Codes as referenced herein. Such regulations apply to activities including, but not limited to, sitework and zoning, building practices and quality, on and offsite disposal, safety, sanitation, nuisance, and environmental quality.
- B. STRUCTURAL OBSERVATION
 - 1. ENGINEER shall make visual inspections of the work to assess general conformance with the Contract Documents at significant construction stages and at completion of the structural system.
 - 2. The following structural milestones shall be considered significant construction stages:
 - a. Structure fill.
 - b. Foundation form work prepared for concrete placement, including matt and pad footings and monolithic slabs on grade.
 - c. Piping systems prior to cover.

1.07 CONTRACTOR DESIGNED STRUCTURAL SYSTEMS

- A. DESIGN ENGINEERING
 - 1. CONTRACTOR shall employ and pay for engineering services from a Professional Engineer registered in the State of California for structural design of CONTRACTOR designed structural systems including, but not limited to temporary shoring and bracing, formwork support, mechanical supports, electrical systems and equipment support systems (including pipe supports), and fabricated wood trusses.
- B. TESTS AND INSPECTIONS OF CONTRACTOR DESIGNED STRUCTURAL SYSTEMS

 CONTRACTOR shall pay for preliminary testing of concrete, grout, and mortar mix designs where required by Code or the submittal process prior to start of such work. CONTRACTOR shall pay for required shop and site inspection of CONTRACTOR designed structural systems where required by Code or these specifications, to the extent such testing and inspection exceeds that required for the structural system on the drawings and in these specifications.

1.08 MANUFACTURERS' FIELD SERVICES AND REPORTS

A. When specified in individual specification Sections, product suppliers or manufacturers shall provide qualified staff personnel to observe site conditions, conditions of surfaces and installation, quality of workmanship, start-up of equipment, test, adjust, and balance of equipment as applicable, and to provide instructions when necessary. CONTRACTOR shall submit qualifications of observer to ENGINEER 30 days in advance of required observations. QCS Inspector shall record observations and site decisions or instructions given to applicators or installers that are supplemental or contrary to manufacturers' written instructions.

1.09 JOB SITE CONDITIONS

A. Schedule project work to ensure all preparatory work has been accomplished prior to proceeding with current work. Proceeding with the work constitutes acceptance of conditions. Allow adequate time for materials susceptible to temperature and humidity to "stabilize" prior to installation in accordance with Manufacturer recommendations. Establish and maintain environmental conditions (i.e., temperature, humidity, lighting) as recommended by the various material manufacturers for the duration of the work.

1.10 SUBMITTALS

- A. The following information shall be provided in accordance with Section 01300:
 - Written description of CONTRACTOR's proposed QCS plan in sufficient detail to illustrate understanding and approach. The QCS plan and submittal shall include a log showing anticipated inspections, Special Inspections, and source and field Quality Assurance procedures. Preliminary submittal of the QCS plan may be made prior to commencing field work. The preliminary submittal will illustrate the project's initial three (3) month's work, and be followed one month later by a final QCS plan submittal.
 - 2. CONTRACTOR's proposed QCS Supervisor, qualifications, and if requested, references.
 - 3. Complete structural system information describing CONTRACTOR designed structural systems, including sealed calculations, shop and erection drawings, product literature for the various components, ICBO Evaluation Reports for structural components, and a discussion of risk issues associated with the proposed system which could adversely impact overall project completion.
 - 4. If requested by the ENGINEER during the work, manufacturer's field services and reports. If not so requested, treat same as Product Data.
 - 5. Records and testing results from Special Inspection testing requirements.

PART 2 PRODUCTS

2.01 SOURCE QUALITY CONTROL

- A. CONTRACTOR RESPONSIBILITIES
 - 1. Provide source quality control according to the reviewed and accepted QCS plan and paragraph 1.05 herein. Provide ready access to sampling and inspection locations and incidental labor customary in such sampling and inspections. Timely prepare and submit submittals, and revise as indicated by review comments. Comply with technical requirements in each specification Section that applies to the work.
- B. ACCEPTANCE CRITERIA
 - 1. Acceptable characteristics and quality of a particular item or construct is defined in the specifications.

2.02 PRODUCT DATA

- A. The following product data shall be provided in accordance with the Supplemental Conditions.
 - 1. Manufacturers' field services and reports unless requested by Construction Manager to be submitted for review.
 - 2. Special Inspection reports, unless otherwise directed in each technical specification Section.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Acceptable characteristics and quality of a particular item is defined in that item's specification Section.

3.02 REGULATORY COMPLIANCE – SPECIAL INSPECTIONS

- A. Under direction of the ENGINEER, the Contractor shall coordinate work to comply with the Special Inspections required to ensure the quality of work performed. The following types of work require Special Inspection according to Chapter 17 of the IBC and each system's specification Section and shall be performed by the OWNER:
 - 1. Structure Fill.
 - 2. Structural concrete and reinforcing.
 - 3. Anchor bolts and post-installed anchor systems.
- B. CONTRACTOR designed structural systems are subject to the same Special Inspection requirements as all other work.

3.03 CORRECTION OF DEFECTIVE WORK:

A. Remove and replace defective, rejected, and condemned work at CONTRACTOR's expense until such work meets the requirements of Contract Documents.

CONTRACTOR'S UTILITIES

1.01 OFFICE (NOT USED)

1.02 POWER

A. The CONTRACTOR shall provide power for construction at the project site. The CONTRACTOR shall make arrangements with the electrical utility and with the OWNER for power takeoff points, voltage and phasing requirements, transformers and metering and shall pay the costs and fees arising therefrom. The CONTRACTOR shall provide the special connections required for his work.

1.03 WATER

A. The CONTRACTOR shall provide all necessary water for construction at the project site. The CONTRACTOR shall make arrangements with WWD to determine an appropriate location to obtain water for the project, including obtaining a water meter. The Contractor shall provide the special connections required for his work.

1.04 SANITARY FACILITIES

A. The CONTRACTOR shall provide toilet and hand washing facilities for his work force at the site of work. The facilities shall comply with applicable laws, ordinances, and regulations pertaining to the public health and sanitation of dwellings and camps.

ENVIRONMENTAL CONTROLS

1.01 SITE MAINTENANCE

A. The CONTRACTOR shall keep the work site clean and free from rubbish and debris. Materials and equipment shall be removed from the site when they are no longer necessary. Upon completion of the work and before final acceptance, the work site shall be cleared of equipment, unused materials, and rubbish to present a clean and neat appearance.

1.02 AIR POLLUTION CONTROL

A. The CONTRACTOR shall not discharge smoke, dust, and other contaminants into the atmosphere that violate the regulations of any legally constituted authority. He shall also abate dust nuisance by cleaning, sweeping, and sprinkling with water, or other means as necessary. The use of water, in amounts which result in mud on public streets, is not acceptable as a substitute for sweeping or other methods.

SHIPMENT, PROTECTION AND STORAGE

PART 1 GENERAL

1.01 GENERAL

A. Equipment, products and materials shall be shipped, handled, stored, and installed in ways which will prevent damage to the items. Damaged items will not be permitted as part of the Work except in cases of minor damage that have been satisfactorily repaired and are acceptable to the ENGINEER.

1.02 PIPE

A. Pipe and appurtenances shall be handled, stored, and installed as recommended by the manufacturer. Pipes with paint, tape coatings, linings or the like shall be stored to protect the coating or lining from physical damage or other deterioration. Pipes shipped with interior bracing shall have the bracing removed only when recommended by the pipe manufacturer.

1.03 EQUIPMENT

- A. PACKAGE AND MARKING:
 - 1. Equipment shall be protected against damage from moisture, dust, handling, or other cause during transport from manufacturer's premises to site. Each item or package shall be marked with the number unique to the specification reference covering the item.
 - 2. Stiffeners shall be used where necessary to maintain shapes and to give rigidity. Parts of equipment shall be delivered in assembled or subassembled units where possible.
- B. IDENTIFICATION:
 - 1. Each item of equipment and valve shall have permanently affixed to it a label or tag with its equipment or valve number designated in this Contract. Marker shall be of stainless steel. Location of label will be easily visible.
- C. SHIPPING:
 - 1. Bearing housings, vents and other types of openings shall be wrapped or otherwise sealed to prevent contamination by grit and dirt.
 - 2. Damage shall be corrected to conform to the requirements of the Contract before the assembly is incorporated into the work. The CONTRACTOR shall bear the costs arising out of dismantling, inspection, repair and reassembly.
- D. FACTORY APPLIED COATINGS:
 - 1. Unless otherwise specified, each item of equipment shall be shipped to the site of the Work with the manufacturer's shop applied epoxy prime coating. The prime coating shall be applied over clean dry surfaces in accordance with the coating manufacturer's recommendations. The prime coating will serve as a base for field-applied finish coats.

- E. STORAGE:
 - 1. During the interval between the delivery of equipment to the site and installation, all equipment, unless otherwise specified, shall be stored in an enclosed space affording protection from weather, dust and mechanical damage and providing favorable temperature, humidity and ventilation conditions to ensure against equipment deterioration. Manufacturer's recommendations shall be adhered to in addition to these requirements.
 - 2. Equipment and materials to be located outdoors may be stored outdoors if protected against moisture condensation. Equipment shall be stored at least 6 inches above ground. Temporary power shall be provided to energize space heaters or other heat sources for control of moisture condensation. Space heaters or other heat sources shall be energized without disturbing the sealed enclosure.

F. PROTECTION OF EQUIPMENT AFTER INSTALLATION:

1. After installation, equipment shall be protected from damage from, including but not limited to, dust, abrasive particles, debris and dirt generated by the placement, chipping, sandblasting, cutting, finishing and grinding of new or existing concrete and metal; and from the fumes, particulate matter, and splatter from welding, brazing and painting of new or existing piping and equipment. As a minimum, vacuum cleaning, blowers with filters, protective shieldings, and other dust suppression methods will be required at all times to adequately protect equipment. During concreting, including finishing, equipment that may be affected by cement dust shall be completely covered. During painting operations, grease fittings and similar openings shall be covered to prevent the entry of paint. Electrical switchgear shall not be installed until after concrete work and sandblasting in those areas have been completed and accepted and the ventilation systems installed.

EQUIPMENT AND SYSTEM PERFORMANCE AND OPERATIONAL TESTING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section contains requirements for the CONTRACTOR's performance in documenting testing work required under this contract. In addition, this section contains requirements for the CONTRACTOR during performance testing of all mechanical, electrical, and instrumentation systems. This section supplements but does not supersede specific testing requirements found elsewhere in this project manual.

1.02 QUALITY ASSURANCE

- A. CONTRACTOR'S QUALITY ASSURANCE MANAGER:
 - The CONTRACTOR shall appoint an operations engineer or equally qualified operations specialist as Quality Assurance Manager to manage, coordinate, and supervise the CONTRACTOR's quality assurance program. The Quality Assurance Manager shall have at least 5 years of total experience, or experience on at least five separate projects, in managing the startup commissioning of mechanical, electrical, instrumentation, and piping systems. Operations engineers shall be graduates from a minimum 4-year course in mechanical or civil engineering. Operations specialists shall have equivalent experience in plant operation and maintenance. The quality assurance program shall include:
 - a. A testing plan setting forth the sequence in which all testing work required under this project manual will be implemented.
 - b. A documentation program to record the results of all equipment and system tests.
 - c. An installed performance testing program for all mechanical, electrical, instrumentation, and systems installed under this contract.
 - d. A calibration program for all instruments, gages, meters, and thermometers used for determining the performance of equipment and systems installed under this contract.
 - e. A testing schedule conforming to the requirements specified in paragraph 01660-2.02 C.
 - 2. For the purposes of this section, a system shall include all items of equipment, devices and appurtenances connected in such a fashion as their operation or function complements, protects or controls the operation or function of the others. The Quality Assurance Manager shall coordinate the activities of all subcontractors and suppliers to implement the requirements of this section.

B. CALIBRATION:

1. All test equipment (gages, meters, thermometers, analysis instruments, and other equipment) used for calibrating or verifying the performance of equipment installed under this contract shall be calibrated to within plus or minus 2 percent of actual value at full scale. Test equipment employed for individual test runs shall be selected so that expected values as indicated by the detailed performance specifications will fall between 60 and 85 percent of full scale. Pressure gages shall

be calibrated in accordance with ANSI/ASME B40.1. Thermometers shall be calibrated in accordance with ASTM E77 and shall be furnished with a certified calibration curve.

- 2. Liquid flow meters installed in pipelines with diameters greater than 2 inches shall be calibrated in situ using either the total count method or as recommended by the flow meter manufacturer. Flow meter calibration work shall be performed by individuals skilled in the techniques to be employed. Calibration tests for flow metering systems shall be performed over a range of not less than 10 percent to at least 75 percent of system full scale. At least five confirmed valid data points shall be obtained within this range. Confirmed data points shall be validated by not less than three test runs with results which agree within plus or minus 2 percent.
- C. REFERENCES:
 - This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
 - 2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI/ASME B40.1	Gauges Pressure Indicating Dial Type—Elastic Element
ASTM E77	Method for Verification and Calibration of Liquid-in-Glass Thermometers
ASHRAE 41.8	Standard Methods of Measurement of Flow of Gas
	Flow Measurement in Open Channels and Closed Conduits, Vol 1, U.S. Department of Commerce, National Bureau of Standards, pg. 361
	Techniques of Water-Resources Investigations of the United States Geological Survey, Chapter 16, Measurement of Discharge Using Tracers

1.03 SUBMITTALS

- A. Submittal material, to be submitted in accordance with Section 01300, shall consist of the following:
 - A copy of this specification section, with addendum updates included, and all
 referenced and applicable sections, with addendum updates included, with each
 paragraph check-marked to indicate specification compliance or marked to indicate
 requested deviations from specification requirements. Check marks (✓) shall denote
 full compliance with a paragraph as a whole. If deviations from the specifications are
 indicated, and therefore requested by the Contractor, each deviation shall be
 underlined and denoted by a number in the margin to the right of the identified
 paragraph referenced to a detailed written explanation for requesting the deviation.

The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. *Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.*

- 2. A complete description of the Contractor's plan for documenting the results from the test program in conformance with the requirements of paragraph 01660-2.02 A, including:
 - a. Proposed plan for documenting the calibration of all test instruments.
 - b. Proposed plan for calibration of all instrument systems, including flow meters and all temperature, pressure, weight, and analysis systems.
 - c. Sample forms for documenting the results of field pressure and performance tests.
- 3. The credentials and certification of the testing laboratory proposed by the Contractor for calibration of all test equipment.
- 4. Preoperational check-out procedures reviewed and approved by the respective equipment manufacturers.
- 5. Detailed testing plans, setting forth step-by-step descriptions of the procedures proposed by the Contractor for the systematic testing of all equipment and systems installed under this contract.
- 6. A schedule and subsequent updates, presenting the Contractor's plan for testing the equipment and systems installed under this contract.
- 7. A schedule establishing the expected time period (calendar dates) when the Contractor plans to commence operational testing of the completed systems, along with a description of the temporary systems and installations planned to allow operational testing to take place.
- 8. A summary of the Quality Assurance Manager's qualifications, showing conformance to paragraph 01660-1.02 A requirements.

PART 2 PRODUCTS

2.01 GENERAL

A. The CONTRACTOR shall prepare test plans and documentation plans as specified in the following paragraphs. The Construction Manager will not witness any test work for the purpose of acceptance until all test documentation and calibration plans and the specified system or equipment test plans have been submitted and accepted.

2.02 DOCUMENTATION

- A. DOCUMENTATION PLANS:
 - 1. The CONTRACTOR shall develop a records keeping system to document compliance with the requirements of this Section. Calibration documentation shall include identification (by make, manufacturer, model, and serial number) of all test equipment, date of original calibration, subsequent calibrations, calibration method, and test laboratory.

- 2. Equipment and system documentation shall include date of test, equipment number or system name, nature of test, test objectives, test results, test instruments employed for the test and signature spaces for the Construction manager's witness and the CONTRACTOR's quality assurance manager. A separate file shall be established for each system and item of equipment. These files shall include the following information as a minimum:
 - a. Metallurgical tests
 - b. Factory performance tests
 - c. Accelerometer recordings made during shipment
 - d. Field calibration tests¹
 - e. Field pressure tests¹
 - f. Field performance tests¹
 - g. Field operational tests¹
- 3. Section 01999 contains samples showing the format and level of detail required for the documentation forms. The CONTRACTOR is advised that these are samples only and are not specific to this project nor to any item of equipment or system to be installed under this contract. The CONTRACTOR shall develop test documentation forms specific to each item of equipment and system installed under this contract. Acceptable documentation forms for all systems and items of equipment shall be produced for review by the Construction Manager as a condition precedent to the CONTRACTOR's receipt of progress payments in excess of 50 percent of the contract amount. Once the Construction Manager has reviewed and taken no exception to the forms proposed by the CONTRACTOR, the CONTRACTOR shall produce sufficient forms, at his expense, to provide documentation of all testing work to be conducted as a part of this contract.
- B. TEST PLANS:
 - 1. The CONTRACTOR shall develop test plans detailing the coordinated, sequential testing of each item of equipment and system installed under this contract. Each test plan shall be specific to the item of equipment or system to be tested. Test plans shall identify by specific equipment or tag number each device or control station to be manipulated or observed during the test procedure and the specific results to be observed or obtained. Test plans shall also be specific as to support systems required to complete the test work, temporary systems required during the test work, subcontractors' and manufacturers' representatives to be present and expected test duration. As a minimum, the test plans shall include the following features:
 - a. Step-by-step proving procedure for all control and electrical circuits by imposing low voltage currents and using appropriate indicators to affirm that the circuit is properly identified and connected to the proper device.
 - b. Calibration of all analysis instruments and control sensors.
 - c. Performance testing of each individual item of mechanical, electrical, and instrumentation equipment. Performance tests shall be selected to duplicate the operating conditions described in the project manual.

¹Each of these tests is required even though not specifically noted in detailed specification section.
- d. System tests designed to duplicate, as closely as possible, operating conditions described in the project manual.
- 2. Test plans shall contain a complete description of the procedures to be employed to achieve the desired test environment.
- 3. As a condition precedent to receiving progress payments in excess of 75 percent of the contract amount, or in any event, progress payments due to the CONTRACTOR eight weeks in advance of the date the CONTRACTOR wishes to begin any testing work (whichever occurs earliest in the project schedule), the CONTRACTOR shall have submitted all test plans required for the systematic field performance and operational tests for all equipment and systems installed under this contract. Once the Construction Manager has reviewed and taken no exception to the CONTRACTOR's test plans, the CONTRACTOR shall reproduce the plans in sufficient number for the CONTRACTOR's purposes and an additional ten copies for delivery to the Construction Manager. No test work shall begin until the CONTRACTOR has delivered the specified number of final test plans to the Construction Manager.

C. TESTING SCHEDULE:

1. The CONTRACTOR shall produce a testing schedule setting forth the sequence contemplated for performing the test work. The schedule shall be in bar chart form, plotted against calendar time, shall detail the equipment and systems to be tested, and shall be coordinated with the CONTRACTOR's construction schedule specified in Section 01300. The schedule shall show the contemplated start date, duration of the test and completion of each test. The test schedule shall be submitted no later than 4 weeks in advance of the date testing is to begin. The Construction Manager will not witness any testing work for the purpose of acceptance until the CONTRACTOR has submitted a schedule to which the Construction Manager takes no exception. The test schedule shall be updated weekly, showing actual dates of test work, indicating systems and equipment testing completed satisfactorily and meeting the requirements of this project manual.

2.03 SYSTEM AND EQUIPMENT PERFORMANCE TESTS

A. Each item of mechanical, electrical, and instrumentation equipment installed under this contract shall be tested to demonstrate compliance with the performance requirements of this project manual. Each electrical, instrumentation, mechanical, and piping system installed or modified under this contract shall be tested in accordance with the requirements of this project manual.

2.04 PRODUCT DATA

A. Product data, to be provided in accordance with Section 01300, shall be the original and three copies of all records produced during the testing program.

PART 3 EXECUTION

3.01 GENERAL

A. The CONTRACTOR's Quality Assurance Manager shall organize teams made up of qualified representatives of equipment suppliers, subcontractors, the CONTRACTOR's independent testing laboratory, and others, as appropriate, to efficiently and expeditiously calibrate and test the equipment and systems installed and constructed under this contract. The objective of the testing program shall be to demonstrate, to the Construction Manager's complete satisfaction, that the structures, systems, and equipment constructed and installed under this contract meet all performance requirements and the facility is ready for the commissioning process to commence. In addition, the testing program shall produce baseline operating conditions for the OWNER to use in a preventive maintenance program.

3.02 CALIBRATION OF FIXED INSTRUMENTS

- A. Calibration of analysis instruments, sensors, gages, and meters installed under this contract shall proceed on a system-by-system basis. No equipment or system performance acceptance tests shall be performed until instruments, gages, and meters to be installed in that particular system have been calibrated and the calibration work has been witnessed by the Construction Manager.
- B. All analysis instruments, sensors, gages, and meters used for performance testing shall be subject to recalibration to confirm accuracy after completion, but prior to acceptance of each performance test or as a condition precedent to commissioning under the provisions of Section 01662.

3.03 PERFORMANCE TESTS

- A. GENERAL:
 - 1. Performance tests shall consist of the following:
 - a. Pressure and/or leakage tests.
 - b. Electrical testing as specified in Division 16.
 - c. Wiring and piping, individual component, loop, loop commissioning and tuning testing as described in Division 16.
 - d. Preoperational checkout for all mechanical and HVAC equipment. Preoperational check-out procedures shall be reviewed and approved by the respective equipment manufacturers.
 - e. Initial operation tests of all mechanical, electrical, HVAC, and instrumentation equipment and systems to demonstrate compliance with the performance requirements of this project manual.
 - 2. In general, performance tests for any individual system shall be performed in the order listed above. The order may be altered only on the specific written authorization of the Construction Manager after receipt of a written request, complete with justification of the need for the change in sequence.

B. PRESSURE AND LEAKAGE TESTS:

1. Pressure and leakage tests shall be conducted in accordance with the drawings. All acceptance tests shall be witnessed by the Construction Manager. Evidence of

successful completion of the pressure and leakage tests shall be the Construction Manager's signature on the test forms prepared by the CONTRACTOR.

- C. FUNCTIONAL CHECKOUT:
 - 1. Prior to energization (in the case of electrical systems and equipment), all circuits shall be rung out and tested for continuity and shielding in accordance with the procedures required in Division 16.
- D. COMPONENT CALIBRATION AND LOOP TESTING:
 - 1. Prior to energization (in the case of instrumentation system and equipment), all loops and associated instruments shall be calibrated and tested in accordance with the procedures required in Division 16.
- E. ELECTRICAL RESISTANCE:
 - 1. Electrical resistance testing shall be in accordance with Division 16.
- F. PREOPERATIONAL TESTS:
 - 1. Preoperational tests shall include the following:
 - a. Alignment of equipment.
 - b. Preoperation lubrication.
 - c. Tests per the manufacturers' recommendations for prestart preparation and preoperational check-out procedures.
- G. FUNCTIONAL TESTS:
 - 1. GENERAL: Once all affected equipment has been subjected to the required preoperational check-out procedures and the Construction Manager has witnessed and has not found deficiencies in that portion of the work, individual items of equipment and systems may be started and operated under simulated operating conditions to determine as nearly as possible whether the equipment and systems meet the requirements of these specifications.
 - a. The equipment shall be operated a sufficient period of time to determine machine operating characteristics, including noise, temperatures and vibration; to observe performance characteristics; and to permit initial adjustment of operating controls. When testing requires the availability of auxiliary systems such as looped piping, electrical power, compressed air, control air, or instrumentation which have not yet been placed in service, the CONTRACTOR shall provide acceptable substitute sources, capable of meeting the requirements of the machine, device, or system at no additional cost to the OWNER. Disposal methods for test water shall be subject to review by the Construction Manager. During the functional test period, the CONTRACTOR shall obtain baseline operating data on all equipment with motors greater than 1 horsepower to include amperage, bearing temperatures, and vibration. The baseline data shall be collected for the OWNER to enter in a preventive maintenance system.
 - b. Test results shall be within the tolerances set forth in the detailed specification sections of this project manual. If no tolerances have been specified, test results shall conform to tolerances established by recognized industry practice. Where, in the case of an otherwise satisfactory functional test, any doubt, dispute, or difference should arise between the Construction Manager and the CONTRACTOR

regarding the test results or the methods or equipment used in the performance of such test, then the Construction Manager may order the test to be repeated. If the repeat test, using such modified methods or equipment as the Construction Manager may require, confirms the previous test, then all costs in connection with the repeat test will be paid by the OWNER. Otherwise, the costs shall be borne by the CONTRACTOR. Where the results of any functional test fail to comply with the contract requirements for such test, then such repeat tests as may be necessary to achieve the contract requirements shall be made by the CONTRACTOR at his expense.

- c. The CONTRACTOR shall provide, at no expense to the OWNER, all power, fuel, compressed air supplies, and chemicals, all labor, temporary piping, heating, ventilating, and air conditioning for any areas where permanent facilities are not complete and operable at the time of functional tests, and all other items and work required to complete the functional tests. Temporary facilities shall be maintained until permanent systems are in service.
- 2. RETESTING: If under test, any portion of the work should fail to fulfill the contract requirements and is adjusted, altered, renewed, or replaced, tests on that portion when so adjusted, altered, removed, or replaced, together with all other portions of the work as are affected thereby, shall, unless otherwise directed by the Construction Manager, be repeated within reasonable time and in accordance with the specified conditions. The CONTRACTOR shall pay to the OWNER all reasonable expenses incurred by the OWNER, including the costs of the Construction Manager, as a result of repeating such tests.
- 3. POST-TEST INSPECTION: Once functional testing has been completed, all machines shall be rechecked for proper alignment and realigned, as required. All equipment shall be checked for loose connections, unusual movement, or other indications of improper operating characteristics. Any deficiencies shall be corrected to the satisfaction of the Construction Manager. All machines or devices which exhibit unusual or unacceptable operating characteristics shall be disassembled and inspected. Any defects found during the course of the inspection shall be repaired or the specific part or entire equipment item shall be replaced to the complete satisfaction of the Construction Manager at no cost to the OWNER.

3.04 OPERATIONAL TESTS

- A. The CONTRACTOR shall provide system operation testing. After completion of all performance testing and certification by the Construction Manager that all equipment complies with the requirements of the specifications, the CONTRACTOR shall conduct an operational test of the entire facility.
- B. The CONTRACTOR shall circulate water through the completed facility for a period of not less than 72 consecutive hours, during which all parts of the system shall be operated as a complete facility at various loading conditions, as directed by the Construction Manager. The operational testing period shall commence after this initial period of variable operation. Should the operational testing period be halted for any reason related to the facilities constructed or the equipment furnished under this contract, or the CONTRACTOR's temporary testing systems, the operational testing program shall be repeated until the specified continuous period has been accomplished without interruption. All process units shall be brought to full operating conditions, including temperature, pressure, and flow.

3.05 TEMPORARY FACILITIES FOR TESTING

A. The CONTRACTOR shall install temporary connections, bulkheads, piping and valves, and make other provisions to recirculate process fluids or otherwise simulate anticipated operating conditions during functional and operational testing. During the operational testing period, the CONTRACTOR's Quality Assurance Manager and testing team shall monitor the characteristics of each machine and system and report any unusual conditions to the Construction Manager.

This page intentionally left blank.

COMMISSIONING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section contains requirements for the CONTRACTOR's performance during the commissioning of the structures, equipment and systems constructed and installed during the course of this contract. All commissioning work, as described in this section, shall be performed by the CONTRACTOR.

1.02 QUALITY ASSURANCE

- A. CLEANUP:
 - 1. Following completion of the operational testing period, the CONTRACTOR shall remove, clean, and replace all permanent and temporary filters and strainers in all pipeline systems, and replace all HVAC filters as a condition precedent to commissioning.
- B. COMMISSIONING TEAM:
 - 1. The CONTRACTOR shall assemble a commissioning team under the direction of an individual duly authorized to commit the CONTRACTOR's personnel and resources to respond to requests for assistance on the part of the ENGINEER or, through the ENGINEER, the OWNER. The commissioning team shall consist of representatives of the CONTRACTOR's mechanical, electrical, and instrumentation subcontractors, and others as appropriate. The director of the commissioning team shall be available at the site of the work during normal working hours (8 hours a day, 5 days a week, Saturdays, Sundays, and legal holidays excepted) and shall be available within 2 hours' notice at all other times upon notice by telephone. The commissioning team shall be available within 2 hours' notice and shall be available within 2 hours' notice and shall be available at and ready to provide for emergency repairs, adjustments, and corrections to the equipment and systems installed and modified as a part of this contract.

1.03 SUBMITTALS

- A. The following information shall be submitted to the Engineer in accordance with the provisions of Section 01300:
 - 1. Detailed plans for commissioning each process unit and each system constructed or modified as a part of the work performed under this contract.
 - 2. The CONTRACTOR's plan for providing a commissioning team conforming to the requirements of paragraph 01662-1.02 B during the commissioning period. The plan shall be complete with a daytime staffing plan and names, qualifications, and telephone numbers of those assigned to off-hour standby duty.

PART 2 PRODUCTS

A. Working with representatives of the OWNER and the ENGINEER, the CONTRACTOR shall develop and produce a detailed, written plan for the startup and initial operation, under actual operating conditions, of the equipment and systems installed and constructed

under this contract. The document, after acceptance by the Engineer, shall serve as the guidance manual for the commissioning process.

PART 3 EXECUTION

- A. After completion of the equipment and system performance and operational testing, the CONTRACTOR shall remove all temporary piping, bulkheads, controls and other alterations to the permanent systems that may have been needed during the performance and operational testing and shall perform the tasks necessary to make the improvements constructed under this contract fully operational. The ENGINEER shall confirm in writing the date(s) that the system is ready for commissioning and on which actual commissioning activities commence. Activities conducted prior to such written confirmation shall not constitute commissioning.
- B. The commissioning period system shall be continuous period of 28 days. Should the commissioning period be interrupted at any time due to the CONTRACTOR's work, the commissioning period shall be restarted from the beginning of the full 28-day period. No additional compensation will be provided.
- C. During the commissioning period, the OWNER shall be responsible for all normal operational costs and the CONTRACTOR shall bear the costs of all necessary repairs or replacements, including labor and materials, required to keep the facility operational.
- D. The CONTRACTOR shall be available at all times during commissioning periods to provide immediate assistance in case of trouble or failure of any portion of the system. At the end of the commissioning period and when all corrections required by the ENGINEER to assure a reliable and completely operational facility are complete, the ENGINEER shall issue a completion certificate. Each system shall have been issued a completion certificate as a condition precedent to the final acceptance of the work of this contract.

SECTION 01664 TRAINING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section contains requirements for training the OWNER's personnel, by persons retained by the CONTRACTOR specifically for the purpose, in the proper operation and maintenance of the equipment and systems installed under this contract.

1.02 QUALITY ASSURANCE

A. Where required by the detailed specifications, the CONTRACTOR shall provide on-the-job training of the OWNER's personnel. The training sessions shall be conducted by qualified, experienced, factory-trained representatives of the various equipment manufacturers. Training shall include instruction in both operation and maintenance of the subject equipment.

1.03 SUBMITTALS

- A. The following information shall be submitted to the ENGINEER in accordance with the provisions of Section 01300. The material shall be reviewed and accepted by the ENGINEER as a condition precedent to receiving progress payments in excess of 50 percent of the contract amount and not less than 3 weeks prior to the provision of training.
 - 1. Lessons plans for each training session to be conducted by the manufacturer's representatives. In addition, training manuals, handouts, visual aids, and other reference materials shall be included.
 - 2. Subject of each training session, identity and qualifications of individuals to be conducting the training, and tentative date and time of each training session.

PART 2 PRODUCTS

2.01 GENERAL

A. Where specified, the CONTRACTOR shall conduct training sessions for the OWNER's personnel to instruct the staff on the proper operation, care, and maintenance of the equipment and systems installed under this contract. Training shall take place at the site of the work and under the conditions specified in the following paragraphs. Approved operation and maintenance manuals shall be available at least 30 days prior to the date scheduled for the individual training session.

2.02 LOCATION

A. Training sessions shall take place at the site and times as designated by the OWNER.

2.03 LESSON PLANS (NOT USED)

2.04 FORMAT AND CONTENT

- A. As a minimum, training session shall cover the following subjects for each item of equipment or system:
 - 1. Familiarization
 - a. Review catalog, parts lists, drawings, etc., which have been previously provided for the plant files and operation and maintenance manuals.
 - b. Check out the installation of the specific equipment items.
 - c. Demonstrate the unit and indicate how all parts of the specifications are met.
 - d. Answer questions.
 - 2. Safety
 - a. Review safety references.
 - b. Discuss proper precautions around equipment.
 - 3. Operation
 - a. Review reference literature.
 - b. Explain all modes of operation (including emergency).
 - c. Check out OWNER's personnel on proper use of the equipment.
 - 4. Preventive Maintenance
 - a. Review preventive maintenance (PM) lists including:
 - 1) Reference material.
 - 2) Daily, weekly, monthly, quarterly, semiannual, and annual jobs.
 - b. Show how to perform PM jobs.
 - c. Show OWNER's personnel what to look for as indicators of equipment problems.
 - 5. Corrective Maintenance
 - a. List possible problems.
 - b. Discuss repairs--point out special problems.
 - c. Open up equipment and demonstrate procedures, where practical.
 - 6. Parts
 - a. Show how to use previously provided parts list and order parts.
 - b. Check over spare parts on hand. Make recommendations regarding additional parts that should be available.
 - 7. Local Representatives
 - a. Where to order parts: name, address, telephone.
 - b. Service problems:
 - 1) Who to call.
 - 2) How to get emergency help.
 - 8. Operation and Maintenance Manuals
 - a. Review any other material submitted.
 - b. Update material, as required.

PART 3 EXECUTION

- A. Training shall be conducted in conjunction with the operational testing and commissioning periods. Classes shall be scheduled such that classroom sessions are interspersed with field instruction in logical sequence. The CONTRACTOR shall arrange to have the training conducted on consecutive days, with no more than 6 hours of classes scheduled for any one day. Concurrent classes shall not be allowed.
- B. Acceptable operation and maintenance manuals for the specific equipment shall be provided to the OWNER prior to the start of any training. Video taping shall take place concurrently with all training sessions.
- C. The following services shall be provided for each item of equipment or system as required in individual specification sections. Additional services shall be provided, where specifically required in individual specification sections.
- D. Hands-on equipment training for maintenance and repair personnel shall include:
 - 1. Locate and identify equipment components.
 - 2. Review the equipment function and theory of operation.
 - 3. Review normal repair procedures.
 - 4. Perform start-up and shutdown procedures.
 - 5. Review and perform the safety procedures.
 - 6. Perform OWNER approved practice maintenance and repair job(s), including mechanical and electrical adjustments and calibration and troubleshooting equipment problems.

This page intentionally left blank.

PROJECT CLOSEOUT

PART 1 GENERAL

1.01 TESTING OF FACILITIES

A. All CONTRACTOR work shall be tested under operating conditions and pressures in accordance with Section 01660. Any leaks or malfunctions shall be repaired to the satisfaction of the ENGINEER at no additional expense to the OWNER. This provision with reference to leakage shall also apply to water-tightness of buildings and/or equipment enclosures.

1.02 CLOSEOUT PROCEDURES

A. Submit written certification that Contract Documents have been reviewed, Work has been inspected, and that Work is complete in accordance with Contract Documents and ready for ENGINEER's inspection. Provide submittals to ENGINEER that are required by governing or other authorities. Submit Application for final payment identifying total adjusted Contract sum, previous payments, and sum remaining due.

1.03 FINAL CLEANING

A. Execute final cleaning prior to final inspection. Clean interior and exterior glass and surfaces exposed to view; remove temporary labels, stains and foreign substances, polish transparent and glossy surfaces, vacuum carpeted and soft surfaces. Clean equipment and fixtures to a sanitary condition. Clean debris from roofs, gutters, downspouts, and drainage systems. Clean site; sweep paved areas, rake clean landscape surfaces. Remove waste and surplus materials, rubbish, and construction facilities from the site.

1.04 PROJECT RECORD DOCUMENTS

- A. Maintain on site, one set of the following record documents; record actual revisions to the Work:
 - 1. contract drawings
 - 2. specifications
 - 3. addenda
 - 4. change orders and other modifications to the Contract
 - 5. reviewed shop drawings, product data, and samples
- B. Store record documents separate from documents used for construction. Record changed information and alterations from original design concurrent with construction progress.
- C. Specifications: Legibly mark and record at each product section description of actual products installed, including the following:
 - 1. Manufacturer's name and product model and number
 - 2. Product substitutions or alternates utilized
 - 3. Changes made by addenda and modifications

- D. Record Documents and Shop Drawings: Legibly mark each item to record actual construction including:
 - 1. Measured depths of foundations in relation to finish floor datum.
 - 2. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
 - 3. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the Work.
 - 4. Field changes of dimension and detail.
 - 5. Details not on original Contract Drawings.
- E. Record drawings shall be in accordance with Section 01720. Submit documents to ENGINEER with final Application for Payment.

1.05 SPARE PARTS AND MAINTENANCE MATERIALS

- A. Provide products, spare parts, maintenance and extra materials in quantities specified in individual specification sections.
- B. Deliver spare parts and maintenance materials to the OWNER; obtain receipt prior to final payment.

1.06 GUARANTEES AND WARRANTIES

- A. The CONTRACTOR expressly warrants that all workmanship and materials performed or furnished under this Contract will conform to the Specifications, Drawings, samples and other applicable descriptions furnished or adopted by the CONTRACTOR and with all applicable laws, provisions and requirements of the Contract Documents. The CONTRACTOR shall remedy any defects due to faulty materials or workmanship which shall appear within a period of one (1) year from the date of acceptance of the work hereunder and pay for any damage to other work resulting therefrom. The OWNER shall give notice of observed defects with reasonable promptness. The CONTRACTOR warranty hereunder is in addition to, and not in limitation of, any obligations found elsewhere in the Contract Documents, any special guarantees provided by the CONTRACTOR or his suppliers, and any obligations imposed by law.
- B. In addition to the above requirements, the CONTRACTOR shall assign material and equipment guarantees and warranties from all manufacturers and suppliers to the OWNER and deliver copies of such guarantees and warranties and the assignments thereof to the OWNER in order to assure the OWNER of the full benefit of such guarantees and warranties.

1.07 RESTORATION

A. The CONTRACTOR shall repair damage resulting from construction activities to adjacent improvements and restore and/or replace paving, curbing, sidewalks, gutters, shrubbery, fences, sod or other disturbed surfaces and structures to a condition equal to that before the work began and to the satisfaction of the ENGINEER and shall furnish all labor and materials incidental thereto.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

This page intentionally left blank.

RECORD DRAWINGS

Record drawings refer to those documents maintained and annotated by the CONTRACTOR during construction and are defined as (1) a neatly and legibly marked set of contract drawings showing the final location of piping, equipment, electrical conduits, outlet boxes and cables; (2) additional documents such as schedules, lists, drawings, and electrical and instrumentation diagrams included in the specifications; and (3) CONTRACTOR layout and installation drawings.

Unless otherwise specified, record drawings shall be full size and maintained in a clean, dry, and legible condition. Record documents shall not be used for construction purposes and shall be available for review by the Construction Manager during normal working hours at the CONTRACTOR's field office. At the completion of the work, prior to final payment, all record drawings shall be submitted to the Construction Manager.

Marking of the drawings shall be kept current and shall be done at the time the material and equipment are installed. Annotations to the record documents shall be made with an erasable colored pencil conforming to the following color code:

Additions - Red Deletions - Green Comments - Blue Dimensions - Graphite*

*Legibly mark to record actual depths, horizontal and vertical location of underground raceways, cables, and appurtenances referenced to permanent surface improvements.

This page intentionally left blank.

OPERATING AND MAINTENANCE INFORMATION

1.01 SCOPE

- A. Operation and maintenance (O&M) instructions shall be provided in accordance with this section and as required in the Contract Documents. O&M information shall be provided for each maintainable piece of equipment, equipment assembly or subassembly, and material provided or modified under this contract.
- B. O&M instructions must be submitted and accepted before on-site training may start.

1.02 TYPES OF INFORMATION REQUIRED

A. GENERAL:

1. O&M information shall contain the names, addresses, and telephone numbers of the manufacturer, the nearest representative of the manufacturer, and the nearest supplier of the manufacturer's equipment and parts. In addition, one or more of the following items of information shall be provided as applicable.

B. OPERATING INSTRUCTIONS:

- 1. Specific instructions, procedures, and illustrations shall be provided for the following phases of operations:
 - a. SAFETY PRECAUTIONS: List personnel hazards for equipment and list safety precautions for all operating conditions.
 - b. OPERATOR PRESTART: Provide requirements to set up and prepare each system for use.
 - c. START-UP, SHUTDOWN, AND POST SHUTDOWN PROCEDURES: Provide a control sequence for each of these operations.
 - d. NORMAL OPERATIONS: Provide control diagrams with data to explain operation and control of systems and specific equipment.
 - e. EMERGENCY OPERATIONS: Provide emergency procedures for equipment malfunctions to permit a short period of continued operation or to shut down the equipment to prevent further damage to systems and equipment. Include emergency shutdown instructions for fire, explosion, spills, or other foreseeable contingencies. Provide guidance on emergency operations of all utility systems including valve locations and portions of systems controlled.
 - f. OPERATOR MAINTENANCE/SERVICE REQUIREMENTS: Provide instructions for services to be performed by the operator such as lubrication, adjustments, and inspection.
 - g. ENVIRONMENTAL CONDITIONS: Provide a list of environmental conditions (temperature, humidity, and other relevant data) which are best suited for each product or piece of equipment and describe conditions under which equipment should not be allowed to run.

C. PREVENTIVE MAINTENANCE:

1. The following information shall be provided for preventive and scheduled maintenance to minimize corrective maintenance and repair:

- a. LUBRICATION DATA: Provide lubrication data, other than instructions for lubrication.
 - 1) A table showing recommended lubricants for specific temperature ranges and applications;
 - 2) Charts with a schematic diagram of the equipment showing lubrication points, recommended types and grades of lubricants, and capacities; and
 - 3) A lubrication schedule showing service interval frequency.
- b. PREVENTIVE MAINTENANCE PLAN AND SCHEDULE: Provide manufacturer's schedule for routine preventive maintenance, inspections, tests, and adjustments required to ensure proper and economical operation and to minimize corrective maintenance and repair. Provide manufacturer's projection of preventive maintenance man-hours on a daily, weekly, monthly, and annual basis including craft requirements by type of craft.
- D. CORRECTIVE MAINTENANCE:
 - 1. Manufacturer's recommendations shall be provided on procedures and instructions for correcting problems and making repairs.
 - a. TROUBLESHOOTING GUIDES AND DIAGNOSTIC TECHNIQUES: Provide step-bystep procedures to promptly isolate the cause of typical malfunctions. Describe clearly why the step-by-step procedure is performed and what conditions are to be sought. Identify tests or inspections and test equipment required to determine whether parts and equipment may be reused or requires replacement.
 - b. WIRING DIAGRAMS AND CONTROL DIAGRAMS: Wiring diagrams and control diagrams shall be point-to-point drawings of wiring and control circuits including factory-field interfaces. Provide a complete and accurate depiction of the actual job-specific wiring and control work. On diagrams, number electrical and electronic wiring and pneumatic control tubing and the terminals for each type identically to actual installation numbering.
 - c. MAINTENANCE AND REPAIR PROCEDURES: Provide instructions and list tools required to restore product or equipment to proper condition or operating standards.
 - d. REMOVAL AND REPLACEMENT INSTRUCTIONS: Provide step-by-step procedures and list required tools and supplies for removal, replacement, disassembly, and assembly of components, assemblies, subassemblies, accessories, and attachments. Provide tolerances, dimensions, settings, and adjustments required. Instructions shall include a combination of test and illustrations.
 - e. SPARE PARTS AND SUPPLY LISTS: Provide lists of spare parts and supplies required for maintenance and repair to ensure continued service or operation without unreasonably delays. Special consideration is required for facilities at remote locations. List spare parts and supplies that have a long lead time to obtain.
 - f. CORRECTIVE MAINTENANCE MANHOURS: Provide manufacturer's projection of corrective maintenance man-hours including craft requirements by type of craft. Corrective maintenance that requires participation of the equipment manufacturer shall be identified and tabulated separately.

E. APPENDICES:

1. The following information shall be provided; include information not specified in the preceding paragraphs but pertinent to the maintenance or operation of the product or equipment.

- a. PARTS IDENTIFICATION: Provide identification and coverage for all parts of each component, assembly, subassembly, and accessory of the end items subject to replacement. Include special hardware requirements, such as requirement to use high-strength bolts and nuts. Identify parts by make, model, serial number, and source of supply to allow reordering without further identification. Provide clear and legible illustrations, drawings, and exploded views to enable easy identification of the items. When illustrations omit the part numbers and description, both the illustrations and separate listing shall show the index, reference, or key number which will cross-reference the illustrated part to the listed part. Parts shown in the listings shall be grouped by components, assemblies, and subassemblies.
- b. WARRANTY INFORMATION: List and explain the various warranties and include the servicing and technical precautions prescribed by the manufacturers or contract documents to keep warranties in force.
- c. PERSONNEL TRAINING REQUIREMENTS: Provide information available from the manufacturers to use in training designated personnel to operate and maintain the equipment and systems properly.
- d. TESTING EQUIPMENT AND SPECIAL TOOL INFORMATION: Provide information on test equipment required to perform specified tests and on special tools needed for the operation, maintenance, and repair of components.

1.03 TRANSMITTAL PROCEDURE

- A. Unless otherwise specified, O&M manuals, information, and data shall be transmitted in accordance with Section 01300. The transmittal form shall be used as a checklist to ensure the manual is complete. Only complete sets of O&M instructions will be reviewed for acceptance.
- B. Three copies of the specified O&M information shall be provided. For ease of identification, each manufacturer's brochure and manual shall be appropriately labeled with the equipment name and equipment number as it appears in the project manual. The information shall be organized in the binders in numerical order by the equipment numbers assigned in the project manual. The binders shall be provided with a table of contents and tab sheets to permit easy location of desired information. Binders shall be heavy duty, white, "D" ring binder with a clear pocket overlay cover.
- C. If manufacturers' standard brochures and manuals are used to describe O&M procedures, such brochures and manuals shall be modified to reflect only the model or series of equipment used on this project. Extraneous material shall be crossed out neatly or otherwise annotated or eliminated.

1.04 PAYMENT

A. Acceptable O&M information for the project must be delivered to the ENGINEER prior to the project being 65 percent complete. Progress payments for work in excess of 65 percent completion will not be made until the specified acceptable O&M information has been delivered to the ENGINEER.

1.05 FIELD CHANGES

A. Following the acceptable installation and operation of an equipment item, the item's instructions and procedures shall be modified and supplemented by the CONTRACTOR to reflect any field changes or information requiring field data.

STORMWATER POLLUTION CONTROL MEASURES FOR CONSTRUCTION ACTIVITIES

1.01 GENERAL

The Contractor shall exercise every reasonable precaution to protect channels, storm drains, and bodies of water from pollution including dechlorination and sediment control.

- A. Conduct and schedule operations to minimize or avoid muddying and silting channels, drains, and waters.
- B. As required, obtain permits for erosion and water pollution control from the appropriate jurisdictional agency before starting Work.
- C. Provide any necessary water pollution control devices to prevent, control, and abate water pollution, and implement good housekeeping pollution control measures to reduce the discharge of pollutants from work sites to the maximum extent practicable. These water pollution control devices include drains, gutters, slope protection blankets and retention basins and shall be constructed concurrently with other Work at the earliest practicable time.
- D. Exercise care in preserving vegetation and protecting property, to avoid disturbing areas beyond the limits of the Work. Promptly repair any damage caused by CONTRACTOR operations.
- E. Comply with the specific requirements based on acreage of disturbed soil.
- F. Penalties: Failure to comply with this Section may result in significant fines and possible imprisonment. The RWQCB or other prosecuting authority may assess fines for each violation. Should the OWNER be fined or penalized as a result of the CONTRACTOR failing to comply with this Section, the CONTRACTOR shall reimburse the OWNER for any and all fines, penalties and related costs.
- G. Notification and Report: If pollution occurs in the work area for any reason or when the CONTRACTOR becomes aware of any violation of this Section, correct the problem and immediately notify the Inspector. In addition, submit a written report to the ENGINEER within seven (7) calendar days describing the incident and the corrective actions taken. If either the Inspector or ENGINEER is first to observe pollution or a violation, the CONTRACTOR shall also explain in the written report why the Work was inadequately monitored.
- H. The provisions of this Section describe minimum compliance and do not preclude other more stringent stormwater pollution control measures that may be required in the Contract.

1.02 DEFINITIONS

A. "Construction activity": Operations such as clearing, grading, disturbances to the ground such as stockpiling, or excavation that results in soil disturbances. If construction activity is part of a larger common plan of development, the amount of disturbed soil is the total land area of disturbed soil that results under the common plan. When estimating total

area to be disturbed for determining SWPPP requirements/applicability areas that are paved and will remain paved for the duration of the project do not need to be included in the estimate of disturbed area.

1.03 PAYMENT

All costs for work required for compliance with this Section shall be included within the Bid Prices.

2.01 CONSTRUCTION ACTIVITY - LESS THAN ONE ACRE OF DISTURBED SOIL

Comply with the following minimum water quality protection requirements:

- A. Retain eroded sediments and other pollutants on-site and do not allow transportation from the site by sheet flow, swales, area drains, natural drainage, or wind. Control slope and channel erosion by implementing an effective combination of best management practices (BMPs). Such BMPs include scheduling grading during non-rainy seasons, planting and maintaining vegetation on slopes and covering erosion-susceptible slopes.
- B. Protect stockpiles of earth and other construction-related materials from being transported from the site by wind or water.
- C. Properly store and handle fuels, oils, solvents, and other toxic materials to not contaminate the soil or surface waters, enter the groundwater, or be placed where they may enter a live stream, channel, drain, or other water conveyance facility. Protect all approved toxic storage containers from weather. Clean spills immediately and properly dispose of cleanup materials. Spills shall not be washed into live streams, channels, drains, or other water conveyance facilities.
- D. Do not wash excess or waste concrete into the public way or any drainage system. Retain concrete wastes on-site until they can be appropriately disposed of or recycled.
- E. Deposit trash and construction-related solid wastes in covered receptacles to prevent contamination of rainwater and dispersal by wind.
- F. Do not allow sediments and other materials to be tracked from the site by vehicle traffic. Stabilize construction entrance roadways to inhibit sediments from being deposited onto public ways. Immediately sweep up accidental depositions. Do not allow depositions to be washed away by rain or by any other means.
- G. Contain non-stormwater runoff from equipment or vehicle washing and any other activity at the work site.
- H. At completion of the Work, clear the worksite of debris and restore to a condition at least equal to or better than prior to construction.
- When construction activity with grading is likely to occur during the rainy season (October 1 through April 15), prepare a Wet Weather Erosion Control Plan (WWECP) per LAMC Section 61.02. The WWECP must be submitted to the ENGINEER for approval within thirty (30) calendar days after execution of the Contract.

- J. Guidance on preparing the WWECP can be found in "Development Best Management Practices Handbook - Part A, Construction Activities", adopted by the Board and as authorized by LAMC Section 64.72. The handbook can be viewed at or obtained at cost at Bureau of Engineering public counters.
- K. When working in live streams, these are additional water pollution control requirements.
 - 1. Erect barriers sufficient to prevent muddying or polluting streams.
 - 2. Prior to removing materials from a flowing stream, use a stream bypass or other equivalent means to keep the flow in the stream free of the mud or silt from the removal operations.
 - 3. Avoid transporting materials across live streams. If not possible, the transportation operation must be designed to prevent materials from falling into the stream and cannot muddy the stream.
 - 4. Equipment may not be operated in a channel unless the CONTRACTOR can demonstrate to the Engineer's satisfaction that no other practical alternatives exist.
 - 5. Do not allow fresh portland cement or fresh portland cement concrete to enter the water channels or drains.
 - 6. Do not allow material derived from the Work to be deposited in a live channel or drain.

2.02 CONSTRUCTION ACTIVITY - ONE ACRE OR MORE OF DISTURBED SOIL

In addition to the requirements for Section 2.1 - "Construction activity - less than one acre of disturbed soil", file a Notice of Intent (NOI) with the State Water Resources Control Board and apply for coverage under the State General Construction Activity Stormwater Permit (GCASP) (NPDES No. CAS000002. Comply with all of the requirements of the GCASP, including preparing and implementing a Storm Water Pollution Prevention Plan (SWPPP). The SWPPP must describe the erosion control practices to be implemented during construction and the selection and implementation of appropriate BMPs to account for site-specific and seasonal conditions. This supercedes the Section 2.1(I) WWECP requirement for describing erosion control practices.

The Waste Discharge Identification Number (WDID) is evidence of NOI submittal. Provide the WDID to the ENGINEER and other agencies that issued permits for the project (such as the Department of Building & Safety). Guidance with the GCASP, NOI and SWPPP is available in the "Construction Handbook" published by the California Stormwater Quality Association and downloadable from their web site at http://www.cabmphandbooks.com/Construction.asp.

- A. Compliance with the GCASP requires:
 - 1. Submitting a NOI to the SWRCB and paying fees prior to start of construction;
 - 2. Preparing the SWPPP before start of construction;
 - 3. Keeping the SWPPP on site, implementing it during construction, and revising it as needed; and
 - 4. Submitting a Notice of Termination with the SWRCB when construction is complete.
- B. Implementing the SWPPP requires:
 - 1. Certifying by July 1 of each year that construction activities are in compliance with the GCASP and SWPPP,

- 2. If there were instances of non-compliance, the CONTRACTOR shall submit notifications of non-compliance to the Regional Water Quality Control Board (RWQCB) within 30 calendar days from the time the non-compliance was first identified.
- 3. If the Contractor, SWRCB, or RWQCB determines that stormwater discharges and/or authorized non-stormwater discharges are causing or contributing to an exceedance of an applicable water quality standard, the Contractor shall:
 - a. Implement corrective measures immediately and notify the RWQCB as soon as possible but no later than 48 hours after discovering the discharges. Unless otherwise directed by the RWQCB, follow up the notification with a report within 14 calendar days to the RWQCB. The report must describe: (1) the nature and cause of the water quality standard exceedance; (2) the BMPs currently being implemented; (3) any additional BMPs which will be implemented to prevent or reduce pollutants that are causing or contributing to the exceedance of water quality standards; (4) any maintenance or repair of BMPs; (5) an implementation schedule for corrective actions; and, (6) a description of actions taken to reduce the pollutants causing or contributing to the exceedance.
 - b. Immediately revise the SWPPP and monitoring program to incorporate the additional BMPs that have been and will be implemented, the implementation schedule, and any additional monitoring needed.
 - c. The CONTRACTOR is advised that none of the foregoing prevent the RWQCB from enforcing any provisions of the GCASP while the CONTRACTOR prepares and implements the above report.
- 4. Amending the SWPPP as needed. Sign and date all amendments, attach them directly to the SWPPP and promptly provide copies of all amendments to the ENGINEER.
- 5. Ensuring that persons responsible for preparing, implementing, and amending the SWPPP and responsible for permit compliance are appropriately trained. This includes personnel responsible for installing, inspecting, maintaining, and repairing BMPs. Include documentation of their training in the SWPPP.
- 6. Inspect BMPs before and after each storm and once each 24-hour period during extended storm events to assess BMP effectiveness. Implement BMP repairs or changes as soon as feasible. Document each inspection with a checklist kept with the SWPPP, using forms provided by the SWRCB, RWQCB or equivalent.
- 7. Develop and implement a sampling and analysis program for pollutants which are not visually detectable in storm water discharges, which are or should be known to occur on the construction site, and which could cause or contribute to an exceedance of water quality objectives in the receiving water.
- 8. In addition to plans or permits required by local, state, or federal agencies, maintain copies of the GCASP, SWPPP their amendments and their reference documents available for review at the construction site.
- 9. Retain records/copies of: data used to complete the NOI; the SWPPP and all attachments and amendments; compliance certifications; notifications of non-compliance; training; incidents such as spills or other releases, including photographs as available; sampling and analysis of discharges discovered through visual monitoring; all reports required by the GCASP; BMP inspections and checklists, and maintenance and repair activities; and activity-based BMPs, such as good housekeeping, that have been implemented.

10. After the Work is complete and final acceptance by SSWD, submit to the ENGINEER, all records/copies of documents required by the GCASP, including, but not limited to, the records/copies of the documents noted above.

This page intentionally left blank.

SEISMIC ANCHORAGE AND BRACING REQUIREMENTS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies the seismic anchorage and bracing for all nonstructural components. Seismic attachment to the structure for all parts or elements of the architectural, mechanical, and electrical systems shall be provided in accordance with this section.

1.02 QUALITY ASSURANCE

A. REFERENCES

- This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
- 2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, whether or not the document has been superseded by a version with a later date, discontinued, or replaced.

Reference	Title
CBC 2019	California Building Code
SMACNA	Seismic Restraint Manual Guidelines for Mechanical Systems
ASCE 7-16	Minimum Design Loads for Buildings and Other Structures

B. DESIGN CRITERIA

1. Seismic attachment for all parts or elements of the architectural, mechanical and electrical systems shall be provided in accordance with the provisions of the referenced codes and guidelines above and the following criteria unless noted otherwise on the drawings:

Design Parameters	Coefficients
Short Period Mapped Spectral Response, S _S :	0.467 g
1 Second Period Mapped Spectral Response, S1:	0.228 g
Site Class:	D
Short Period Design Spectral Response, S _{DS} :	0.444 g
1 Second Period Design Spectral Response, S _{D1} :	0.326 g
Importance Factor (Ie):	1.25

Design Parameters	Coefficients
Component Importance Factor (I _p):	1.0, except I _p =1.5 for fire protection sprinkler systems or components containing hazardous materials
Seismic Design Category	D

1.03 SUBMITTALS

- A. Submit shop drawings and calculations no less than four weeks in advance of the installation of any component to be anchored to the structure or installation of any structural member to which the component will be attached.
- B. The following submittals shall be provided in accordance with Section 01300:
 - 1. List of all equipment requiring seismic anchorage.
 - 2. Shop drawings showing details of complete seismic attachment assemblies including connection hardware, and embedment into concrete.
 - 3. Calculations for all seismic attachments clearly showing the criteria used and sealed by a Professional Engineer, qualified to perform structural engineering, licensed by the state of California. Concrete anchorage calculations shall be coordinated with thickness and strength of concrete members.
 - 4. Product Data: Manufacturer's certificates of compliance with the seismic force requirements of this section.

PART 2 PRODUCTS

A. Attachments and supports transferring seismic loads to the structure shall be constructed of materials and products suitable for the application and designed and constructed in accordance with nationally recognized standards.

PART 3 EXECUTION

- A. The Contractor shall provide anchorage to the structure of all architectural, mechanical and electrical system elements whether or not anchorage of the specific item is called for in any specification section or on the drawings. Seismic attachments shall be made in such a manner that the component seismic force is transferred to the lateral force-resisting system of the structure.
- B. Components mounted on vibration isolation systems shall have snubbers in each horizontal direction and vertical restraints where required to resist overturning.
- C. Piping shall be anchored in such a manner as to ensure that the piping system has adequate flexibility and expansion capabilities at flexible connections and expansion joints.
- D. All piping and ductwork suspended more than 12 inches below the supporting structure shall be braced for seismic effects.
- E. Tall and narrow equipment such as motor control centers, telemetry equipment shall be anchored at the base and near the top.

F. Details of and calculations for all seismic anchorages, including anchor bolt embedment lengths, shall be submitted and accepted in accordance with paragraph 01900-1.03 prior to placement of concrete or erection of other structural supporting members. Submittals received after structural supports are in place will be rejected if proposed anchorage method would create an overstressed condition of the supporting member. The Contractor shall be responsible for revisions to the anchorages and/or strengthening of the structural support so that there is no overstressed condition at no additional cost to the Owner.

This page intentionally left blank.

REFERENCE FORMS

PART 1 FORMS

1.01 DESCRIPTION

A. The forms listed below and included in this section are referenced from other sections of the project manual:

Form No.	Title
01300-A	Submittal Transmittal Form
01660-A	Equipment Test Report Form
01730-A	Operation and Maintenance Transmittal Form
01730-B	Equipment Record Form
01730-C	Equipment Record Form
09900-A	Coating System Inspection Checklist
16000-A	Wire and Cable Resistance Test Data Form
16000-B	Installed Motor Test Data Form
16000-C	Dry Transformer Test Data Form
16000-D	Motor Control Center Test Form
16000-E	Medium Voltage Motor Starter Test Form
16000-F	Medium Voltage Switchgear Test Form
16000-G	Protective Relay Test Form
16000-H	Low Voltage Switchgear Test Form
16000-I	Medium Voltage Load Interrupter Switch Test Form
16000-J	Liquid-Filled Transformer Test Form
16000-K	Automatic Transfer Switch Test Form
16000-L	Neutral Grounding Resistor Test
17000-A	Loop Wiring and Insulation Resistance Test Data Form
17000-В	Control Circuit Piping Leak Test Form
17000-C	Controller Calibration Test Data Form
17000-D	Panel Indicator Calibration Test Data Form
17000-E	Recorder Calibration Test Data Form
17000-F	Signal Trip Calibration Test Data Form
17000-G	Field Switch Calibration Test Data Form
17000-H	Transmitter Calibration Test Data Form
17000-I	Miscellaneous Instrument Calibration Test Data Form
17000-J	Individual Loop Test Data Form
17000-K	Loop Commissioning Test Data Form
11000-A	Manufacturer's Installation Certification Form
11000-В	Manufacturer's Instruction Certification Form
11000-C	Unit Responsibility Certification Form
11002-A	Rigid Equipment Mount Installation Inspection Checklist
11060-A	Motor Data Form

01300-A. SUBMITTAL TRANSMITTAL FORM

Submittal Transmittal

Submittal Description: Submittal No:1		:	Spec Section:	
		I	I	1
		Routing	Sent	Received
Owner:		Contractor	/CM	
Project:		CM/Engineer		
		Engineer/	СМ	
Contractor:		CM/Contra	actor	

We are sending you:

- □ Attached
- Under separate cover via _____
- □ Submittals for review and comment
- $\hfill\square$ Product data for information only

Remarks:

Item	Copies	Date	Section No.	Description	Review action ^a	Reviewer initials	Review comments attached

^aNote: NET = No exceptions taken; MCN = Make corrections noted; A&R = Amend and resubmit; R = Rejected Attach additional sheets if necessary.

Contractor

Certify either a or b:

- a. \Box We have verified that the material or equipment contained in this submittal meets all the requirements, including coordination with all related work, specified (no exceptions).
- b. \Box We have verified that the material or equipment contained in this submittal meets all the requirements specified except for the attached deviations.

No.	Deviation

Certified by:	
Contractor's Signature:	

¹See Section 01300-1.04. A, Transmittal Procedure.

01660-A. EQUIPMENT TEST REPORT FORM

NOTE: This example equipment test report is provided for the benefit of the Contractor and is not specific to any piece of equipment to be installed as a part of this project. The example is furnished as a means of illustrating the level of detail required for the preparation of equipment test report forms for this project.

City Of Sample

Example Water Treatment Plant

Stage IV Expansion Project

ABC Construction Company, Inc., General Contractor XYZ Engineering, Inc., Construction Manager

Equipment Test Report

• Equipment Name: Sludge Pump 2

Equipment Number: P25202

Specification Ref: 11390

East Sedimentation Basin Gallery

Location:

٠

٠

		Contractor		Construction Manager	
		Verified	Date	Verified	Date
A. Preoperatio	nal Checklist				
1. Mechanical					
a. Lubrica	tion				
b. Alignme	ent				
c. Anchor	bolts				
d. Seal wa	ater system operational				
e. Equipm	ent rotates freely				
f. Safety	guards				
g. Valves	operational				
h. Hopper	purge systems operational				
i. Sedime	entation tank/hopper clean				
j. 0&M m	anual information complete				
k. Manufa	acturer's installation certificate complete				
2. Electrical (ci	rcuit ring-out and high-pot tests)	T		1	1
a. Circuits	:				
1) Po	wer to MCC 5				
2) Co	ntrol to HOA				
3) Inc	licators at MCC:				
a)	Red (running)				
b)	Green (power)				
C)	Amber (auto)				
4) Inc	licators at local control panel				
b. Wiring l	abels complete				
c. Namep	lates:				
1) MO	00				
2) Co	ntrol station				
3) Co	ntrol panel				

		Contractor		Construction Manager	
		Verified Date		Verified	Date
	d. Equipment bumped for rotation				
3.	Piping Systems				
	a. Cleaned and flushed:				
	1) Suction				
	2) Discharge				
	b. Pressure tests				
	c. Temporary piping screens in place				
4.	Instrumentation and Controls				
	a. Flowmeter FE2502F calibration				
	1) Calibration Report No.				
	 Flow recorder FR2502G calibrated against transmitter 				
	 vFD speed indicator calibrated against independent reference 				
	d. Discharge overpressure shutdown switch calibration				
	e. Simulate discharge overpressure Shutdown				
В.	Functional Tests				
1.	Mechanical		1		I
	a. Motor operation temperature satisfactory				
	b. Pump operating temperature satisfactory				
	c. Unusual noise, etc?				
	d. Pump operation: 75 gpm/50 psig				
	(1) Measurement:				
	(a) Flow:				
	(b) Pressure:				
	(c) Test gage number:				
	e. Alignment hot				
	f. Dowelled in				
	g. Remarks:				
2.	Electrical				
	a. Local switch function:				
	1) Runs in HAND				
	2) No control power in OFF				
	3) Timer control in AUTO				
	b. Overpressure protection switch PS2502C functional in both HAND and AUTO				
	c. Overpressure protection switch PS2502C set at 75 psig				
	d. PLC 2500 set at 24-hour cycle, 25 min ON				
C.	Operational Test			1	1
1.	48-hour continuous test. Pump cycles as specified, indicators functional, controls functional, pump maintains capacity, overpressure protection remains functional, hour meter functional				
RECOMMENDED FOR BENEFICIAL OCCUPANCY:

Construction Manager

Date

Date

ACCEPTED FOR BENEFICIAL OCCUPANCY

Owner's Representative

Westlands Water District Broadview ASR Project

01730-A. OPERATION AND MAINTENANCE TRANSMITTAL FORM

Date:	Submittal No: ²
То:	Contract No:
	Spec. Section:
	Submittal Description:
Attention:	From:

Checklist	Contra	ctor	Construction Manager		
	Satisfactory	N/A	Accept	Deficient	
1. Table of contents					
2. Equipment record forms					
3. Manufacturer information					
4. Vendor information					
5. Safety precautions					
6. Operator prestart					
7. Start-up, shutdown, and postshutdown procedures					
8. Normal operations					
9. Emergency operations					
10. Operator service requirements					
11. Environmental conditions					
12. Lubrication data					
13. Preventive maintenance plan and schedule					
14. Troubleshooting guides and diagnostic techniques					
15. Wiring diagrams and control diagrams					
16. Maintenance and repair procedures					
17. Removal and replacement instructions					
18. Spare parts and supply list					
19. Corrective maintenance man-hours					
20. Parts identification					
21. Warranty information					
22. Personnel training requirements					
23. Testing equipment and special tool information					

Remarks:

Contractor's Signature :

² See Section 01300-1.04.A, Transmittal Procedure.

01730-B. EQUIPMENT RECORD FORM

Equip Descrip			Equip Loc							
Equip No.		Shop Dwg No.	Date Inst			Co	Cost			
Mfgr			Mfgr Contact							
Mfgr Address						Ph	one			
Vendor Vendor Contact										
Vendor Address						Ph	one			
Maintenance Re	equirements			D	W	M	Q	S	A	Hours
Lubricants:	Recommende	ed:								
	Alternative:									

Misc. Notes:

Recommended Spare Parts					Electrical Nameplate Data				
Part No	Quan	Part Name	Cost	Equip	Equip				
				Make					
				Serial No.		ld No.	ld No.		
				Model No.		Frame No.			
				Нр	V	Amp	Hz		
				Ph	Rpm	Sf	Duty		
				Code	Insl. Cl	Des	Туре		
				Nema Des	C Amb	Temp Rise	Rating		
				Misc.					
					Mechanical	Nameplate Data			
				Equip					
				Make					
				Serial No.		ld No.			
				Model No.		Frame No.			
				Нр	Rpm	Сар	Size		
				Tdh	Imp Sz	Belt No.	Cfm		
				Psi	Assy No.	Case No.			
				Misc					

01730-C. EQUIPMENT RECORD FORM

Equip Descrip			Equip Loc					
Shop Dwg No.	Date Inst				Cost			
	Mfgr Contact				_			
	·			Pho	ne			
	Vendor Contact							
	·			Pho	ne			
		D	w	м	Q	s	A	Hours
				<u> </u>				
						-		
						-		
						-		
						-		
						-		
							+	
							1	
							1	
							1	
				1			1	
	Shop Dwg No.	Equip Loc Shop Dwg No. Date Inst Mfgr Contact Vendor Contact	Equip Loc Shop Dwg No. Date Inst Wfgr Contact Vendor Contact Vendor Contact D Image: Contact Image: Contact Image:	Equip Loc Shop Dwg No. Date Inst Mfgr Contact Image: Contact Vendor Contact D W Image: Contact Image: Contact Image: Contact Image: Contact	Equip Loc Shop Dwg No. Date Inst Cos Mfgr Contact Pho Vendor Contact Pho D W M	Equip Loc Cost Shop Dwg No. Date Inst Cost Mfgr Contact Phone Vendor Contact Phone Vendor Contact Phone D W M Q Image: Strate St	Equip Loc Cost Shop Dwg No. Date Inst Cost Mfgr Contact Phone Vendor Contact Phone Vendor Contact Phone Phone Phone Vendor Contact Phone Phone Phone Vendor Contact Phone Phone Phone Vendor Contact Phon	Equip Loc Cost Mfgr Contact Phone Vendor Contact Vendor Contact Vendor Contact Vendor Conta

09900-A COATING SYSTEM INSPECTION CHECKLIST

Project Name

Owner	Coating System Manufacturer (CSM)	
General Contractor (GC)	Coating System Applicator (CSA)	
Area or Structure	Location within Structure	
Coating System (eg E-1)	Coating Type (eg Epoxy, etc.)	

Coating System Inspection Checklist

Step	Description		Name	Signature	Date
1	Completion of cleaning and substrate	GC QC			
	decontamination prior to abrasive blast	CSM QC			
	cleaning.	CSA QC			
2	Installation of protective enclosure of structure	GC QC			
	or area and protection of adjacent surfaces or	CSM QC			
	structures that are not to be coated.	CSA QC			
3	Completion of ambient condition control in	GC QC			
	structure or building area and acceptance of	CSM QC			
	ventilation methods in structure or Area.	CSA QC			
4	Completion of Surface Preparation for	GC QC			
	Substrates to Be Coated.	CSM QC			
		CSA QC			
5	Completion of Primer Application.	GC QC			
		CSM QC			
		CSA QC			
6	Completion of Concrete Repairs If Required	GC QC			
	and Related Surface Preparation Rework Prior	CSM QC			
	to Coating System Application.	CSA QC			
7	Completion of Concrete Filler/ Surface	GC QC			
	Application to Concrete.	CSM QC			
		CSA QC			
8	Completion of First Finish Coat Application and	GC QC			
	of Detail Treatment at Transitions or	CSM QC			
	l erminations.	CSA QC			

Coating System Inspection Checklist

Step	Description		Name	Signature	Date
9	Completion of Second Finish Coat Application	GC QC			
	and of Detail Treatment at Transitions and	CSM QC			
	lerminations.	CSA QC			
10	Completion of Full and Proper Cure of Coating	GC QC			
	System.	CSM QC			
		CSA QC			
11	Completion of Testing of Cured Coating System	GC QC			
	including Adhesion, Holiday (Continuity) Testing	CSM QC			
	and Dry Film Thickness.	CSA QC			
12	Completion of Localized Repairs to Coating	GC QC			
	System Following Testing.	CSM QC			
		CSA QC			
13	Final Acceptance of Coating System Installation	GC QC			
	Including Final Clean-Up Complying with	CSM QC			
	Specification Requirements and the CSM's Quality Requirements.	CSA QC			

16000-A. WIRE AND CABLE RESISTANCE TEST DATA FOR	M
--	---

Wire or Cable N	No.:	_ Temperature, °F:	
Location of Test			Insulation resistance, megohms
1.			
2.			
3.			
4.			
5.			
6.			
(.			
CERTIFIED		Date	
	Contractor's Representative		
WITNESSED		Date	
	Owner's Representative		

16000-B. INSTALLED MOTOR TEST DATA FORM

Motor Equipment Number:	Date of test:
Equipment Driven:	
MCC Location:	

			Ambi	ent temp	٩F	
Resistance:						
Insulation resistance phase-to-ground megohms:						
Phase A	Phase B		Р	hase C		
Current at Full Load:						
Phase		Curr	ent, amps			
Phase		Curr	ent, amps			
Phase		Curr	ent, amps			
Thermal Overload Device:	Manufacturer/catalog #	#	Amperes			
Circuit breaker (MCP) setting:						

Motor Nameplate Markings:

Mfr		Mfr Model Fran		me		HP			
Volts			Phase		RPN			Service factor**	
Amps			Freq		Ambient temp rating			C°	
Time rating						Design I	etter**		
(NI		(NEMA 1-	(NEMA 1-10.35)		-		(NEMA MG-	1.16)	
Code letter						Insulatio	n class		

**Required for 3-phase squirrel cage induction motors only.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

16000-C. DRY TRANSFORMER TEST DATA FORM

(Note: Use Data Form for dry type transformers with voltage rating of 600 Vac or less and sizes to 167 kVA single phase and 500 kVA three phase. Use NETA Test Forms and Test Procedures for higher voltages and larger transformers.)

Equipment Tag No.:		_ Temperature Rating:	
Description/Location:		_ Feeder size/Source:	
Primary Voltage:	_Secondary Voltage:	Winding Connection:	

A. VISUAL INSPECTION

	Transformer Inspection	Pass	Fail	Note
1.	Nameplate data as specified			
2.	Mechanical condition			
	a. Free of dents and scratches			
	b. Anchored properly			
	c. Shipping brackets removed			
	d. Spacing from wall per nameplate			
3.	Grounding *			
	a. Equipment grounding			
	b. System grounding			

B. INSULATION-RESISTANCE TESTS:

Perform tests with calibrated megohmeter. Apply 1000 Vdc test voltage for 60 seconds and record readings in megohms at 30-seconds and 60-seconds intervals.

Test Group	Resis betv	tance veen	30-second reading	60-second reading	Absorption Ratio Index 60-sec. / 30-sec.
	А	GRD			
Primary Winding to ground	В	GRD			
	С	GRD			
Secondary Winding to ground with * N-G Bond removed	а	GRD			
	b	GRD			
	С	GRD			
	А	а			
Primary Winding to	В	b			
Secondary Winding	С	С			

Submit resistance readings to the Construction Manager immediately after the tests that are less than the manufacturer's recommended value or less than 10-megohms. Record the Absorption Ratio Index values for future reference. Ratio must be 1.0 or greater, with infinity (∞) equal to 1.0.

Contractor Representative Certifie	d: Date	
Owner Representative Witnessed:	Date	

16000-D. MOTOR CONTROL CENTER TEST FORM

Equipment No.: Ambient room temperature:

Location:

A. MECHANICAL CHECK:

All bolted connections either bus to bus or cable to bus shall be torqued to the manufacturer's recommendations.

- B. **ELECTRICAL TESTS:**
 - 1. Measure insulation resistance of each bus section phase to phase and phase to ground for 1 minute using a megohmmeter at 1000 volts.

	Test results	(megohms)	
Ph	ase	Pha	ase
A-GRD		A-B	
B-GRD		B-C	
C-GRD		C-A	

- 2. Set the circuit breaker in the starter unit to comply with the requirements of NEC. Article 430-52 and Table 430-152.
- 3. Motor overload heater elements shall be sized and installed based on the actual nameplate full load amperes of the motor connected to the starter.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

16000-E. MEDIUM VOLTAGE MOTOR STARTER TEST FORM

Equipment No.:

Location:

Room Temperature: _____

The protective devices shall be set in accordance with the specification before the tests are performed.

1. Measure contact resistance (micro-ohms)

	Phase: A		В		С	
--	----------	--	---	--	---	--

Contacts shall be replaced if resistance exceeds 50 micro-ohms.

2. Perform an insulation resistance test (1000 volts DC for 1 minute).

Phase		А		В		С	
Pole to ground							megohms
Across open pole							megohms
Pole to pole	AB		BC		CA		megohms

- 3. Perform minimum pickup voltage tests on trip and close coils.
- 4. Motor RTDs shall be tested by using a hot oil bath. The temperature at which the sensor trips shall be recorded for each RTD.
- 5. The Contactor shall be tripped by operation of each protective device.

16000-F. MEDIUM VOLTAGE SWITCHGEAR TEST FORM

Equipment No.:

Location:

Room Temperature: _____

The protective devices shall be set in accordance with the specification before the tests are performed.

1. Measure contact resistance (micro-ohms).

Phase: A B C		Phase: A		В		С	
--------------	--	----------	--	---	--	---	--

Contacts shall be replaced if resistance exceeds 50 micro-ohms.

2. Perform an insulation resistance test (1000 volts DC for 1 minute).

Phase		А		В		С	
Pole to ground							megohms
Across open pole							megohms
Pole to pole	AB		BC		CA		megohms

- 3. Perform minimum pickup voltage tests on trip and close coils.
- 4. Verify the instrument transformer ratios. Check the transformer's polarity electrically.
- 5. The Contactor shall be tripped by operation of each protective device.

16000-G. PROTECTIVE RELAY TEST FORM

Location:

Switchgear Breaker No.: _____

Protective Relay Description:

The protective relays shall be tested in the following manner:

- 1. Each protective relay circuit shall have its insulation resistance tested to ground.
- 2. Perform the following tests on the specified relay setting:
 - a. Pickup parameters on each operating element.
 - b Timing test shall be performed at three points on the time dial curve.
 - c. Pickup target and seal-in units.

The results shall be recorded and signed. A copy shall be given to the Construction Manager in accordance with paragraph 16000-1.05 Corrosive Areas.

16000-H. LOW VOLTAGE SWITCHGEAR TEST FORM

Equipment No.:

Location:

Room Temperature: _____

The protective devices shall be set in accordance with the specification before the tests are performed.

1. Measure contact resistance (micro-ohms).

Phase: A B C

Contacts shall be replaced if resistance exceeds 50 micro-ohms.

2. Perform an insulation resistance test (1000 volts DC for 1 minute).

Phase		А		В		С	
Pole to ground							megohms
Across open pole							megohms
Pole to pole	AB		BC		CA		megohms

- 3. Minimum pickup current shall be determined by primary current injection.
- 4. Long time delay shall be determined by primary injection at three hundred percent (300%) pickup current.
- 5. Short time pickup and time delay shall be determined by primary injection of current.
- 6. Instantaneous pickup current shall be determined by primary injection.
- 7. Trip unit reset characteristics shall be verified.
- 8. Auxiliary protective devices, such as ground fault or under voltage relays, shall be activated to ensure operation of shunt trip devices.

16000-I. MEDIUM VOLTAGE LOAD INTERRUPTER SWITCH TEST FORM

Equipment Number:

Location:

Date:

Measure switch blade resistance (micro-ohms). 1.

Phase: A B C

Contacts shall be replaced if resistance exceeds 50 micro-ohms.

2. Perform an insulation resistance test (1000 volts DC for 1 minute).

Phase		А		В		С	
Pole to ground							megohms
Across open pole							megohms
Pole to pole	AB		BC		CA		megohms

The results shall be recorded and signed. A copy shall be given to the Construction Manager in accordance with paragraph 16000-2.06 Product Data.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

16000-J. LIQUID-FILLED TRANSFORMER TEST FORM

Equipment Number:

Location:

Date/Weather Conditions:

- A. Perform the "Insulation-Resistance Test" and "Dielectric Absorption Test" using Form 16000-C, Dry Transformer Test Data Form.
- B. Perform an applied voltage (low frequency dielectric) test in accordance with ANSI C57.12.90, paragraph 10.5, Applied Voltage Test. Applied voltage levels shall be 75 percent of recommended factory test levels or recommended test levels of ANSI C57.12.00, Table 5.
- C. Insulating oil shall be sampled and shall be laboratory tested for the following:
 - 1. Dielectric strength.
 - 2. Acid neutralization.
 - 3. Interfacial tension.
 - 4. Color.
 - 5. Power factor.
- D. Perform a turns ratio test between the windings for all tap positions.
- E. The temperature and pressure switches shall be tested using a hot oil bath and air pump.
- F. The results shall be recorded and signed by the Contractor and Construction Manager. A copy shall be given to the Construction Manager in accordance with paragraph 16000-2.06 Product Data. Any readings which are abnormal to ANSI industry standards shall be reported to the Construction Manager.

16000-K. AUTOMATIC TRANSFER SWITCH TEST FORM

Equipment Number: _____

Location:

Date:

1. Perform an insulation resistance test (1000 volts DC for 1 minute):

Phase		А		В		С	
Pole to ground							megohms
Pole to pole	AB		BC		CA		megohms

- 2. Perform the following operations and initial:
 - a. Manual transfer _____
 - b. Loss of normal power; __sec delay
 - c. Return to normal power; <u>sec delay</u>

The results shall be recorded and signed. A copy shall be given to the Construction Manager in accordance with paragraph 16000-2.06 Product Data.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

16000-L. NEUTRAL GROUNDING RESISTOR TEST

Equipment No.:

Location:

The pickup and time delay setting on the ground fault relay shall be set in accordance with Section 16431.

- 1. The transformer neutral insulation resistance shall be measured with and without the grounding resistor connected to insure no parallel ground paths exist.
- 2. The protective relay pickup current shall be determined by injecting test current into the current sensor. The pickup current should be within 10 percent of the dial setting. Record the dial setting and actual pickup tie.
- 3. The relay timing shall be tested by injecting 150 and 300 percent of pickup current into the current sensor. The relay timing shall be in accordance with the manufacturer's published time-current characteristic curves. Record the relay timing at 150 and 300 percent of pickup current.
- 4. The circuit interrupting device shall be operated by operating the relay.

The results shall be recorded and signed by the Contractor and Construction Manager. A copy shall be given to the Construction Manager in accordance with paragraph 16000-2.06 Product Data.

17000-A. LOOP WIRING AND INSULATION RESISTANCE TEST DATA FORM

Loop No.:

List all wiring associated with a loop in table below. Make applicable measurements as indicated after disconnecting wiring.

			Continuity Resistance ^a		Insulation Resistance ^b			
			Cond./	Cond./	Shield/	Shield/	Cond./	Shield/
Wire No.	Panel Tie	Field TB	Cond.	Shield	Gnd.	Cond.	Gnd.	Shield
А				(A/SH)				
В			(A/B)					
С			(A/C)					
D			(A/D)					
etc.								

NOTES:

- Continuity Test. Connect ohmmeter leads between wires A and B and jumper opposite ends together. Record a. resistance in table. Repeat procedure between A and C, A and D, etc. Any deviation of +2 ohms between any reading and the average of a particular run indicates a poor conductor, and corrective action shall be taken before continuing with the loop test.
- b. Insulation Test. Connect one end of a 500 volt megger to the panel ground bus and the other sequentially to each completely disconnected wire and shield. Test the insulation resistance and record each reading.

CERTIFIED Date

Contractor's Representative

WITNESSED _____ Date _____

17000-B. CONTROL CIRCUIT PIPING LEAK TEST FORM

Loop No.:_____

List tubing associated with loop in table below. Make applicable measurements after isolating any air consuming pilots from circuit.

Tube No.	Tubing Equivalent Length of 1/4-Inch Copperª	Test Period (seconds)	Permitted Pressure Drop (psi) ^ь	Measured Pressure Drop (psi)
А				
В				
С				
D				
etc.				

NOTES:

Convert actual tubing and air motor volume to equivalent 1/4-inch copper tubing. a.

Pressure drop shall not exceed 1 psi per hundred feet 1/4-inch tubing per 5 seconds. b.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

17000-C. CONTROLLER CALIBRATION TEST DATA FORM

Serial No.:
Process Variable (PV) Scale:
Output Scale:

PV Scale Calibration

% of Range	Input	Expected Reading	Actual Reading	% Deviation
0				
50				
100				
			% Deviation Allowed:	

Connect output to PV for following tests:

Set Point (SP) Indicator Accuracy		Output Meter Accuracy			Controller Accuracy			
SP	PV Reading	Expected % Dev.	Actual Reading	Expected Reading	Actual % Dev.	OUTPU T	OUTPUT	% Dev.
(0%)								
(50%)								
(100%)								
% Deviation Allowed:		% Deviation Allowed:			% Devia	tion Allowed:		

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

17000-D. PANEL INDICATOR CALIBRATION TEST DATA FORM

Tag No. and Description:	
Make & Model No.:	_Serial No.:
Input:	-
Scale:	Range:

PV Scale Calibration

% of Range	Input	Expected Reading	Actual Reading	% Deviation
0				
50				
100				
			% Deviation Allowed:	

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

17000-E. RECORDER CALIBRATION TEST DATA FORM

Tag No. and Description:	
Make & Model No.:	Serial No.:
Input:	_Chart:
Scale:	_Range:

% of Range	Input	Expected Reading	Actual Reading	% Deviation
0				
50				
100				
			% Deviation Allowed:	

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

Owner's Representative

Westlands Water District Broadview ASR Project

17000-F. SIGNAL TRIP CALIBRATION TEST DATA FORM

Tag No. and Description:	
Make & Model No.:	Serial No.:
Input:	
Scale:	Range:
Set Point(s):	

After setting set point(s), run signal input through entire range and calculate deadband.

	Incr. Input	Decr. Input	Calc.	Required
Set Point	Trip Point	Trip Point	Deadband	Deadband

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

17000-G. FIELD SWITCH CALIBRATION TEST DATA FORM

Tag No. and Description:

Make & Model No.: ______ Serial No: _____

Range:_____ Set Point(s):

Input: _____

Simulate process variable (flow, pressure, temperature, etc.) and set desired set point(s). Run through entire range of switch and calculate deadband.

	Incr. Input	Decr. Input	Calc.	Required
Set Point	Trip Point	Trip Point	Deadband	Deadband

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

17000-H. TRANSMITTER CALIBRATION TEST DATA FORM

Tag No. and Description:	
Make & Model No.:	Serial No.:
Input:	
Output:	
Range:	Scale:

Simulate process variable (flow, pressure, temperature, etc.) and measure output with appropriate meter.

% of Range	Input	Expected Reading	Actual Reading	% Deviation
0				
50				
100				
			% Deviation Allowed:	

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

17000-I. MISCELLANEOUS INSTRUMENT CALIBRATION TEST DATA FORM

(For instruments not covered by any of the preceding test forms, the Contractor shall create a form containing all necessary information and calibration procedures.)

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

17000-J. INDIVIDUAL LOOP TEST DATA FORM

Loop No.: _____

Description: (Give complete description of loop's function using tag numbers where appropriate.) P&ID No.: (Attach copy of P&ID.)

- Wiring tested: a. (Attach test form 17000-A)
- b. Instrumentation tubing/piping tested: (Attach test form 17000-B)
- Instruments calibrated: c. (Attach test forms 17000-C through I)
- d. List step-by-step procedures for testing loop parameters. Test loop with instruments, including transmitters and control valves, connected and functioning. If it is not possible to produce a real process variable, then a simulated signal may be used with the Construction Manager's approval.

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

17000-K. LOOP COMMISSIONING TEST DATA FORM

Loop No.:

- a. Loop tested: (Attach test form 17000-J)
- b. Controlled or connected equipment tests confirmed:
- Give complete description of loop's interface with process. c.
- d. With associated equipment and process in operation, provide annotated chart trace of loop response to changes in set points for verification of performance. This chart should demonstrate 1/4-amplitude damping as output adjusts to set point change. Show set points, starting and finishing times on chart, as well as any other pertinent data.

Connect 2-pen recorder to process variable (PV) and to controller output. Use 1 inch/second chart speed.

Pen 1 - PV - Connections:

Pen 2 - Output - Connections:

CERTIFIED _____ Date _____

Contractor's Representative

WITNESSED _____ Date _____

11000-A. MANUFACTURER'S INSTALLATION CERTIFICATION FORM

Contract No:	Specification section:	
Equipment name:		
Contractor:		
Manufacturer of equipment iten	1:	
The undersigned manufacturer installation of the equipment an accordance with the manufactu satisfactory.	of the equipment item described above hereby certifies that he has checked the d that the equipment, as specified in the project manual, has been provided in rer's recommendations, and that the trial operation of the equipment item has been	
Comments:		
Manufacturer	Contractor	
Signature of Authorized Represe	Intative Signature of Authorized Representative	
Date	Date	

11000-B. MANUFACTURER'S INSTRUCTION CERTIFICATION FORM

Contract No:	Specification Section:
Equipment name:	
Contractor:	
Manufacturer of equipment item:	

The undersigned manufacturer certifies that a service engineer has instructed the wastewater treatment plant operating personnel in the proper maintenance and operation of the equipment designated herein.

Operations Check List (check appropriate spaces)	
Start-up procedure reviewed	
Shutdown procedure reviewed	
Normal operation procedure reviewed	
Others:	
Maintenance Check List (check appropriate spaces)	
Described normal oil changes (frequency)	
Described special tools required	
Described normal items to be reviewed for wear	
Described preventive maintenance instructions	
Described greasing frequency	
Others:	

Manufacturer

Signature of Contractor Representative

Signature of Authorized Representative

Date

Signature of Authorized Representative Date

Date

11000-C. UNIT RESPONSIBILITY CERTIFICATION FORM

WESTLANDS WATER DISTRICT - BROADVIEW ASR PROJECT

CERTIFICATE OF UNIT RESPONSIBILITY

FOR SPECIFICATION SECTION _____

[SECTION TITLE]

In accordance with Section 11000-1.02 Unit Responsibility of the contract documents, the undersigned manufacturer of driven equipment ("manufacturer") accepts unit responsibility for all components of equipment furnished to the Project under specification Section______, and for related equipment manufactured under sections______, and ______.

We have reviewed the requirements for sections 11000 and 11050 where applicable) and all sections referencing this (these) section(s), including but not limited to drivers, supports for driving and driven equipment and all other specified appurtenances to be furnished to the Project by manufacturer. And, we have further reviewed, and modified as necessary, the requirements for associated variable speed drives and motor control centers. We hereby certify that all specified components are compatible and comprise a functional unit suitable for the specified performance and design requirements whether or not the equipment was furnished by us. We will make no claim nor establish any condition that problems in operation for the product provided under this specification Section ______ are due to incompatibility of any components covered by this Certificate of Unit Responsibility. Nor will we condition or void any warranty for the performance of the product of this specification Section _______ due to incompatibility of any components covered under this Certificate of Unit Responsibility.

Our signature on this Certificate of Unit Responsibility does not obligate us to take responsibility for, nor to warrant the workmanship, quality, or performance of related equipment provided by others under specification sections _____, ____, and ______. Our obligation to warranty all equipment provided by us shall remain unaffected.

Notary Public

Commission expiration date

Seal:

Name of Corporation

Address

By:

Duly Authorized Official

Legal Title of Official

Date

11002-A. RIGID EQUIPMENT MOUNT INSTALLATION CHECKLIST

Equipment Tag No.: Date:		
Grout Product Name and Type:		
Grouting System Manufacturer:		
Grouting Application Contractor:		
General Contractor:		
Step 1: Verify Equipment Anchor Installation Co	nformance to Equipment Pad Details	
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Millwright		Date
Step 2: Completion of Cleaning and Concrete St	ubstrate Preparation Prior to Grouting	
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date
Name: Grout Manufacturer's Technical Rep.		Date
Step 3: Equipment Leveling		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Millwright		Date
Step 4: Installation of Protection of Adjacent Su	rfaces or Structures NOT TO BE GROUTED	
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date
Name: Grout Manufacturer's Technical Rep.		Date
Step 5: Preparation and Construction of Forms	and Epoxy Grout Filling Standpipes	
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date
Name: Grout Manufacturer's Technical Rep.		Date
Step 6: Completion of Ambient Condition Contr Apply to Application and Curing Requirements for	ol in Structure or Building Area and Acceptance of Amb or the Grouting System	ient Conditions as They
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date
Name: Grout Manufacturer's Technical Rep.		Date
Step 7: Epoxy Grout Installation		
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date
Name: Grout Manufacturer's Technical Rep.		Date
Step 8: Completion of Full and Proper Cure of Ep	poxy Grout	
Name: Contractor Rep.		Date
Name: Construction Manager		Date
Name: Grouting Contractor Rep.		Date

Name: Grout Manufacturer's Technical Rep.	Date
Step 9: Completion of Localized Repair of Grout	t Voids
Name: Contractor Rep.	Date
Name: Construction Manager	Date
Name: Grouting Contractor Rep.	Date
Name: Grout Manufacturer's Technical Rep.	Date
Step 10: Final Acceptance of Grouting System In Specification Requirements and the GSM's Qua	nstallation Including Final Clean-Up of the Work Site Complying with All ality Requirements
Name: Contractor Rep.	Date
Name: Construction Manager	Date
Name: Grouting Contractor Rep.	Date
Name: Grout Manufacturer's Technical Rep	Date

11060-A. MOTOR DATA FORM

Equipment Name: ______ Equipment No(s): _____

Project Site Location:	
------------------------	--

Nameplate Markings

Mfr:			Mfr Model:		Frame:			Horsepower:	
Volts:	olts:		Phase:		RPM:			Service Factor:	
FLA:			LRA:		Freq	uency:		Amb Temp Rating:	°C
Time rating:					Design Letter:				
		(NEMA	MG1-10.35)					(NEMA MG-1.16)	
KVA Code Letter:				Insulation Class:					

The following information is required for explosion-proof motors only:

- A. Approved by UL for installation in Class _____, Div _____, Group _____
- B. UL frame temperature code (NEC Tables 500-8B)

The following information is required for all motors 1/2 horsepower and larger:

A. Guaranteed minimum efficiency

(Section 11060-2.04 Motor Efficiency)

B. Nameplate or nominal efficiency _____

Data Not Necessarily Marked on Nameplate

Type of Enclosure:				Enclosure Material:				
Temp Rise:		°C (NE	°C (NEMA MG1-12.41,42)					
Space Heater included?	ΠY	es	🗆 No	If Yes:	Watts	Volts		
Type of motor winding ov	er-tempera	ure protec						

Provide information on other motor features specified:
SECTION 13110

PRE-ENGINEERED METAL STRUCTURES

PART 1 GENERAL

1.01 SUMMARY

A. THE REQUIREMENT:

1. Design, detail, supply and the installation of a pre-engineered metal shade structure as shown on the Contract Drawings, including: structural steel system primary and secondary members; metal roof system; column base plates and anchor bolts; trim, flashing and accessories; sealants; and galvanizing and coatings as described in this section and shown on the Contract Drawings.

B. SYSTEM DESCRIPTIONS:

- 1. Pre-Engineered Metal Shade Structure: An open mono-sloped roof canopy structure as shown on the Contract Documents.
- 2. Roof System: Metal roof deck. No insulation is required for the open structure.
- 3. Lateral System: As defined by the Pre-Engineered Metal Structure engineer in accordance with the applicable codes. The structure shall be open at the front side without cross-bracing.

1.02 REFERENCES

A. REFERENCES: The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

References	Title
AISC 303	Code of Standard Practice for Steel Buildings and Bridges
AISC 341	Seismic Provisions for Structural Steel Buildings
AISC 360	Specification for Structural Steel Buildings
AISC	American Institute of Steel Construction, Manual of Steel Construction
AISC DG3	Serviceability Design Considerations for Steel Buildings
	(AISC Design Guide)
AISI S100	Design of Cold-Formed Steel Structural Members
ACI 318	Building Code Requirements for Structural Concrete
AWS D1.1	Structural Welding Code – Steel
AWS D1.3	Structural Welding Code – Sheet Steel
AISE 13	Design and Construction of Mill Buildings
ASCE 7	Minimum Design Loads for Buildings and Other Structures (ASCE 7-16)
ASTM A36	Carbon Structural Steel
ASTM A108	Steel Bar, Carbon and Alloy, Cold-Finished

References	Title
ASTM A123	Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
ASTM A307	Carbon Steel Bolts, Studs, and Threaded Rod 60,000 psi Tensile Strength
ASTM A325	Structural Bolts, Steel, Heat Treated 120/105 ksi Minimum Tensile Strength
ASTM A653	Steel Sheet, Zinc Coated (Galvanized) or Zinc Iron Alloy Coated (Galvannealed) by the Hot Dip Process
ASTM A792	Standard Specification for Steel Sheet, 55 % Aluminum-Zinc Alloy-Coated by the Hot-Dip Process
IAS AC472	Accreditation Criteria for Inspection Programs for Manufacturers of Metal Building Systems
CBC	California Building Code (2019 CBC)
MBMA	Metal Building Manufacturer's Association
Cal/OSHA	U.S. Dept. of Labor, Occupational Safety and Health Administration

1.03 SUBMITTALS

- A. METAL STRUCTURE DESIGN AND DRAWINGS:
 - 1. Drawings for the pre-engineered metal structure shall be prepared and sealed by a Professional Civil or Structural Engineer registered in the state of California. Drawings shall include the following:
 - a. Design criteria shall be in accordance with the CBC and as indicated on the contract drawings. The lateral force resisting system and base shear, for each direction, shall be clearly noted on the drawings.
 - b. Structure plans, elevations, and sections with dimensions consistent with the Contract Documents.
 - c. Primary and secondary framing systems, location, sizes, material strength, and connection details for the lateral force resisting system in each direction. Unless otherwise noted, the section properties for the primary and secondary framing used in the design shall be clearly noted on the drawings.
 - d. Roof diaphragm and connections that substantiate a clear and direct load path consistent with the calculations. Roof diaphragm section properties, material strength, and their connections shall be clearly noted on the drawings.
 - e. Metal roof decking and metal siding layout and connection details.
 - f. Trim, flashing, etc. details shall be provided.
 - 2. Design calculations of the pre-engineered metal structures, shall be prepared and sealed by a Professional Civil or Structural Engineer registered in the state of California. The minimum calculation and reference drawing requirements:
 - a. Calculations shall be comprehensible and complete. When evaluating the structural strengths, indicate stress for comparing with strengths or show the demand versus capacity ratio in the structural elements. Evaluating the results

by stating "Okay by Inspection" is not acceptable. When spreadsheets are used, clearly reference equations and formulas presented in submittal calculations.

- b. Design calculation shall substantiate a complete load path for the wind and seismic lateral force resisting systems
- c. Design calculations shall include supporting information for the structural roof deck with a current and relative ICC-ES or IAPMO-UES report substantiating the capacity of the roof deck to act as a diaphragm to transfer in-plane and out-of-plane loading. The roof deck and connections shall be designed to withstand wind components and cladding forces in accordance with the CBC and ASCE 7.
- d. Design loads shall include dead and live loads associated with the photovoltaic solar panels as indicated on electrical contract documents.
- e. Column end connections shall not transfer moments in any direction to the foundation.
- f. Calculations shall include design of column anchorage.
- g. The calculations and details shall demonstrate a complete vertical and lateral load path, and shall clearly indicate all forces imposed on the supporting structure.
- B. ANCHOR BOLT DESIGN AND DRAWINGS:
 - 1. Drawings shall include anchor bolt location plans, anchor bolt size, spacing, quantity, embedment, material, orientation, maximum not to exceed grout pad thickness, and structure column base plate details and base attachments where required. The minimum edge distance, consistent with the calculations, shall be included on the anchor bolt drawings.
 - 2. Anchor bolt drawings shall include the unfactored structure column loads imposed on the foundations. Unfactored column load are to be separately shown for dead load, live loads, snow loads (if applicable), wind loads and seismic loads.
 - 3. Anchor bolt calculations prepared and sealed by a Professional Civil or Structural Engineer registered in the state of California.
 - a. Anchor bolt calculations shall clearly show that the capacity of the anchor and the capacity of the concrete that the anchor is embedded in are adequate to resist all applicable load combinations and overstrength factors.
 - b. The design of anchors resisting seismic forces shall satisfy the ductility requirements stated in the CBC.
 - c. Reduction factors associated with edge distance, embedment length, grout and base plate thickness, and bolt spacing shall be considered in the design and consistent with the submittal drawings.

- C. SAMPLES AND CHARTS:
 - 1. Roof deck and wall siding samples
 - 2. Color charts showing full range of colors, textures and patterns available.

1.04 QUALITY ASSURANCE

A. QUALIFICATIONS

- 1. MANUFACTURER QUALIFICATIONS:
 - a. The manufacturer shall have a minimum of (10) ten years experience in the manufacture of metal structures and shall be accredited under the IAS AC472.
- 2. ERECTOR QUALIFICATIONS:
 - a. Erector shall have a minimum of (5) five years experience in the erection of metal structures.
 - b. Erector shall be familiar with Manufacturer's pre-engineered metal structure systems, standard and/or custom concepts.
 - c. Erection shall be performed by qualified erector using proper tools and equipment in accordance with manufacturer's recommendations.
- 3. WORKMAN QUALIFICATIONS:
 - a. The erector shall provide at least one person who shall be present at all times during execution of the work and who shall be thoroughly familiar with the preengineered metal structure concept and the requirements, and who shall direct all work performed.
 - b. Workers employed by the erector shall be skilled in performing tasks related to pre-engineered metal structures.
 - c. Certified welding procedures and welding operators in accordance with AWS.
- 4. SOURCE LIMITATIONS:
 - a. Obtain metal structure components, including primary and secondary framing and metal panel assemblies, from single source from single manufacturer.

1.05 DELIVERY, STORAGE AND HANDLING

- A. The pre-engineered metal structure manufacturer and their installation Contractor are responsible for the delivery, storage and handling of materials.
- B. Materials shall be delivered in a dry and undamaged condition and stored out of contact with the ground. Storage accommodations for roof deck and wallsiding shall provide good air circulation and protection from surface staining.

1.06 SPECIAL WARRANTY

- A. Provide a Special Warranty in accordance with the following:
 - 1. 1 year workmanship guarantee against failures caused by faulty erection.
 - 2. 2 year materials guarantee against failures.
 - 3. Manufacturer's written weather tightness warranty for 10 years against leaks in roof panels arising out of or caused by ordinary wear and tear under normal weather and atmospheric conditions.
 - 4. Manufacturer's paint film written warranty for 20 years against chipping, cracking, peeling, chalking, and fading of the coating on painted wall panels, painted roof panels and soffit panels.
 - a. Chalking shall not exceed #8 per ASTM D4214.
 - b. Fading shall be 5 NBS units or less per ASTM D2244.

PART 2 PRODUCTS

2.01 PERFORMANCE / DESIGN CRITERIA

- A. GENERAL:
 - 1. Design of steel systems, members and components shall be in accordance with the Design Codes shown below.
 - 2. Workmanship, detailing of connections, fabrication and erection shall conform to the AISC Manual of Steel Construction.
- B. DESIGN CODES:
 - 1. The following standard codes have applications at this site for:

Design	Code
Buildings/Structures:	2019 California Building Code and ASCE 7-16
Structural steel:	AISC 360-16 and AISC 341-16
Cold formed steel:	AISI S100, Latest Edition
Welding:	AWS Welding Codes, Latest Edition
Occupational health and safety requirements:	Cal/OSHA

C. DESIGN LOADS

- 1. DEAD LOADS:
 - a. Dead loads used in the calculations shall be the weight of the pre-engineered metal structure system construction, such as framing, roofing, purlins, accessories, covering materials, and photovoltaic panels.

- b. Add an additional allowance for future collateral loads as follows:
 - 1) Lighting and conduit unless noted otherwise: 10 psf
- 2. UNIFORM LIVE LOADS:

Roof	20 psf
Columns:	No column live load reduction allowed

- 3. WIND LOADS:
 - a. In accordance with the building codes and as indicated on drawings.
- 4. SEISMIC LOADS:
 - a. In accordance with the building codes and as indicated on drawings.

D. LOAD COMBINATIONS:

1. Design pre-engineered metal structure systems to withstand the load combinations as specified in the governing building code. Where the exclusion of live load or impact load would cause a more severe load condition for the member under investigation, then ignore the load when evaluating that member.

E. DESIGN CONSIDERATIONS:

- 1. Roof slope: as shown on Drawings.
- 2. Design structures and components for the following climatic conditions.
 - a. Climatic Conditions:

Maximum design temperature:	105	degrees Fahrenheit
Minimum design temperature:	32	degrees Fahrenheit

F. DEFLECTIONS:

- 1. Calculations for structure deflections shall be performed using only the bare frame method. Reductions based on engineering judgment using the assumed composite stiffness of the structure envelope shall not be allowed.
- 2. PRIMARY FRAMING:
 - a. Horizontal Drift: In accordance with ASCE 7-16.
 - b. Vertical Deflection: In accordance with the CBC limits; L/450 for members supporting a monorail.

- 3. SECONDARY FRAMING:
 - a. Horizontal Deflection: L/360 for load cases that include wind and L/180 for load cases that include seismic.
 - b. Vertical Deflection: In accordance with the CBC limits.
- Deflections not listed above shall be in accordance with the applicable provisions of the AISC Steel Design Guide Series 3 – Serviceability Design Considerations for Steel Buildings.

G. GUTTERS AND DOWNSPOUTS:

1. Exterior gutters and downspouts shall be designed for rainfall intensity based upon a 5-year recurrence interval for a five-minute duration. Interior gutters, valleys, and downspouts shall be designed for rainfall intensity based upon a 25-year recurrence interval based on a five-minute duration.

H. ANCHOR BOLTS:

1. Anchor bolt design, size and arrangements shall be coordinated between the preengineered metal structure manufacturer and the foundation design as shown on the Drawings. Anchor bolt arrangements shall meet the minimum bolt spacing requirements per AISC codes. Anchor bolt design shall meet the requirements of ACI 318.

I. METAL PANELS

1. Roof paneling system shall be designed to support design roof live load and wind components and cladding loads. Wall siding shall be designed to resist components and cladding wind loads.

2.02 MATERIALS

A. MATERIAL SPECIFICATIONS:

Material	Specification
Primary Framing Steel	
Square and Rectangular Hollow Structural Sections (HSS)	ASTM A500, Grade B (Fy = 46 ksi)
Structural Bolts	
Steel	ASTM A325
Galvanized Steel	ASTM A325 (Type 1)
Roof and Wall Panels	
Galvanized Steel	ASTM A653 Grade 80 or Grade 50 (Class 3)

2.03 MANUFACTURED UNITS AND COMPONENTS

- A. PRIMARY FRAMING SYSTEM:
 - 1. COLUMNS AND BEAMS:
 - a. Columns and beams shall be constructed of HSS shapes.
 - 2. ANCHOR BOLTS

Anchor bolts to concrete shall be galvanized steel or stainless steel.

- B. ROOF PANELS:
 - 1. Roof panels shall be factory roll-formed roof panels. Panel material shall be a minimum 22 gauge with G90 zinc-coated per ASTM A653. Finish coating of the panels shall be as specified below in the "Finish" paragraph of this section.
 - 2. Panels of maximum possible lengths shall be used to minimize end laps.
- C. WALL SIDING:
 - 1. 22 gage minimum, pre-painted G90 zinc-coated.
 - 2. Fasteners shall be color coordinated with siding.
- D. TRIMS AND FLASHING:
 - 1. The system shall be complete with integrated pre-engineered trims and flashings to accommodate reasonable variances in tolerances and thermal movement. Minor flashings may be field fabricated.
 - 2. Rake flashing, corner trim, eave trim, and all other necessary trim shall be 26 gage G90 zinc-coated, pre-painted, color to match wall panels.
 - 3. Trims and flashings shall be painted with the metal panel coating system listed below and shall match the color of the wall or roof panels.
- E. GUTTERS AND DOWNSPOUTS:
 - 1. Gutters shall be 24-gage G90 zinc-coated, pre-painted, color coordinated to match wall panels.
 - 2. Downspouts shall be rectangular, 28 gage G90 zinc-coated, pre-painted, color coordinated to match wall panels.
 - 3. Gutters shall be provided on the exterior of the structure along perimeter.
 - 4. Downspouts shall be provided at corners. Intermediate downspouts shall be provided to limit spacing between downspouts to 50 feet.

- 5. Gutters and downspouts shall be painted with metal panel coating system listed below.
- F. CLOSURES AND SEALANTS:
 - 1. Preformed closed cell non-shrinking, laminated polyethylene closures along the eave, ridge, and rake for weather tightness.
 - 2. 20 gage metal closures at roof panels, color coordinated with the same coating system as roof panels.
 - 3. Sealant for end laps, roof flashing laps, ridges, and eave shall be tape mastic, 100% solid ethylene propylene copolymer tape.

2.04 FINISHES

- A. COATING OF FRAMING MEMBERS:
 - 1. Primary structural steel framing , secondary steel framing shall be primed and painted.
- B. COATING OF PANELS:
 - 1. The metal panel coating system for both sides of roof panels shall be a full strength, 70% Kynar 500®/Hylar 5000(TM) fluoropolymer coating, Flurothane IV system, or approved equal.
- C. PAINTING
 - The Contractor shall supply all paint, thinner, cleaners, and any other materials, including all application, inspection, and measurement tools (thickness gages, temperature measurement, etc.), required to complete the work. Product information sheets such as the manufacturer's descriptive catalog, data sheets, and product application requirement sheets will be supplied to the Inspector prior to beginning work.
 - 2. The painting system shall be Devoe Bar-Rust 235 and Devthane 379 finish coat, as manufactured by Devoe Company, Inc., or an Owner approved equal. Substituted equivalents shall be supported by manufacturer's descriptive catalog or data sheets. The prime coat will be light in color (white or light gray). The top coats will be Kelly Moore 379 New Baby Blue (CF030524437087).

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine and accept existing conditions before beginning work.
- B. Check lines and elevations of concrete bearing surfaces.
- C. Confirm locations of anchor bolts and similar devices before the pre-engineered metal structure erection proceeds.

D. Report discrepancies immediately to the Owner. Do not proceed with erection until corrections have been made, or until compensating adjustments to the steelwork have been agreed upon.

3.02 PREPARATION

- A. Prior to performing work of this section, verify that work of other trades, as applicable, is complete for commencement of installation.
- B. Obtain manufacturer's written instructions before commencing erection or installation.

3.03 ERECTION

- A. Erect the work in accordance with Specifications, Drawings, and manufacturer's directions.
- B. Conform to configurations and connections indicated on reviewed and accepted shop and erection drawings.
- C. Accurately position and assemble structural framing to lines and members of framing system prior to permanent fastening.
- D. Erector shall not make any field modifications to any structural member except as authorized and/or specified by manufacturer in writing, with a copy to the Owner.
- E. APPROVED FIELD MODIFICATION: Perform in manner not to impair appearance, weather tightness, or structural quality of material or structure.
- F. Install metal panels, fasteners, trim, and related items in conformance with approved drawings and requirements of manufacturers.

3.04 REPAIR AND RESTORATION

- A. Replace damaged panels and other components that cannot be repaired by finish touch-up or similar minor repair.
- B. Touch-up coatings: Immediately after erection, clean field welds, bolted connections, and areas where coating is abraded. Apply coating to exposed areas using same material as used for shop coating.
- C. Replace or restore the following to original condition:
 - 1. Surface finishes damaged prior to or during erection.
 - 2. Components where material and workmanship does not meet specified requirements.
- D. Minor Scratches, Dents, And Holes: Repair and paint with similar enamel of thickness and color to match original coating.

3.05 FIELD QUALITY CONTROL

- A. MANUFACTURER'S FIELD SERVICES: The Pre-Engineered Metal Structure's Representative shall be present at jobsite for installation assistance, inspection, and certification of installation.
- B. The Owner's Special Inspector will inspect and indicate if work is in conformance with specifications. This inspection will include products, erection, welding, grouting and similar construction. The Inspector will verify that the work has been performed in accordance with AISC and this specification.
- C. Maximum deviations from plumb, level, and alignment are not to exceed AISC specifications, and tolerances specified in this section.
- D. Defective Work: Promptly remove and replace materials and fabricated components that do not comply. Furnish, perform, and install to specified requirements.

3.06 CLEANING

A. Upon completion of the services, the Pre-Engineered Metal Structure Manufacturer and their installation Contractor shall remove excess materials, tools, scaffolds and rubbish which has accumulated on the premises and leave same in a clean and satisfactory condition.

END OF SECTION

This page intentionally left blank.

SECTION 16000

GENERAL REQUIREMENTS FOR ELECTRICAL WORK

PART 1 GENERAL

1.01 DESCRIPTION

- A. Scope:
 - 1. This section specifies general requirements for electrical work. Detailed requirements for specific electrical items are specified in other sections but are subject to the general requirements of this section. The electrical drawings and schedules included in this project manual are functional in nature and do not specify exact locations of equipment or equipment terminations.

B. Definitions:

- 1. Elementary or Schematic Diagram:
 - a. A schematic (elementary) diagram shows, by means of graphic symbols, the electrical connections and functions of a specific circuit arrangement. The schematic diagram facilitates tracing the circuit and its functions without regard to the actual physical size, shape, or location of the component devices or parts.
- 2. One-Line Diagram:
 - a. A one-line diagram shows by means of single lines and graphical symbols the course of an electrical circuit or system of circuits and the components, devices or parts used therein. Physical relationships are usually disregarded.
- 3. Block Diagram:
 - a. A block diagram is a diagram of a system, instrument, computer, or program in which selected portions are represented by annotated boxes and interconnecting lines.
- 4. Wiring Diagram or Connection System:
 - a. A wiring or connection diagram includes all of the devices in a system and shows their physical relationship to each other including terminals and interconnecting wiring in an assembly. This diagram shall be (a) in a form showing interconnecting wiring only by terminal designation (wireless diagram), or (b) a panel layout diagram showing the physical location of devices plus the elementary diagram.
- 5. Interconnection Diagram:
 - a. Interconnection diagrams shall show all external connections between terminals
 of equipment and outside points, such as motors and auxiliary devices.
 References shall be shown to all connection diagrams which interface to the
 interconnection diagrams. Interconnection diagrams shall be of the continuous
 line type. Bundled wires shall be shown as a single line with the direction of
 entry/exit of the individual wires clearly shown. Wireless diagrams and wire lists
 are not acceptable.
 - 1) Each wire identification as actually installed shall be shown. The wire identification for each end of the same wire shall be identical. All devices and equipment shall be identified. Terminal blocks shall be shown as actually installed and identified in the equipment complete with individual terminal identification.

- 2) All jumpers, shielding and grounding termination details not shown on the equipment connection diagrams shall be shown on the interconnection diagrams. Wires or jumpers shown on the equipment connection diagrams shall not be shown again on the interconnection diagram. Signal and DC circuit polarities and wire pairs shall be shown. Spare wires and cables shall be shown.
- 6. Arrangement, Layout, Or Outline Drawings:
 - a. An arrangement, layout, or outline drawing is one which shows the physical space and mounting requirements of a piece of equipment. It may also indicate ventilation requirements and space provided for connections or the location to which connections are to be made.

1.02 QUALITY ASSURANCE

- A. References:
 - This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
 - 2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
NECA-1	National Electrical Contractors Association – Standard Practices for Good Workmanship in Electrical Contracting
NFPA	National Fire Protection Association
NFPA-70	National Electrical Code (NEC)
NFPA-70E	Standard for Electrical Safety in the Workplace
ANSI C2	National Electrical Safety Code (NESC)
ACI 318	Building Code Requirements for Structural Concrete

- B. Identification of Listed Products:
 - List electrical equipment and materials for the purpose for which they are to be used, by an independent testing laboratory. Three such organizations are Underwriters Laboratories (UL), Canadian Standards Association (CSA), and Electrical Testing Laboratories (ETL). Independent testing laboratory shall be acceptable to the inspection authority having jurisdiction.
 - 2. When a product is not available with a testing laboratory listing for the purpose for which it is to serve, the product may be required by the inspection authority, to

undergo inspection at the manufacturer's place of assembly. All costs and expenses incurred for such inspections shall be included in the original contract price.

- C. Factory Tests:
 - 1. Where specified in the individual product specification section, perform factory tests at the place of fabrication and performed on completion of manufacture or assembly. Include the costs of factory tests in the contract price.

1.03 SUBMITTALS

A. Provide submittals in accordance with Section 01300. Each specification will identify any additional requirements beyond those identified in 01300.

1.04 PROJECT/SITE CONDITIONS

- A. General: Unless otherwise specified, size and derate equipment and materials for ambient temperature of not less than 47 degrees C at an elevation ranging from sea level to 400 feet without exceeding the manufacturer's stated tolerances.
- B. Corrosive Areas:
 - 1. Chemical feed system.
- C. Enclosure Material and Rating
 - 1. Table A specifies the electrical enclosure material and rating for the location and application.

TABLE A

Location	Electrical Enclosure Material and NEMA Rating
Outdoor: Corrosive Area	NEMA 4X: Stainless Steel
Outdoor: Non-Corrosive Areas	NEMA 4X: Stainless Steel

D. Support Material and Rating

1. Table B specifies the support material for mounting and supporting equipment and rating for the location and application.

TABLE B

Location	Framing Channel	Threaded Rod,	Hardware, & Fittings
Outdoor, Corrosive Area	Stainless Steel	Stainless Steel	
Outdoor Areas,			
Non-corrosive	Steel	Steel	

HDG = Hot Dip Galvanized Finish

PVC = PVC Coated

E. Seismic:

1. Design and install electrical equipment, supports, and anchorage in accordance with the seismic design requirements specified in Section 01900.

1.05 STORAGE OF MATERIALS AND EQUIPMENT

A. Store materials and equipment as specified in Section 01605.

PART 2 PRODUCTS

2.01 EQUIPMENT AND MATERIALS

- A. General:
 - 1. Provide equipment and materials new and free from defects. Provide all material and equipment of the same or a similar type from the same manufacturer throughout the work. Use standard production materials wherever possible.
- B. Equipment Finish:
 - 1. Unless otherwise specified, manufacturer will paint electrical equipment as specified in Section 09900.

2.02 NAMEPLATES

- A. Nameplates shall be made from laminated phenolic plastic.
 - 1. Nominal size: 3/4 inch high by 2 inches long.
 - 2. Black backgrounds with 3/16-inch white letters.
 - 3. Fastened using self-tapping stainless steel screws.Nameplate adhesives will not be permitted on the outside of enclosures.
 - 4. Abbreviations shall be submitted to the Construction Manager prior to manufacture because of space limitations.

2.03 PRODUCT DATA

- A. The following information and product data specified under individual specification sections shall be provided in accordance with Section 01300.
 - 1. Applicable operation and maintenance information on an item-by-item basis in accordance with Section 01730. Provide operation and maintenance information at the time of equipment, device, or material site delivery, or at a certain stage of project completion as required by Section 01730, whichever is the earlier. Reduce full-size drawings to 11 x 17 inches.
 - 2. Provide test results for motors and electrical systems on the forms specified in Section 16030. Maintain a file of the original test. Prior to acceptance of work, provide the resulting file to the Construction Manager.
 - 3. Description of functional checkout procedures provided 14 days prior to performing functional checkout tests.
 - 4. Record documents specified in Section 01720 and paragraph 3.03.

PART 3 EXECUTION

3.01 GENERAL

- A. Construction:
 - 1. The work under Division 16 shall be performed in accordance with these specifications.
 - 2. Refer to the National Electrical Contractors Association's (NECA) National Electrical Installation Standards (NEIS) for Standard Practices for Good Workmanship in Electrical Contracting (NECA-1) as a minimum baseline of quality and workmanship for installing electrical products and systems that defines what is meant by "neat and workmanlike" as required by the National Electrical Code Section 110-12. Specified requirements supersede NECA practices.
 - 3. Electrical layout drawings are diagrammatic, unless otherwise detailed or dimensioned. The Contractor shall coordinate the location of electrical material or equipment with the work.
 - 4. Major electrical openings may compromise the structural integrity of the slab and wall elements. Major electrical openings are defined as openings or penetrations greater than two times the wall thickness in any dimension, and include duct bank transitions into a building through structural elements. Major electrical openings shall be constructed according to standard details on the drawings, up to an opening dimension of three feet. For opening dimensions greater than three feet, construct walls and slabs as specifically detailed on the drawings for that case. Major electrical openings proposed by the Contractor shall be submitted to the Structural Engineer of Record for the project for review.
 - 5. Minor changes in location of electrical material or equipment made prior to installation shall be made at no cost to the Owner.
- B. Housekeeping:
 - 1. Protect electrical equipment from dust, water and damage. Wipe motor control centers, switchgear, and buses free of dust and dirt, keep dry, and vacuum on the inside within 30 days of acceptance of the work.
 - 2. Before final acceptance, the touch up any scratches on equipment.
 - 3. Protect electrical equipment temporarily exposed to weather, debris, liquids, or damage during construction as specified in Section 01605.
- C. Electrical Equipment Labeling:
 - 1. Provide electrical equipment with field marked signs and labeling to warn qualified persons of the potential electric arc flash hazards per NEC Article 110.16 Flash Protection.
 - 2. Provide electrical distribution equipment and utilization equipment with field labels to identify the power source and the load as specified. Refer to NEC Article 110.22 for Identification of Disconnecting Means installation criteria. Specific information is required such as the equipment tag number and equipment description of both the power source and the load equipment.
- D. Motor Connections
 - 1. Verify that the motors are purchased with the correct size motor termination boxes for the circuit content specified as shown on the power single line diagrams or submit

custom fabrication drawing indicating proposed motor termination box material, size, gasket, termination kit, grounding terminal, motor lead connection method, and motor terminal box connection/support system. Verify the motor termination box location prior to raceway rough-in.

3.02 TESTING

A. Provide testing in accordance with Section 16030

3.03 RECORD DOCUMENTS

- A. Maintain and annotate contract documents and during construction, including the record drawings specified in Section 01720 and the following additional schedules, lists, and drawings:
 - 1. Interconnection Diagrams (Section 16000)
 - 2. Original Submittal Drawings (Section 01300)

END OF SECTION

SECTION 16030

ELECTRICAL ACCEPTANCE TESTING

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies the acceptance testing of electrical materials, power distribution and utilization equipment and circuits. Contractor shall provide all labor, tools, material, power, and other services necessary to provide the specified tests.

1.02 REFERENCES:

- A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
- B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
NETA ATS	Acceptance Testing Specifications for Electric Power Distribution Systems
NFPA-70	National Electrical Code (NEC)

1.03 SUBMITTALS

A. Functional testing and checkout procedures and schedule shall be provided in accordance with Section 01300.

PART 2 PRODUCTS

2.01 TEST EQUIPMENT AND MATERIALS

A. Test instruments shall be calibrated to references traceable to the National Institute of Standards and Technology and shall have a current sticker showing date of calibration, deviation from standard, name of calibration laboratory and technician, and date recalibration is required.

Form No.	Title
16000-A	Wire and Cable Resistance Test Data Form
16000-C	Dry Transformer Test Data Form
17000-A	Loop Wiring and Insulation Resistance Test Data Form
17000-B	Control Circuit Piping Leak Test Form
17000-C	Controller Calibration Test Data Form
17000-D	Panel Indicator Calibration Test Data Form
17000-E	Recorder Calibration Test Data Form
17000-F	Signal Trip Calibration Test Data Form
17000-G	Field Switch Calibration Test Data Form
17000-H	Transmitter Calibration Test Data Form
17000-I	Miscellaneous Instrument Calibration Test Data Form
17000-J	Individual Loop Test Data Form
17000-К	Loop Commissioning Test Data Form

2.02 PRODUCT DATA

A. In accordance with Section 01300, the Contractor shall submit the completed test report Section 16000-Forms A and B as specified in Part 3 herein.

PART 3 EXECUTION

3.01 TESTING

- A. General:
 - 1. The following specified tests, including correction of defects where found and the subsequent re-testing, shall be completed prior to energization of the equipment or systems. Submit all completed test report forms in a 3-ring binder type notebook at the project Substantial Completion date.
 - 2. A megohmmeter shall be used for insulation resistance measurements.
- B. INSULATION RESISTANCE MEASUREMENTS:
 - 1. General:
 - a. Insulation resistance measurements shall be made on conductors and electrical equipment that will carry current. Minimum acceptable values of insulation resistance shall be in accordance with the applicable NETA-ATS, ICEA, NEMA, or ANSI standards for the equipment or material being tested. The ambient temperature at which insulation resistance is measured shall be recorded on the test form.
 - 2. Conductor and Cable Tests:
 - a. The phase-to-ground insulation resistance shall be measured for all circuits 120 volts and above except lighting circuits. Measurements may be made with motors and other load equipment connected. Insulation resistance measurements shall be recorded in a format similar to Form 16000-A contained in Section 01999, and submitted for acceptance. Insulation with resistance of less than 10 megohms is not acceptable.

- 3. Motor Tests:
 - a. The Installed Motor Test Form, Form 16000-B, contained in Section 01999, shall be completed for each motor after installation and submitted for acceptance. All motors shall have their insulation resistance measured before they are connected.
- 4. Motors 50 HP and larger shall have their insulation resistance measured at the time of delivery and when they are connected. Insulation resistance values less than 50 megohms are not acceptable.
- 5. Verify that motors are connected to rotate in the correct direction. Verification may be accomplished by momentarily energizing the motor, provided the Contractor confirms that neither the motor nor the driven equipment will be damaged by reverse operation.
- 6. Power Distribution Equipment:
 - a. Transformers, panelboards, and other power distribution equipment shall have their insulation resistance measured phase-to-phase and phase-to-ground.
- 7. Power Utilization Equipment:
 - a. Test receptacles and power outlets using a device to verify polarity, grounding, and the correct wiring connections.
- C. Functional Testing:
 - 1. Contractor shall submit a description of proposed functional test and checkout procedures conforming to the following requirements, including a schedule for conducting these procedures, not less than 30 days prior to the performance of functional testing.
 - 2. Prior to functional testing, all protective devices shall be adjusted and made operative.
 - 3. Prior to energization of associated equipment, perform a functional checkout of all electrical and instrumentation control circuits as specified in the following and in Division 17. Checkout shall consist of energizing each control circuit and operating each control, alarm, safety device, and each interlock, in turn, to verify that the specified action occurs.

END OF SECTION

This page intentionally left blank.

SECTION 16110

RACEWAYS, BOXES, AND SUPPORTS

PART 1 GENERAL

1.01 SCOPE

A. This section covers the furnishing and installation of electrical conduits, wireways, pull boxes, manholes, handholes, cable trays, fittings and supports. Raceways shall be provided for lighting, receptacles, power, control, instrumentation, signaling and grounding systems.

1.02 REFERENCES

- A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
- B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI C80.1	Rigid Steel Conduit-Zinc Coated
ANSI C80.3	Electrical Metallic Tubing-Zinc Coated
ASTM F512	Smooth-Wall Polyvinylchloride Conduit and Fittings for Underground Installation
FEDSPEC WW-C-581E	Conduit, Metal, Rigid and Intermediate; and Coupling, Elbow, and Nipple, Electrical Conduit; Zinc Coated
FEDSPEC W-C-1094A	Conduit and Conduit Fittings, Plastic, Rigid
JIC EMP-1	Electrical Standards for Mass Production Equipment
NEMA ICS 6	Industrial Control and Systems Enclosures
NEMA TC2	Electrical Plastic Tubing (EPT) and Conduit (EPC 40 and EPC 80)
NEMA TC6	PVC and ABS Plastic Utilities Duct for Underground Installation
NEMA VE1	Cable Tray Systems
NEMA 250	Enclosures for Electrical Equipment (1000 volts maximum)
CEC	California Electrical Code
NFPA 79	Electrical Standards for Industrial Machinery
CBC	California Building Code
UL 1	Flexible Metal Electrical Conduit
UL 6	Rigid Metal Electrical Conduit
UL 360	Liquid Tight Flexible Electrical Conduit

Reference	Title
UL 514	Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers
UL 651	Rigid Nonmetal Electrical Conduit
UL 797	Electrical Metallic Tubing
UL 870	Wireways, Auxiliary Gutters, and Associated Fittings
UL 884	Underfloor Raceways and Fittings
UL 886	Outlet Boxes and Fittings for Hazardous (Classified) Locations

1.03 SUBMITTALS

- A. The following information shall be provided in accordance with Section 01300:
- B. Products:
 - 1. Manufacturer's descriptive literature for materials.

PART 2 PRODUCTS

2.01 RACEWAYS AND FITTINGS

A. General requirements for raceway materials specified in this section are listed in the RACESPECS sheets at the end of this section. The type of raceways and raceway fittings to be used for any given area and application shall conform to the requirements in this section.

2.02 BOXES, GUTTERS, TERMINAL CABINETS, MANHOLES, AND HANDHOLES

- A. Materials and classifications of equipment and material is specified in Section 16000
- B. Pull Boxes And Wiring Gutters:
 - Indoor boxes and enclosures larger than FD boxes shall be constructed of sheet steel and galvanized after fabrication. Outdoor boxes and enclosures shall be provided with neoprene gaskets on the hinged doors and removable covers. Box and gutter sizes, metal thickness, and grounding shall comply with the National Electrical Code. Bolt-on junction box covers 3 feet square or larger, or heavier than 25 pounds, shall have a rigid handle. Covers larger than 3 x 4 feet shall be split.
- C. Terminal Cabinets:
 - 1. Terminal cabinets shall be provided with adjustable terminal strip mounting, backpanels for equipment mounting, print pockets in the doors, continuous door hinges, and three-point lockable latches.
 - 2. Classifications, ratings and enclosure material is specified in 16000.
- D. Manholes:
 - Unless otherwise specified, manholes shall be precast concrete, 3000 psi strength at 28 days, with reinforcing with the manhole cover designed for H 20 bridge loading. Necking and shaft shall have 36 inch minimum clear opening.
 - 2. Manhole dimensions shall be as shown on the drawings and where not shown shall be sized in accordance with the NEC. Manhole cover and frame shall be Class 30B gray cast iron per ASTM A48 with machine finished flat bearing surfaces. Manhole

covers shall be engraved " ELECTRICAL – LOW VOLTAGE". 2. "ELECTRICAL – MEDIUM VOLTAGE". 3. "SIGNAL/COMMUNICATIONS". " as appropriate.

- 3. Manholes shall be watertight. Exterior walls of manholes shall be provided with 6 mils of waterproof membrane, Sonneborn HLM 5000 Series, or equal. Manhole walls shall be provided with boxouts with waterstops on all sides of each boxout. Waterstops shall be as specified in the Cast-in-Place Concrete section.
- 4. Raceway duct entries shall be no less than 14 inches above floor and below ceiling. Raceway boxouts shall be sized to accommodate the penetrating underground duct banks. Raceways bell-ends shall be flush with the interior finished manhole wall. From each duct bank entry into the manhole, the continuous duct bank bare copper grounding conductor shall be supported and routed around the interior manhole walls and bonded together.
- 5. Floor shall slope to a sump pit with dimensions shown in the manhole detail or with a minimum of 18 inch length x 18 inch width x 12 inches depth.
- E. Handholes:
 - 1. Handholes shall be precast concrete with checker plate, galvanized, traffic covers designed for H 20 loading. Handholes shall be provided with precast solid concrete slab bottoms with sumps. Handholes shall be constructed of 3000 psi reinforced concrete. Handhole cover shall be engraved "ELECTRICAL" or "SIGNAL" as applicable.
 - 2. Dimensions shall be as specified on the drawings. Handhole walls shall be provided with boxouts, as specified for manholes.
- F. Manhole And Handhole Cable Supports:
 - Provide heavy-duty, non-metal cable racks for support of conductors. Racks shall be UL listed glass-reinforced nylon consisting of slotted wall brackets for support arms designed for a minimum of a 400-pound load. Each support bracket shall from the top to the bottom and the arms shall be adjustable and installed on 24-inch centers. Use ¹/₂-inch stainless steel bolts, hardware, inserts, and fasteners. Cables supports, clamps or racks shall be provided to support the cable at minimum 2-foot intervals. Concrete inserts shall be embedded on 24-inch centers in walls and ceiling.
 - 2. Cable Support Products:
 - a. Underground Devices Incorporated Type RA arms with CR36 support brackets.
 - b. Unistrut Power-Rack F20N-STA33 Stanchions with F20N-ARM14 Arms.
 - c. Or equal
- G. Ground Bus:
 - Provide a ground bus in concrete manholes, handholes, and electrical pullboxes with dimension of 3-foot width x 3-foot length x 3-foot depth and larger. Provide a NEMA threaded 4-hole grounding plate for connecting two to four-1-hole ground connectors that enter the enclosure from two to four duct banks. From each duct bank entry into the manhole, the continuous duct bank bare copper grounding conductor shall be supported and routed around the interior manhole walls and bonded together or to a ground bus
 - a. Products:
 - 1) Burndy, T&B, or equal.

2.03 RACEWAY SUPPORTS

- A. Conduit Supports:
 - 1. Framing channel with end caps and straps shall be provided to support groups of conduitIndividual conduit supports shall be one-hole pipe straps used with clamp backs and nesting backs where required
 - 2. Conduit supports shall be one-hole clamps or oversized clamps with clamp backs and nesting backs where required .
 - 3. Fiberglass spray sealant shall be applied to all field cuts made to fiberglass framing channel.
- B. Ceiling Hangers:
 - 1. Ceiling hangers shall be adjustable. Provide J-Type conduit support for single conduit. Straps or hangers of plumber's perforated tape are not acceptable. Unless otherwise shown, hanger rods shall meet ASTM A193 and be sized as 3/8-inch up to 2-inch conduit and shall be 1/2 inch all-thread rod over 2-inch conduit.
 - 2. Ceiling hangers for fiberglass framing channel shall be 1/2 inch fiberglass reinforced plastic threaded rod hangers with FRP fasteners.
- C. Suspended Raceway Supports and Racks:
 - 1. Suspended raceway supports shall consist of concrete inserts, rod hangers, and jamb nuts supporting framing channel or lay-in pipe hangers as required. Framing channel shall be a minimum of 12-gauge.
 - 2. Hanger rods supporting fiberglass framing channel shall be 1/2 inch fiberglass reinforced plastic with FRP or nylon jamb nuts.
 - 3. Hanger rods shall be 1/2-inch diameter all-thread rod and shall meet ASTM A193. Suspended raceway supports and racks shall be braced for seismic forces as specified in Section 16000.
- D. Materials:
 - 1. Mounting and supporting material and ratings are specified in Section 16000.

2.04 CONCRETE ENCASED DUCT BANKS

A. Concrete used for duct banks shall have a minimum strength of 3,000 psi.

2.05 UNDERGROUND MARKING TAPE

- A. Underground detectable marking tape shall be for early warning protection of digging around direct buried cables, conduits, and concrete duct banks. Tape shall be OSHA approved.
- B. Marking Tape Example:
 - 1. tape example: Low density polyethylene plastic, nominally 6 inches wide and 4 mil thickness with metallic lined tape with red polyethylene film on top and clear polyethylene film on the bottom. Tape shall be imprinted with a warning continuously along the length similar to: "CAUTION STOP DIGGING BURIED ELECTRIC LINE BELOW."

- C. Tape Products:
 - 1. Brady "Identoline"; Services and Materials "Buried Underground Tape"; Somerset (Thomas & Betts) "Protect-A-Line"; or equal.

2.06 NAMEPLATES

A. Nameplates are specified in Section 16000

2.07 FIRESTOPS

A. Firestops and seals shall be Flamemastic 77, Vimasco No. 1-A, or equal, and shall be applied in accordance with manufacturer's recommendations. Products which are affected by water are not acceptable.

2.08 RACEWAY IDENTIFICATION

- A. Provide raceway numbering as specified in Section 3.06.
- B. Raceway number tags:
 - 1. Solid brass with 0.036-inch minimum thickness.
 - 2. Raceway number stamped in 3/16-inch minimum height characters
 - 3. Attached to the raceway with 316 stainless steel wire.

2.09 ELECTRICAL SEALANT

A. Electrical sealant putty shall be non-hardening, non-oxidizing, non-corrosive, nonpoisonous, and non-injurious to human skin with service temperature range of 30 to 200 degrees Fahrenheit. Product shall be used to seal against the entrance of water.

2.10 HAZARDOUS AREA AND CORROSIVE AREA CONDUIT SEALS

- A. Sealing compound shall be non-hardening type for corrosive areas. Seal fittings for conduit systems in hazardous atmosphere locations shall be hot-dip galvanized cast ferrous alloy or aluminum alloy. Seal fittings shall be 40-percent fill type.
- B. Sealing compound shall be hard type installed in UL listed for explosion-proof sealing fittings after the conductors are installed, tested, and accepted.
- C. Provide PVC-coated seal fittings used for PVC-coated conduit with 40-mil factory coating. Seal fitting and sealing compound manufacture: Appleton, Crouse-Hinds, or equal.

2.11 PULLING LINE

A. Pulling line shall be polyethylene type, mildew and rot resistant with minimum of 200-pound tensile strength and minimum 1/4-inch diameter. Install in all "future" or "spare" raceways. Manufacture: Greenlee, Ideal, or equal.

2.12 CONDUIT THREAD LUBRICANT

A. Thread lubricant shall be conductive with anti-seize and anti-corrosion properties, compatible with steel and aluminum conduit materials. Manufacture: T&B CP8 KOPR-Shield; Robroy Threadcompound; or equal.

2.13 TERMINAL BLOCKS

1. Terminal blocks are specified in Section 16120.

PART 3 EXECUTION

3.01 GENERAL

- A. Refer to Sections 16000 for identification of hazardous and corrosive areas.
- B. Table A specifies the type of raceway required for each location and application by RACESPEC sheet. Unscheduled conduit shall be galvanized, rigid steel, RACESPEC type GRS.

Location	Application/Condition	RACESPEC
Outdoor	Exposed	GRS
Concealed	Power circuits embedded in concrete structure or beneath slab-on-grade	PVC4
Concealed	Instrumentation, communications and data signals encased in concrete, duct bank	PVC4
Underground	Power circuits encased in concrete, duct bank	PVC4
Underground	Instrumentation, communications and data signals directly buried	PVC4

Table A

3.02 CONDUIT

- A. General:
 - 1. The conduit systems, installation, and hazardous location fittings are specified herein.
- B. Indoor and Outdoor Conduit Systems:
 - 1. Conduit installation shall conform to the requirements of the RACESPEC sheets and the following specified installation requirements:
 - a. Install exposed conduit parallel or perpendicular to structural members and surfaces. Install conduit horizontally and allow minimum headroom of 7 feet.
 - b. Route two or more exposed conduits in the same general routing parallel with symmetrical bends.
 - c. Space exposed conduit installed on supports not more than 10 feet apart. Space multiple conduits in parallel and use framing channel.
 - d. Comply with the requirements herein, where conduits are suspended from the ceiling.

- e. Secure conduit rack supports to concrete walls and ceilings with cast-in-place anchors or framing channel concrete inserts.
- f. Install conduits at least 6 inches from high temperature piping, ducts, and flues with temperatures higher than 90 degree C.
- g. Install conduits between the reinforcing steel in walls or slabs that have reinforcing in both faces.
- h. Place conduits under the reinforcement in slabs with only a single layer of reinforcing steel. Separation between conduits, conduits and reinforcement, and conduits and surfaces of concrete shall be maintained in accordance with UBC.
- i. Route conduit clear of structural openings and indicated future openings.
- j. Provide conduits with flashed and watertight seals routed through roofs or metal walls.
- k. Grout conduits into openings cut into concrete and masonry structures.
- Cap conduits or plug flush conduits during construction to prevent entrance of dirt, trash, and water. Cap or plug empty conduits designated as "future", "spare", or "empty" and include a pulling line accessible at both ends. Use antiseize compound on cap and plug threads prior to installation.
- m. Determine concealed conduit stubup locations from the manufacturer's shop drawings. Terminate concealed conduit for future use in specified equipment.
- n. Install conduit flush with structural surfaces with galvanized couplings and plugs. Caps and plugs shall match the conduit system.
- o. Provide concealed portions of conduits for future equipment where the drawings indicate future equipment. Match the existing installation for duplicate equipment.
- p. Terminate conduits that enter enclosures with fittings that match the NEMA rating of the enclosure.
- q. Underground metallic or nonmetallic conduit that turn out of concrete, masonry or earth: Install a 90-degree elbow of PVC-coated rigid steel conduit before emergence above ground.
- r. Provide O-Z Gedney "Type DX" or Crouse-Hinds "Type XD" bonded, weathertight expansion and deflection fitting for the conduit size where conduit across structural joints that allows structural movement.
- C. Underground Conduit System:
 - 1. Excavation, backfilling, and concrete work shall conform to respective sections of these specifications. Underground conduit shall conform to the following requirements:
 - a. Underground conduits under roadways or traffic areas that are not shown otherwise on the drawings shall be reinforced concrete encased.
 - b. Concrete encased conduit shall have minimum concrete thicknesses of 2 inches between conduits, 1 inch between conduit and reinforcing, and 3 inches between reinforcing and earth, unless shown otherwise in an electrical detail.
 - c. Concrete encasement on exposed outdoor conduit risers shall continue to 3 inches above grade, with top crowned and edges chamfered.
 - d. Underground conduit bend radius shall be not less than 2 feet minimum at vertical risers and shall be not less than 3 feet elsewhere.

- e. Where conduit and concrete encasement are terminated underground, the conduit and reinforcing shall both extend at least 2 feet past the concrete. Conduits shall be capped and threads protected. Steel surfaces shall be given two coats of epoxy paint.
- f. Underground conduits and conduit banks shall have 2 feet minimum earth cover unless otherwise shown.
- g. Underground conduit banks through building walls shall be cast-in-place or installed with concrete into boxouts with waterstops on all sides of the boxout. Water-stops shall be as specified in the Cast-in-Place Concrete section. Extend the horizontal reinforcement from the duct bank into the boxout terminating with J-hook bends.
- h. Conduits not encased in concrete and passing through walls with one side in contact with earth shall be sealed watertight with special rubber gasketed sleeve and joint assemblies or with sleeves and modular rubber sealing elements.
- i. Thoroughly swab conduits and raceways on the inside, immediately upon completion of pouring concrete.
- j. Label raceways in accordance with 2.08 and 3.05.
- k. After the concrete has set and before backfilling, pull a mandrel through each conduit. The mandrel shall have a diameter equal to the nominal conduit inside diameter minus 1/2 inch and shall not be less than 4 inches long.
- I. If the mandrel showed signs of protrusions on the inside of the conduit, the conduit shall be repaired or replaced.
- m. Provide manufactured plastic conduit spacers anchored to prevent movement during the concrete pour. Manufacture: Carlon, PW Pipe, Underground Devices, or equal.
- n. Form the concrete pour ten feet from the wall, manhole, or handhole and form to allow for future conduit entry.
- o. Allow for a minimum of two days to cure prior to backfilling.
- p. Allow and provide for two offsets per conduit and raceway for each 100 linear feet to account for unexpected field conditions including for excavation and backfill limited to three feet of extra width and/or depth. Include these specified provisions in the bid price.
- q. Provide PVC threaded adapter with female threads where PVC conduit is joined to steel conduit.
- r. Procedure:
 - 1) Before assembly: Double coat steel conduit with Red-Robroy, Green-Permacote, Blue-Ocal or equal product.
 - After assembly: Seal with 65-mil thick, 2-inch wide mastic sealing tape to 1/2 inch beyond threads. Procucts: 3M Scotch 2228; Plymouth 02625; or equal.
 - Cover with 20-mil corrosion protection tape applied in ¹/₂-lap layers to 2 inch beyond threads. Products: 3M Scotchwrap 51; Plymouth Plywrap 12; or equal.
- s. Where reinforced concrete duct banks enter the side of a building, manhole, or handhole and the reinforcement cannot be brought into a window and be terminated, then drill the structure and embed the reinforcement in epoxy to minimum of 3-inches depth.

- t. Provide PVC conduit with bell ends where duct banks terminated at walls, manholes, or handholes. Install bell ends flush with finished concrete.
- u. Provide PVC conduit with bell ends where conduit rise below grade into a floor mounted electrical panel, electrical cabinet, MCC, switchboard, or switchgear.
- v. Separate power conduits from signal conduit within the same ductbank by 12 inches or greater separation, as shown. Refer to the drawings or schedules for signal to be installed in metal conduits instead of PVC ducts.
- w. Separate high voltage ductbanks from low voltage ductbanks, as shown.
- x. Provide wireways for transition from underslab conduits rising into wall-mounted panels where the number of conduits exceed the NEC allowable panel space in the bottom of the panel. Provide conduit sleeves or fitting for panel transition. Continuous thread or all-thread is prohibited.
- D. Conduit In Block Walls
 - 1. Install multiple runs of conduit that stub-up into a block wall and connect to recessed electrical panels with adequate space for the conduit. Coordinated the electrical work with the structural work and block installers to provide a chase to install the conduit. Install conduit in the cells that do not contain structural reinforcement. Install conduits in the center of the cell to avoid affecting the structural integrity of the wall.
 - 2. Avoid conduit and electrical boxes installation that blocks the cell from being grouted or that blocks the cell reinforcing bars from being grouted. Avoid conduit in the first cell adjacent to doors, windows, corners and wall intersections and install conduits in the center of the first available cell a minimum of 1'-0" from the edge of these openings.
 - 3. Where solid grouting of masonry walls is specified, install conduit and electrical boxes so as to provide sufficient space for grout to flow pass the boxes and conduit in order to fully fill the space beneath and behind. Where boxes need to be held in place, secure the boxes from the face of the block wall. Do not place items behind or next to electrical boxes to hold in place.
 - 4. Coordinate split-face, slump and scored block installation with the masonry contractor to supply smooth face block at the location of receptacles and switches so that the device covers install flush to the wall. Install translucent weather-proof sealing material under device covers on outdoor or wet area locations.
- E. Conduit Seal-Off Fittings:
 - 1. Conduits passing:
 - a. Between Class I, Division 1 area and Class I, Division 2 area; provide sealing fittings located at the boundary in accordance with NEC Article-500.
 - b. From hazardous or corrosive area into a non-hazardous or non-corrosive area.
 - 2. Install the seal-off material in the conduit seal-off fittings after inspection.
- F. Conduit And Innerduct Sealing Material:
 - 1. Provide HYDRA-SEAL® Handi-Polyurethane-Foam or equal product to seal conduits and innerducts.
 - 2. Sealing product required features:
 - a. Compatible with common cable jacket materials.
 - b. ASTM E-84 flame spread requirements and UL Classified.

- c. Pre-pressurized, portable, one-component closed-cell foam sealing system.
- d. Dries tack-free within 15 minutes and cures within 24 hours.
- e. Reacts with applied moisture or with ambient humidity.
- f. Remove over-spray with acetone and remove cured foam mechanically
- 3. Application Criteria:
 - a. Apply in ambient temperatures between 60 and 100 degrees Fahrenheit.
 - b. Apply bead onto clean surface.
- G. Conduits in Concrete Construction:
 - 1. Conduits for power, control and instrumentation may be embedded in and pass through concrete construction subject to the limitations in this paragraph. Where concrete strength or serviceability requirements prevent the direct embedment of conduit, provide adequate support, bracing, and serviceability details:
 - a. Do not impair significantly concrete strength by the embedment of conduits in or through structural sections.
 - b. Provide conduit layout to the requirements of ACI 318, Sections 3.3 Aggregates and 6.3 Conduits and Pipes Embedded in Concrete.
 - c. Treat conduits similarly to reinforcing steel for purposes of clearance. In general, code sections require conduit spacing the greater of:
 - d. 1.33 times the maximum concrete aggregate size, clear
 - 1) Three diameters center to center
 - 2) Alternate spacing and layout shall be as reviewed and accepted by the Engineer.
 - 2. Conduit and raceway penetrations through walls and slabs where:
 - a. one side is a conditioned or an occupied space and the other side not, or
 - b. one side has liquid or groundwater contact and the other not,
 - c. be detailed and constructed to prevent liquid and moisture penetration through the wall or slab section for each conduit.

3.03 MANHOLES AND HANDHOLES

- A. Unless otherwise specified, manhole and handhole installation shall be as follows:
 - 1. Manholes, handholes, and pull boxes shall be set on a minimum of 6 inches of crushed rock on top of undisturbed or compacted earth.
 - 2. Manholes and handholes shall be set plumb so that water shall drain to the sump.
 - 3. Manhole covers shall be 36-inches in diameter and set at 2 inches above finish grade with surrounding pavement sloping away from the manhole cover.
 - 4. Metallic hardware inside manholes and handholes shall be bonded to the ground plate or ground bus using bolted connections, bonding jumpers and grounding bushings.
- B. CABLE RACKS: Cable rack assemblies shall be installed as follows:
 - 1. Attach rack stanchion to manhole/handhole wall with $\frac{1}{2}$ -inch drop-in anchors and $\frac{1}{2}$ -x 3/8-inch stainless steel hex head cap screw. Stanchions shall be anchored at the top and bottom of each stanchion as well as above each cable arm.

- 2. Provide cable arms to support cables on each rack along the cable run within the manhole/handhole. Provide a minimum of two racks on each wall and two spare cable arms per rack.
- 3. Secure each cable or cable bundle to the cable arm with heavy duty, nylon wire ties, Richo WIT-225L or equal. Cable bundles shall be organized by circuit voltage and area served. Multiple circuits may be bundled together where the circuits are derived from the same immediate source and serve the same area. 480 volt AC circuits, No. 6 and larger, shall be individually bundled.

3.04 CABLE TRAY

- A. Unless otherwise specified or shown, cable tray installation shall be as follows:
 - 1. Cable trays shall be supported at intervals not to exceed 5 feet.
 - 2. Corners shall be supported by two supports installed as close as possible to the corner, with one support on each side of the corner.
 - 3. Field cuts on steel cable tray shall be treated with zinc rich paint.
 - 4. Expansion joint splice plates shall be used to allow 1 1/2 inch free movement between adjacent trays when crossing building expansion joint.
 - 5. Cable tray shall have minimum clearance of 3/4 inch from concrete surfaces and minimum spacing of 12 inches from other trays. The top of the tray shall be minimum 9 inches from the ceiling.
 - 6. Signal cable trays shall be provided with solid type covers.
 - 7. Provide each cable tray with No. 2/0 AWG or No. 4/0 AWG minimum bare copper equipment ground conductor attached to the outside of each tray section using UL Listed bolted bronze or brass ground clamp and bond to the ground grid system.
 - 8. Power cables shall be placed in cable trays in accordance with the NEC.
 - 9. Cables shall be arranged in trays for minimum cross-over for entry or exit.
 - 10. Provide cable tray barrier between power and control cables, if not in separate cable trays.
 - 11. Provide cable tray barrier between control and instrument cable in the same cable tray.

3.05 RACEWAY NUMBERING

- A. Each new and reused conduit shall be provided with a number tag at each end and in each manhole, handhole, or pull box. Cable trays shall be identified by stencils at intervals not exceeding 50 feet, at intersections, and at each end to identify power cable tray voltage, control cable tray, or instrument cable tray.
- B. Raceway Numbers:
 - 1. Tag raceways at all terminations. Raceway numbers will comply with raceway lables assigned on the drawings. Where raceway numbers have not been assigned, assigne raceway numbers in accordance with the following system:

Raceway Prefix	Type of Function
С	Control or power - 120V or less
Н	Power above 600V
Ν	Pneumatic tubing

Raceway Prefix	Type of Function
Р	Power 208V to 600V
S	Signal - data communication or instrumentation
Х	Spare

- Provide 4-digit number after the prefixes . Add a letter suffix to distinguish the raceways where more than one raceway is routed to a particular piece of equipment. Example: Raceway number = P3109A where:
 - a. P = conduit contains power
 - b. 3109 = unique 4-digit number
 - c. A = letter to distinguish raceways to same equipment

3.06 RACEWAY SCHEDULE

- A. General:
 - 1. Raceways are scheduled on the drawings.
- B. Unscheduled Raceway:
 - 1. With the exception of lighting, communication, paging, fire alarm, security and receptacle circuits, the type and size of raceway shall be as specified on the drawings or schedules.
 - 2. Unscheduled lighting and receptacle raceways shall be sized by the Contractor in accordance with the NEC. Minimum size shall be 3/4 inch for exposed and 1 inch for embedded raceway.
 - 3. The number and size of communication, paging, fire alarm, and security raceways shall be as required for the particular equipment provided subject to the minimum sizes specified herein.

3.07 RACESPEC SHEETS

- A. The following RACESPECS are included in this section:
- 1. RACEWAY SPECIFICATION SHEETS (RACESPEC) GRS
 - a. Raceway Identification:
 - 1) GRS
 - b. Description:
 - 1) Galvanized Rigid Steel Conduit (GRS)
 - c. Compliance:
 - 1) ANSI and UL
 - d. Finish:
 - 1) Hot-dip galvanized after fabrication, inside and outside. Smooth finished surfaces.
 - e. Manufacturers:
 - 1) Allied Tube and Conduit Corp., Wheatland Tube Co., or equal.
 - f. Minimum size:
 - 1) Unless otherwise specified, 3/4 inch for exposed, 1 inch for embedded, encased, or otherwise inaccessible.

- g. Fittings:
 - 1) Locknuts, Rings, Hubs:
 - a) Hot-dip galvanized insulated throat with bonding locknut or ring,. The hubs shall utilize a neoprene "O" ring and provide a watertight connection. O-Z Gedney, CHM-XXT, or equal
 - 2) Unions:
 - a) Electro-galvanized ferrous alloy type Appleton UNF or UNY, Crouse-Hinds UNF or UNY, or equal. Threadless fittings are not acceptable.
 - 3) Conduit Bodies:
 - a) Oversized conduit bodies: Ferrous alloy type with screw taps for fastening covers to match the conduit system. Gaskets shall be made of neoprene.
- h. Boxes:
 - 1) Indoor:
 - a) Type FD cast ferrous for all device boxes and for junction boxes less than 6 inches square.
 - 2) Outdoor:
 - a) Type FD cast ferrous for all device boxes and for junction boxes less than 6 inches square.
 - 3) Corrosive:
 - a) NEMA 4X stainless steel or nonmetallic, as specified.
 - 4) Hazardous:
 - a) NEMA Class 7 cast ferrous.
- i. Elbows:
 - 1) 3/4" thru 1-1/2" -- Factory fabricated or field bent.
 - 2) 2" thru 6" -- Factory fabricated only.
- j. Conduit Bodies (Oversized):
 - 3/4" thru 4" -- Malleable iron, hot-dip galvanized, unless otherwise noted. Neoprene gaskets for all access plates. Tapered threads for conduit entrances.
 - 2) 5" and 6" -- Electro-galvanized iron or cast iron box.
- k. Expansion Fittings:
 - 1) Expansion fittings in embedded runs shall be watertight with an internal bonding jumper. The expansion material shall be neoprene allowing for 3/4-inch movement in any direction.
- I. Manufacturers:
 - 1) Appleton, Crouse-Hinds, Hubbell, O. Z. Gedney, or equal.
- m. Installation:
 - Rigid steel conduit shall be made up tight and with conductive thread compound. Joints shall be made with standard couplings or threaded unions. Steel conduit shall be supported away from the structures using hot-dip galvanized malleable iron straps with nesting backs or framing channel.
 - 2) Conduit entering boxes shall be terminated with a threaded hub with a grounding bushing.

- 3) Exposed male threads on rigid steel conduit shall be coated with zinc-rich paint.
- 2. RACEWAY SPECIFICATION SHEETS (RACESPEC) PVC4
 - a. Raceway Identification:
 - 1) PVC4
 - b. Description:
 - 1) Rigid Nonmetallic Conduit.
 - c. Application:
 - 1) Heavy wall thickness for direct bury, concrete encasement or surface mounting where not subject to physical damage.
 - d. Compliance:
 - 1) NEMA TC2, UL 651
 - e. Construction:
 - 1) Schedule 40, high-impact, polyvinylchloride (PVC)
 - f. Minimum size:
 - 1) 3/4 inch exposed; 1 inch embedded or encased
 - g. Fittings:
 - 1) PVC solvent weld type
 - h. Boxes:
 - 1) Indoor:
 - a) NEMA Class 4, nonmetallic
 - 2) Outdoor and corrosive:
 - a) NEMA Class 4X, nonmetallic
 - i. Installation:
 - 1) PVC conduit entering fiberglass boxes or cabinets shall be secured by threaded bushings on the interior of the box and shall be terminated with a threaded male terminal adapter having a neoprene O ring.
 - 2) Joints shall be made with standard PVC couplings.
 - 3) PVC conduit shall have bell ends where terminated at walls and boxes.
- 3. RACEWAY SPECIFICATION SHEETS (RACESPEC) LFS
 - a. Raceway Identification:
 - 1) LFS
 - b. Description:
 - 1) Liquidtight Flexible Steel Conduit
 - c. Application:
 - 1) Final connection to equipment subject to vibration or adjustment.
 - d. Compliance:
 - 1) UL 360
 - e. Construction:
 - 1) Spirally wound galvanized steel strip with successive convolutions securely interlocked and jacketed with liquidtight plastic cover.
 - f. Minimum Size:
- 1) 3/4 inch
- g. Fittings:
 - 1) Cadmium-plated malleable iron body and gland nut with cast-in lug, brass grounding ferrule threaded to engage conduit spiral.
 - 2) O-ring seals around the conduit and box connection and insulated throat.
 - 3) Provide forty-five and ninety degree fittings where applicable.
 - 4) Provide PVC coated flexible conduit and fittings where the conduit system is PVC coated.
- h. Installation:
 - 1) Length of flexible liquidtight conduit shall not exceed 15 times the trade diameter of the conduit and not exceed 36 inches in length. Use conductive thread compound.

END OF SECTION

This page intentionally left blank.

SECTION 16120

600V CONDUCTORS, WIRE, AND CABLE

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies stranded copper cables, conductors, and wire rated 600 volts insulation used for power; lighting, analog, digital, or pulse signals and control circuits.

1.02 REFERENCES

- A. This section contains references to the following documents. They are a part of this section. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
- B. Unless otherwise specified, references to document shall mean the documents in effect at the time of Advertisement for bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, whether or not the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM B3	Soft or Annealed Copper Wire
ASTM B8	Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B33	Tinned Soft or Annealed Copper Wire for Electrical Purposes
ICEA S-68-516	Ethylene-Propylene-Rubber-Insulated Wire
NEMA WC7	Cross-Linked-Thermosetting Insulated Wire and Cable for the Transmission and Distribution of Electric Energy
NFPA 70	National Electric Code (NEC)
UL 44	Rubber-Insulated Wires and Cables
UL 83	Thermoplastic-Insulated Wires and Cables

1.03 SUBMITTALS

- A. The following information shall be provided in accordance with Section 01300.
 - 1. Complete catalog cuts for all conductors, wire, and cable.

PART 2 PRODUCTS

2.01 GENERAL

- A. Unscheduled Conductors and Cables:
 - 1. Where not specified on the Drawings, conductors and cables shall be sized in accordance with the National Electrical Code for the particular equipment served with

the minimum size as specified herein. Unscheduled conductor with insulation shall be provided in accordance with the following:

- a. CABLESPEC "XHHW" multi-conductor power and control cable
- b. CABLESPEC "XHHW" for single conductors
- B. Cable Specification Sheets (CABLESPEC):
 - 1. General requirements for conductors and cables specified in this Section are listed on CABLESPEC sheets in paragraph 3.06.

2.02 COLOR CODING

- A. Control Conductors:
 - 1. Single-conductor control conductors shall have the following colors for the indicated voltage:

Control Conductor	120V
Power (AC)	Black
Control (AC)	Red
Neutral	White
Ground	Green
Foreign Voltage (DC)	Blue/White
Foreign Voltage (AC)	Yellow
Power (DC)	Blue
Control (DC)	Violet

B. Power Conductors:

1. Power conductors shall have the following colors for the indicated voltage:

Power Conductor	480V	240/120V
Phase A	Brown	Black
Phase B	Orange	Red
Phase C	Yellow	-
Ground	Green	Green
Neutral	Gray	White

- C. Cables may be black with colored 3/4-inch vinyl plastic tape applied at each cable termination and in pull boxes, handholes and manholes. Tape shall be wrapped with 25 percent overlay to provide 3 inches minimum coverage.
- D. Signal Conductors:
 - 1. Signal cable conductors shall be color coded black and white for pairs or black, white, and red for triads. Each conductor and each group of conductors shall be numbered.

2.03 POWER AND CONTROL CONDUCTORS AND CABLE, 600 VOLT

- A. Single Conductor:
 - Provide stranded conductors for all cable or wires. Provide minimum conductor size of 12 AWG for power and lighting circuits and minimum conductor size of 14 AWG for control circuits.
- B. Multiconductor Cable:
 - 1. Provide multiconductor power cable and multiconductor control cable where identified on the drawings. Provide multi-conductor cable designations as per the drawings Provide stranded conductors for all cable or wires.

2.04 SIGNAL CABLES

- A. General:
 - 1. Factory cable between manufactured instrument system components shall be provided in compliance with the instrument manufacturer's recommendations.
 - 2. Signal cable shall be provided for instrument signal transmission. Single instrument cable (SIC) shall be provided in accordance with the following examples:
 - a. CABLESPEC "SIC":
 - 1) Cable designation:
 - a) 1PR#16S shielded twisted pair (STP)
 - 2) Cable designation:
 - a) 1TR#16S triad (STT)
- B. Communication, Paging, and Security System Cables:
 - 1. Voice communication, paging, and security system cables shall be specified in their respective specification sections.

2.05 PORTABLE CORD

A. Portable cord shall be provided in accordance with CABLESPEC "CORD," unless otherwise specified. Cords shall contain an equipment grounding conductor.

2.06 SPLICING AND TERMINATING MATERIALS

- A. Connectors shall be tool applied compression type of correct size and UL listed for the specific application. Connectors shall be tin-plated high conductivity copper. Wire nuts for a splice is prohibited.
- B. Signal and control conductors shall be connected to terminal blocks and field devices and instruments shall be terminated with conductor terminals as specified in 2.10.
- C. Connectors for wire sizes No. 8 AWG and larger shall be compression tool installed onehole lugs up to size No. 3/0 AWG, and two-hole or four-hole lugs for size No. 4/0 and larger. Mechanical clamp, dimple, screw-type connectors are not acceptable. In-line splices and taps shall be used only by written consent of the Construction Manager.

- D. Power conductor splices shall be compression type, made with a compression tool die approved for the purpose, as made by Thomas and Betts Corp., or equal. Splices shall be covered with electrical products designed for the application, insulated, and covered with a heat-shrinkable sleeve or boot, as specified elsewhere.
- E. Motor connection kits shall consist of heat-shrinkable, polymeric insulating material over the connection area and high dielectric strength mastic to seal the ends against ingress of moisture and contamination. Motor connections may use the Tyco Electronics removable boot product line.
- F. Motor connection kits shall accommodate a range of cable sizes for both in-line and stubtype configurations. Connection kits shall be independent of cable manufacturer's tolerances.

2.07 CORD GRIPS

A. Cord grips shall be provided where indicated on the Drawings to attach flexible cord to equipment enclosures. Cord grips shall consist of a threaded aluminum body and compression nut with a neoprene bushing and stainless steel wire mesh for strain relief. Cord grip shall provide a watertight seal at enclosure interface and sized to accommodate the flexible cord.

2.08 CONDUCTOR NUMBERING

- A. Conductor Numbers:
 - 1. Identify conductors with numbers at both ends. Conductor tag numbers are the equipment number followed by a dash followed by the conductor number specified on the control diagram. Example:
 - a. Equipment Tag number = 1900 L1 where:
 - b. 1900 = cable number
 - c. L1 = conductor number
 - 2. Conductors in parallel or in series between equipment have the same conductor number. Neutral conductors s have the same conductor number. Wherever possible, the conductor number is the same as the equipment terminal to which it connects.
 - 3. Where factory-wired equipment has terminal numbers different than the conductor numbers shown on the control diagrams:
 - a. Show both on the interconnection diagram
 - b. Include a copy of the interconnection diagram inside of the equipment cabinet.

2.09 WIRE MARKERS

- A. Identify aach power and control conductor at each terminal to which it is connected. Provide identification sleeves for conductors size No. 10 AWG or smaller. Use locking tab type cable markers for conductors No. 8 AWG and larger. Provide white plastic tabs with conductor identification number permanently embossed.
- B. Identify conductors in accordance with paragraph 1.07 Conductor Numbers. Adhesive strips are not acceptable.

C. Machine print the letters and numbers that identify each wire on sleeves with permanent black ink with figures 1/8 inch high. Provide yellow or white tubing for sleeves sized to fit the conductor insulation. Shrink the sleeves with hot air after installation to fit the conductor.

2.10 TERMINAL BLOCKS

- A. Unless otherwise specified, terminal blocks shall be panhead strap screw type. Terminals shall be provided with integral marking strips that permanently identify with the connecting wire numbers as shown on the drawings:
 - 1. Terminal blocks for P-circuits (power 208-600 volts)
 - a. Rated not less than the conductor current rating
 - b. Rated less than 600 volts AC.
 - 2. Terminal blocks for C-circuits and S-circuits:
 - a. Rated not less than 20 amperes
 - b. Rated less than 600 volts AC.
 - 3. Terminals shall be tin-plated.
 - 4. Insulating material shall be nylon.

PART 3 EXECUTION

3.01 GENERAL

- A. Conductors shall be identified at each connection terminal, in pull boxes, manholes, handholes and at splice points. The identification marking system shall comply with Section 16000.
- B. Pulling wire and cable into conduit or trays shall be completed without damaging or putting undue stress on the insulation or jacket. Manufacture recommended and UL Listed pulling compounds are acceptable lubricants for pulling wire and cable. Grease is not acceptable.
- C. Raceway construction shall be complete, cleaned, and protected from the weather before cable is installed. Where wire or cable exits a raceway, a wire or cable support shall be provided.
- D. Provide tin-plated bus bar. Scratch-brush the contact areas and tin plate the connection where flat bus bar connections are made with un-plated bar. Bolts shall be torqued to the bus manufacturer's recommendations.

3.02 600 VOLT CONDUCTOR AND CABLE

- A. Conductors in panels and electrical equipment shall be bundled and laced at intervals not greater than 6 inches, spread into trees and connected to their respective terminals. Lacing shall be made up with plastic cable ties. Cable ties shall be tensioned and cut off by using a tool specifically designed for the purpose such as a Panduit GS2B. Other methods of cutting cable ties are unacceptable.
- B. Conductors crossing hinges shall be bundled into groups not exceeding 10 to 15 conductors and protected using nylon spiral flexible covers to protect conductors. Provide oversized plastic panel wiring duct within panels and panelboards.

- C. Slack shall be provided in junction and pull boxes, handholes and manholes. Slack shall be sufficient to allow cables or conductors to be routed along the walls. Amount of slack shall be equal to largest dimension of the enclosure. Provide dedicated electrical wireways and insulated cable holders mounted on unistrut in manholes and handholes.
- D. Raceway fill limitations shall be as defined by NEC and the following:
 - 1. Lighting and receptacle circuits may be in the same conduit in accordance with derating requirements of the NEC. Lighting and receptacle circuits shall not be in conduits with power or control conductors. Signal conductors shall be in separate conduits from power and control conductors. Motor feeder circuits shall be in separate conduits including small fan circuit unless combination fan-light fixture.
 - 2. Power conductors derived from uninterruptible power supply systems shall not be installed in raceways with conductors of other systems. Install in separate raceways.
 - 3. Slices and terminations are subject to inspection by the Construction Manager prior to and after insulating.
 - 4. Motor terminations at 460-volt motors shall be made by bolt-connecting the lugged connectors.
 - 5. In-line splices and tees, where approved by the Construction Manager, shall be made with tubular compression connectors and insulated as specified for motor terminations. Splices and tees in underground handholes or pull boxes shall be insulated using Scotch-cast epoxy resin or Raychem splicing kits.
 - 6. Terminations at solenoid valves, 120 volt motors, and other devices furnished with pigtail leads shall be made using self-insulating tubular compression connectors within the termination box.
 - 7. Terminations at valve and gate motor actuators shall be made directly into the actuator where possible. Power termination shall be made in the actuator power disconnect. Control and signal cable may be routed to a termination box near the actuator on 20-ampere rated terminal strips with label identification for the control and signal conductors. Single wire control conductors and analog cable (SIC or MIC) then installed in flexible conduit to the actuator control and signal termination compartments.
 - 8. Install and route multi-conductor as shown on the drawings. Submit installation and routing layouts of multi -conductor cables branching out to multiple field destinations to the Engineer for pre-approval. If approved, terminate on terminals in a terminal box located adjacent to the first field device served, or in the common junction boxlocated at the equipment as depicted on the motor feed standard detail Drawings. Make final connection to field devices with single conductors.

3.03 SIGNAL CABLE

- A. Provide terminal blocks at instrument cable junctions within dedicated terminal boxes provided by the installer. Signal circuits shall be run without splices between instruments, terminal boxes, or panels.
- B. Circuits shall not be made using conductors from different pairs or triads. Triads shall be used wherever 3-wire circuits are required.

- C. Shields are not acceptable as a signal path, except for circuits operating at radio frequencies utilizing coaxial cables. Common ground return conductors for two or more circuits are not acceptable.
- D. Unless otherewise specified, shields shall be bonded to the signal ground bus at the control panel only and isolated from ground at the field instrument or analyzer and at other locations. Shields or drain wires for spare circuits shall not be grounded at either end of the cable run. Terminals shall be provided for running signal leads and shield drain wires through junction boxes.
- E. Spare circuits and the shield drain wire shall be terminated on terminal blocks at both ends of the cable run and be electrically continuous through terminal boxes.
- F. Where instrument cable splicing is required, provide an instrument stand with terminal box rated for the area and environment and mounted approximately 3 feet above grade for instrument cable splices with the circuits and individual conductors provided with nameplate as specified in Section 16000.
- G. Cable for paging, security, voice communication, and telephone systems shall be installed and terminated in compliance with the manufacturers and the Utilities recommendations.

3.04 PORTABLE CORD

A. Portable power cords feeding permanent equipment, such as pendant cords feeding motors for pumps, cranes, hoists, and portable items shall have a wire mesh cord grip of flexible stainless steel wire to relieve the tension from the cable termination. Connection of portable cords to permanent wiring shall be accomplished with dedicated boxes and terminals blocks.

3.05 TESTING

A. The Contractor shall test conductors, wire, and cable in accordance with Section 16030.

3.06 CABLE SPECIFICATION SHEETS (CABLESPEC)

- A. General:
 - 1. Conductor, wire, and cable types for different locations, service conditions and raceway systems are specified on individual cable specification sheets. Scheduled and unscheduled conductors, wires, and cables shall be installed in accordance with the CABLESPEC Sheets.
- B. CABLESPEC Sheets:
 - 1. The following CABLESPEC sheets are included in this section:

Туре	Volt	Product	Purpose
SIC	600	P-OS: 1-PR#18 or 16SH or 1-TR#18 or 16SH	CABLE TRAY RATED INSTRUMENT CABLE
XHHW	600	XLP INSULATED INDUSTRIAL GRADE CONDUCTOR	POWER, CONTROL, LIGHTING, & RECEPTACLES
COAX	600	RADIO FREQUENCY CO-AXIAL CABLE	DATA COMMUNICATIONS
PV	600	PV CABLE	PV CABLE

3.07 CABLE SPECIFICATION SHEETS (CABLESPEC) - SIC

- A. Cable System Identification:
 - 1. SIC
- B. Description:
 - 1. Single twisted, shielded pair or triad, 18 or 16 AWG, instrumentation and signal cable; UL listed; Cable Tray rated
- C. Voltage:
 - 1. 600 volts
- D. Conductor Material: Bare annealed copper; stranded per ASTM B8
- E. Insulation:
 - 15 mil, Polyvinyl Chloride (PVC) with 4 mil nylon, 90 degree C temperature rated; Color Code per ICEA Method-1: Pairs-Black and White with one conductor in each pair printed alpha-numerically for identification
- F. Lay:
 - 1. Twisted on a 2-inch lay
- G. Shield:
 - 1. 100 percent, 1.35 mil aluminum-Mylar tape with a 7-strand tinned copper drain wire
- H. Jacket:
 - 1. 45 mil Polyvinyl Chloride (PVC)
- I. Flame Resistance:
 - 1. UL 1685
- J. Manufacturer(s):
 - 1. Okonite, Okoseal-N Type P-OS (Pair(s) Overall Shield) and Type TOS (Triad(s) Overall Shield); or Cooper Industries-Belden equal; or General Cable equal
- K. Execution:
 - 1. Use:
 - a. Analog signal cable and RTD device Triad extension cable.
 - 2. Installation:
 - a. Install in accordance with paragraph 3.03.
 - 3. Testing:
 - a. Test in accordance with paragraph 3.05.

3.08 CABLE SPECIFICATION SHEETS (CABLESPEC) – XHHW

- A. Cable System Identification:
 - 1. XHHW
- B. Description:
 - 1. Industrial grade single conductor
 - 2. Sizes: 14 AWG through 750 kcmil as shown
- C. Voltage:
 - 1. 600 volts
- D. Conductor Material:
 - 1. Bare annealed copper; stranded per ASTM B8
- E. Insulation:
 - 1. NEC Type XHHW-2; 90 degree C dry and C wet;
 - 2. Cross-Linked Polyethylene (XLP) per ANSI/NEMA WC70 ICEA S-95-658 and UL-44;
 - 3. Color in sizes 14, 12 and 10 AWG: Black, Green, Yellow, White, Orange, Brown, Red, Blue
- F. Jacket:
 - 1. None
- G. Flame Resistance:
 - 1. Not applicable
- H. Manufacturer(s):
 - 1. Okonite, X-Olene; Cablec, Durasheath XLP; or equal.
- I. Uses Permitted:
 - 1. Power, control, lighting and outlet circuits.
- J. Execution:
 - 1. Installation:
 - a. Install in accordance with paragraph 3.02.
 - 2. Testing:
 - a. Test in accordance with Section 16000-3.02 and Section 16030.

3.09 CABLE SPECIFICATION SHEETS (CABLESPEC) – COAX

- A. Cable System Identification:
 - 1. COAX
- B. Description:
 - 1. Premise Cable: Indoor Riser and Plenum with FRPE Jacket Outdoor /Watertight:

- a. Ductbanks Systems with PE Jacket Low Loss Flexible Communication Coaxial Cable
- C. Voltage:
 - 1. 300 V; Voltage Withstand: 3000 Volts DC;
- D. Conductor Material:
 - 1. Solid 18 AWG;
 - 2. Nominal Impedance: 50-ohm;
 - 3. Nominal Capacitance: 20 Pico-Farad per foot;
 - 4. Bend Radius: 2 inches
- E. Insulation Material:
 - 1. Foam Polyethylene (PE) or Tetrafluoroethylene (TFE) UL Flame Test:
 - a. NFPA-262 NEC Type Specification: CMP
- F. Jacket:
 - 1. Polyethylene (PE), Fire Retardant Polyethylene (FRPE) or Fluorinated Ethylene Propylene (FEP)
- G. Manufacturer(s):
 - 1. Times Microwave System: LMR-500;
 - 2. Belden Number 83242: 50-ohm Coax -- RG Type 142 B/U; or
 - 3. Engineer accepted equal.
- H. Execution:
 - 1. Applications:
 - a. Giga-Hertz Data Communications, CCTV Fixed.
 - b. Component or Composite Video, Digital Video
 - 2. Installation:
 - a. Install in accordance with associated equipment manufacturer's instruction. Provide male, female, TNC Male, UHF Male, straight, bulkhead, right-angle etc connectors, fittings, with crimp tools, dies, strip tools, deburr tools and cutting tools as required for the installation.
 - 3. Testing:
 - a. Test in accordance with paragraph 3.05.

3.10 CABLE SPECIFICATION SHEETS (CABLESPEC) - PV

- A. Cable System Identification:
 - 1. PV
- B. Description:
 - 1. Photovoltaic single conductor
 - 2. Sizes: 14 AWG through 4/0 AWG as shown
 - 3. UL 4703 Listed

C. Voltage:

- 1. 600 Volt
- D. Conductor Material:
 - 1. Bare annealed copper; stranded per ASTM B8
- E. Insulation:
 - 1. 105 degree C dry and 90 degree C wet;
 - 2. Cross-Linked Polyethylene (XLP) per ANSI/NEMA WC70 ICEA S-95-658 and UL-44;
 - 3. 600V rated
 - 4. Sunlight Resistant
 - 5. Oil & Gas Resistant Cat II
- F. Jacket:
 - 1. None
- G. Flame Resistance:
 - 1. FV-1 Flame Retardant
- H. Manufacturer(s):
 - 1. KrisTech PV Wire; or equal.
- I. Uses Permitted:
 - 1. Solar PV circuits.
- J. Execution:
 - 1. Installation:
 - a. Install in accordance with paragraph 3.02.
 - 2. Testing:
 - a. Test in accordance with Section 16000-3.02 and Section 16030.

END OF SECTION

This page intentionally left blank.

SECTION 16175

MISCELLANEOUS ELECTRICAL DEVICES

PART 1 GENERAL

1.01 DESCRIPTION

- A. The vendor, manufacturer, and custom control panels shall provide enclosures, selector switches, pushbuttons, indicators, terminal strips, surge devices, nameplates, testing procedures, wiring method, wiring color coding, wire labeling, separation between power, controls, and instruments, hardwired logic relays or PLC logic products as specified herein and in Section 17110.
- B. This section specifies electrical control and monitoring devices:
 - 1. Pushbuttons
 - 2. Selector Switches
 - 3. Indicating Lights
 - 4. Control Station Enclosures
 - 5. Horns
 - 6. Beacons
 - 7. Thermostats
 - 8. Elapsed Time indicators
- C. This section specifies Control Relays:
 - 1. Load-Switching
 - 2. Logic Level Switching
 - 3. Timers
 - 4. Time Switch
 - 5. Alternators
- D. This section specifies power devices:
 - 1. Overcurrent Protection:
 - a. Circuit breakers
 - b. Power Fuses
 - c. Control Fuses
 - 2. Current transformers and transducers
- E. This section specifies terminal strips, blocks, and devices.
- F. This section specifies specialty contactors:
 - 1. Intrusion Switches
 - 2. Override Key Switches
- G. Request clarification where conflicts occur with this section and other sections in Divisions 16 and 17.

1.02 REFERENCES

- A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
- B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid or on the effective date of the Agreement if there were no Bids.
- C. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.
- D. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
NEMA 250	Enclosures for Electrical Equipment (1000 volts maximum)
NEMA ICS-1	General Standards For Industrial Controls and Systems
NEMA ICS-2	Industrial Control Devices, Controllers, and Assemblies

1.03 SUBMITTALS

- A. The following submittals shall be provided in accordance with Section 01300 and Section 17110:
 - 1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
 - a. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.
 - b. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications.
 - c. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

- 2. Arrangement drawings of the panel enclosure indicating the front door and panel equipment arrangement and dimensions, and enclosure type.
- 3. Nameplate legend with engraving and sizes.
- 4. Internal layout drawings showing all components.
- 5. List of materials and components with the layout drawings.
- 6. Elementary / schematic diagrams.
- 7. Internal wiring connection diagrams.
- 8. External wiring interconnection diagrams including interlocks.
- 9. Power and control single line diagrams, where motor controllers are included.
- 10. Manufacturer's catalog data for all material provided under this section shall be assembled in a folder with each page clearly marked with the item model number and reference number to the specification.
- 11. Operation and maintenance data as specified in Section 01730 including approved submittal manufacturer's catalog data, as-built drawings, and instructions for all configurable or programmable components.

PART 2 PRODUCTS

2.01 CONTROL DEVICES

- A. Pushbuttons:
 - 1. Pushbuttons shall be flush head, heavy-duty, with NEMA rating to match enclosure type. Operators shall be green for start function, red for stop functions, and black for all other functions. The escutcheon legend shall be as specified on the drawings.
 - a. UL Listed.
 - b. Dielectric Strength: 1300 Volts for one minute for Logic Reed contacts, 2200 Volts for one minute for other contacts.
 - c. 30.5mm mounting hole.
 - d. Temperature operating range -10 degree C. to +55 degree C.
 - e. Momentary contact type.
 - f. When switching circuits are monitored by programmable controllers or other solid state circuits, furnish hermetically-sealed, logic-reed type contacts rated not less than 0.15 amperes at 150 Vac and 0.06 amperes at 30 Vdc.
 - g. When switching circuits are not monitored by programmable controllers or other solid state circuits, furnish contacts with NEMA Utilization Category rating A600 rated not less than 10 amperes continuous and 6 amperes break at 120 Vac.
 - 2. Manufacturer: Allen-Bradley 800T/800H series or equal.
- B. Selector Switches:
 - 1. Selector switches shall be heavy-duty with NEMA rating to match enclosure type. Selector switches shall have maintained position contacts. Switches shall be provided with contact blocks and number of positions as required performing the specified or indicated operations.
 - 2. The escutcheon legend shall be as specified on the drawings. Provide:
 - a. UL Listed.

- b. Dielectric Strength: 1300 Volts for one minute for Logic Reed contacts, 2200 Volts for one minute for other contacts.
- c. 30.5mm mounting hole.
- d. Temperature operating range -10 degree C. to +55 degree C.
- e. Standard knob operator (not lever type nor wing lever type).
- f. Number of positions and contact configuration as shown on Drawings.
- g. When switching circuits are monitored by programmable controllers or other solid state circuits, furnish hermetically-sealed, logic-reed type contacts rated not less than 0.15 amperes at 150 Vac and 0.06 amperes at 30 Vdc.
- h. When switching circuits are not monitored by programmable controllers or other solid state circuits, furnish contacts with NEMA Utilization Category rating A600 rated not less than 10 amperes continuous and 6 amperes break at 120 Vac.
- 3. Manufacturer: Allen-Bradley 800T/800H series or equal.
- C. Indicating Lights:
 - 1. Red, amber, green, and blue indicating lights shall be heavy-duty full voltage 120Vac or 24Vdc push-to-test LED type with NEMA rating to match enclosure type for installation in a 30.5mm hole. Furnish with 28 chip high visibility LED. The escutcheon and lens color shall be as shown on Drawings or scheduled.
 - 2. White indicating lights shall be as above, incandescent type lamp.
 - 3. Manufacturer:
 - a. Allen-Bradley 800H-QRTH10 series or equal for 120Vac applications with colors other than white.
 - b. Allen-Bradley 800HQRTH24 series or equal for 24Vdc applications with colors other than white.
 - c. Allen-Bradley 800H-QRT10 series or equal for 120Vac applications with white.
 - d. Allen-Bradley 800H-QRT24 series or equal for 24Vdc applications with white.
 - 4. Indicating Light Lens Color:

Lens Color	Typical Function	Example
Red	Danger, running, open	Equipment operating, motor running, valve open, power voltage applied, cycle in automatic
Amber	Fault condition, attention	Equipment failure, status abnormal
Green	Off, closed, ready	End of cycle; unit or head returned; motors stopped; motion stopped; contactors open, valve closed
White or Clear	Normal condition	Normal pressure of air, water, lubrication, control power on, status okay
Blue	Advisory	Control mode not in automatic

- D. Control Station Enclosures:
 - 1. Enclosures locations and ratings:
 - a. Indoors conditioned space: NEMA 12.
 - b. Outdoors, process and Corrosive areas: NEMA 4X
 - c. NEC 500 Hazardous Areas: NEMA-7.

- E. Horns:
 - 1. The horn shall be a surface mount 120-volt AC enclosed buzzer and shall be Federal Signal Model 350WB (NEMA 4X); Model 31X (NEMA 7) or equal.
 - 2. Each horn located standalone shall include a 6 x 10 inch Red with white letter lamacoid nameplate with the specific warning such as the following:
 - a. DANGER GAS.
 - b. VENTILATION SYSTEM FAILURE.
 - c. As needed for each application.
- F. Beacons:
 - 1. The alarm beacon shall be a 75-watt sealed-beam lamp with motor driven rotating reflector; Beacon shall be for 120-volt AC service and shall be Federal Signal Model 191XL or equal.
 - 2. Each beacon located standalone shall include a 6 x 10 inch Red with white letter lamacoid nameplate with the specific warning such as the following:
 - a. DANGER GAS.
 - b. VENTILATION SYSTEM FAILURE.
 - c. As needed for each application.
- G. Thermostats:
 - 1. Thermostats shall be line voltage type with motor current rated contact and 70-degree to 140-degree Fahrenheit setpoint range.
 - a. Manufacturer: Honeywell T631A-1022 or equal.
- H. Elapsed Time Indicators:
 - 1. Elapsed time indicators shall be panel mounted, non-resettable, 5.5-digit, hour indicator, rated 120Vac, 60-Hertz.
 - a. Manufacturer: Trumeter 722-series or equal.

2.02 CONTROL RELAYS

- A. Load-Switching Control Relays:
 - 1. Control relays used for switching loads such as solenoids, actuators, contactors, motor starter coils, remote interlocking, etc. shall be heavy-duty machine tool type.
 - 2. Contacts shall be 4-pole and be field interchangeable to either normally-open or normally- closed. Relay shall be capable of accepting a 4-pole adder.
 - AC relays shall have NEMA A600 contact ratings and electrical clearances for 600 volts. DC relays shall have NEMA P300 contact ratings and electrical clearances for 250 volts.
 - 4. Manufacturer:
 - a. Allen Bradley Bulletin-700.
 - b. Square D Class 8501.
 - c. or equal.

- B. Logic Level Switching Control Relays:
 - 1. Control relays for signal circuits shall have a minimum of three SPDT, gold-flashed, fine silver contacts rated 10-ampere resistive at 120V AC or 28Vdc.
 - 2. Control relays shall be plug-in type with heavy-duty, barrier-protected screw terminal sockets and clear polycarbonate dust cover with clip fastener.
 - 3. AC models shall have neon lamp indicator wired in parallel with coil. DC models shall have LED lamp indicator wired in parallel with coil.
 - 4. Manufacturer: Potter Brumfield series KUP; IDEC Series RH; or equal.
- C. Timers:
 - 1. Multi-function, micro-controller based, socket mounted timing relay.
 - 2. Single functions:
 - a. Delay on Make.
 - b. Delay on Break.
 - c. Recycle (on time first, equal recycle delays).
 - d. Single shot.
 - e. Interval.
 - f. Trailing edge single shot.
 - g. Inverted single shot.
 - h. Inverted delay on break.
 - i. Accumulative delay on make.
 - j. Re-triggerable single shot.
 - 3. Dual functions:
 - a. Delay on make/delay on break.
 - b. Delay on make/recycle (on time first, equal recycle delays.)
 - c. Delay on make/interval.
 - d. Delay on make/single shot.
 - e. Interval/recycle (on time first, equal recycle delays).
 - f. Delay on break/recycle (on time first, equal recycle delays).
 - g. Single shot/recycle (on time first, equal recycle delays).
 - h. Recycle both times adjustable (on time first).
 - i. Recycle both times adjustable (off time first).
 - j. Interval/delay on make.
 - k. Accumulative delay on make/interval.
 - 4. Time delay range, switch selectable:
 - a. Single function 0.1 second to 1,705 hours in 8 ranges.
 - b. Dual function 0.1 second to 3,100 minutes in 8 ranges.
 - c. Setting accuracy +/- 1 percent or 50 milliseconds, whichever is greater.
 - d. Repeat accuracy +/- 0.1 percent or 16 milliseconds, whichever is greater.

- 5. Output:
 - a. Two Form-C electromechanical isolated contacts rated 10-amperes resistive at 240Vac.
 - b. Rated 1/3-horsepower at 120 or 240Vac.
 - c. Double-pole double-throw: DPDT.
 - d. Mechanical life: 10,000,000 operations.
- 6. Electrical life: 1,000,000 operations at full load.
 - a. Mounting: Magnal Plug 11-pin socket.
- 7. Environment: -20 to +65 degree C.
- 8. Manufacturer:
 - a. ABB / SSAC's multifunction type TRDU time delay relay with dip-switch function setting with 12Vdc, 24Vac, 120Vac, 240Vac inputs as required or indicated or equal.
- D. Alternating Relay:
 - 1. Alternate assignment between "Duty" and "Stand-by" at the end of each run cycle.
 - 2. Double-pole, double-throw output relay rated for 7-amps inductive at 120-volts AC. Isolation not less than 1,500-volt RMS input to output. Life of 1,000,000 operations at full electrical load.
 - 3. Switch to select alteration or continuous operation of either load.
 - 4. Mount in Magnal 11-pin socket.
 - 5. Operating temperature range of -20 to +60-degree C.
 - 6. Manufacturer:
 - a. ABB-SSAC type ARP series.
 - b. or Engineer accepted substitute.

2.03 POWER DEVICES OVERCURRENT PROTECTION

- A. Overcurrent Protection:
 - 1. CIRCUIT BREAKERS: Circuit breakers shall be thermal magnetic, molded case type with the ampere rating as specified. Unless otherwise specified or indicated, circuit breaker interrupting rating shall be 22,000 amperes symmetrical.
 - POWER FUSES: Provide Class R fuses and fuse holders where required for proper protection of equipment. Fuse clips shall be Class R rejection type and sized for UL Class R, one-time, time-delay fuses. Fuse assembly shall have a minimum short circuit capacity of 100,000 amps symmetrical. Provide fuses as shown and one set of spare fuses with each switch.
 - 3. CONTROL FUSES: Fuses for 120 Vac circuits shall have a minimum of 12,000amperes interrupting capacity and blown fuse indicators. Fuses for 24 Vdc circuits shall be fast acting glass tube type rated 1/8 or 1/10 amp for 4-20 mA loops. Fuses for 24 Vdc circuits shall be 1/2 amp for the power supply to individual instruments. Fuse holders shall be tip-out or draw-out type.
- B. Current Transformers And Transducers:
 - 1. Provide monitoring current transformers with 600Vac insulation and primary ampere rating as indicated with 5-ampere output.

- 2. Provide AC current transducer for any one of the phase conductors of the power circuit to be installed through onboard toroid. Provide a loop-powered transducer with input rated from 0 to 50 ampere with 4-20madc analog output scaled for the primary current of the current transformer. Provide zero and span adjustments.
- 3. Provide a DIN rail or back plate mounted AC current transducer that is a looppowered transducer with input rated from 0 to 5-ampere and with 4-20madc analog output scaled for the primary current of the current transformer.
- 4. Manufacturer:
 - a. ABB AC current transducer DCSA Series Loop Powered and mounting accessories, or equal.
 - b. ABB AC current transducer TCSA Series Loop Powered and mounting accessories, or equal.

2.04 TERMINAL STRIPS, BLOCKS, AND DEVICES

- A. Power Wiring: Provide back plate mounted terminal strips rated at 600 Vac.
- B. Control Wiring: Provide a DIN rail with spring powered contact rated at 300 Vac 24 ampere with pluggable terminals.
- C. Terminal identification standard to the product provided.
- D. Manufacturer:
 - 1. Standard: Allen Bradley or equal.
 - 2. Standard: DIN rail: Phoenix Contact or Weidmuller Z-Series.

2.05 SPECIALTY CONTACTORS

- A. Intrusion Device:
 - 1. The intrusion switch shall be wide-gap industrial grade magnetic door switch with maximum gap 2.5 inches between the sensing elements. The magnet element shall be mounted on the moving part of the door. The sensor switch shall close when the door is closed. The sensor switch shall open when the door is opened. Provide with appropriate mounting bracket for the entrance doors.
 - 2. Manufacturer:
 - a. George Risk Industries Series 4400.
 - b. or equal.
- B. Load Shedding Contactor
 - 1. The load shedding contactor shall comply with NEMA ICS and NEMA rated for the load specified.
 - 2. Manufacturer:
 - a. ABB
 - b. GE
 - c. Eaton Cutler Hammer
 - d. Siemens
 - e. Square D

f. Or Equal

2.06 NAMEPLATES

A. Nameplates for all control stations, relays, timers, and motor contactors shall be provided in accordance with the requirements of Section 16000.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Control stations shall be mounted 48 inches above the floor, ground, or slab to center of device.
- B. Devices shall be tested in accordance with Section 16000 and Section 16030.

END OF SECTION

This page intentionally left blank.

SECTION 16450

GROUNDING SYSTEM

PART 1 GENERAL

1.01 DESCRIPTION

- A. This section specifies the system for grounding electrical distribution and utilization equipment, including but not limited to cabinets, motor frames, manholes, instrumentation, metal surfaces of process/mechanical equipment that contain energized electrical components, metal structures and buildings, outdoor metal enclosures, fences and gates.
- B. The Equipment Grounding Conductor shall ground or bond equipment, structures, or equipment frames to the Grounding Electrode System as defined in the National Electrical Code Article 250 and addressed herein.
- C. The minimum size of the Equipment Grounding Conductors installed with the circuit conductors shall be per the National Electrical Code Table 250.122. The circuit grounding conductor size routed with a feeder or branch circuit conductors is as shown on the drawings.

1.02 REFERENCES:

- A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
- B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
IEEE 81	Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE Std 81.2-1991	Guide to Measurement of Impedance and Safety Characteristics of Large, Extended or Interconnected Grounding Systems
NETA - ATS	InterNational Electrical Testing Association Inc Acceptance Testing Specifications
NFPA 70	National Electric Code (NEC) Article 250

1.03 SUBMITTALS:

- A. The following information shall be submitted for review in accordance with Section 01300:
- B. Product Literature:
 - 1. Marked product literature for ground rods, test wells, and equipment ground plate.

PART 2 PRODUCTS

2.01 GROUND CONDUCTORS

- A. The System Ground Conductor shall be soft-drawn, bare annealed copper, concentric stranded, as specified. The minimum sizes shall be as follows, where American Wire Gage (AWG) conductor sizes are not shown or specified:
 - 1. Lighting & Power panels 2 AWG
 - 2. Exposed metal cabinets 2 AWG
 - 3. Electrical equipment 2 AWG
 - 4. Buildings and enclosure 2 AWG
 - 5. Fences and gates 2 AWG

2.02 GROUND RODS

A. Ground rods shall be copper covered steel, 3/4-inch diameter and 10-feet long. Rods shall have threaded type removable caps so that extension rods of same diameter and length may be added where necessary.

2.03 COMPRESSION CONNECTORS

A. Compression connections shall be irreversible, cast copper as manufactured by Thomas and Betts, or equal.

2.04 BOLTED CONNECTORS

A. Bolted connectors shall be Burndy, O. Z. Gedney, or equal.

2.05 WELDED CONNECTORS

A. Exothermic welding products shall be Erico's Cadweld Plus system with a remotely operated battery powered electronic ignition device and moisture resistant weld metal cup for the required mold, or equal.

2.06 TEST WELLS

A. Provide concrete test well with cover and connect the ground grid extension using a removable connector.

2.07 EQUIPMENT GROUND BARS

A. Copper equipment ground bars shall be Erico Eritech EGB Series or equal, sized as required for the installation.

2.08 GROUND ELECTRODE GROUNDING BARS

- A. Ground electrode grounding bars shall be 1/4-inch thick copper electro-tin plating, Erico Eritech EGBA Series CC Pattern, Burndy Type BBB or equal. Minimum length shall be 12 inches.
- B. Insulators (Stand Off) material shall be halogen-free, fiberglass-reinforced thermal set unsaturated polyester molded compound with indoor rating of 600 volts.
- C. Brackets shall be 1/8-inch thick, Type 304 stainless steel.
- D. Fasteners shall be 3/8-inch Type 304 stainless steel.

2.09 EQUIPMENT GROUND PLATE

A. Equipment ground plate shall be two-hole copper flush mounted grounding plate, Erico Cadweld, Burndy YGF Series, or equal.

2.10 PRODUCT DATA

A. Ground resistance readings shall be provided.

PART 3 EXECUTION

3.01 GENERAL

- A. Grounding system shall be provided in compliance with the NFPA 70 National Electrical Code (NEC). Grounding conductor shall not be used as a system neutral.
- B. Embedded and buried ground connections shall be made by compression connectors utilizing diamond or hexagon dies and a hand compression tool for wire sizes 2 AWG and smaller and a hydraulic pump and compression head for wire sizes 2/0 AWG and larger. Alternate method allowed: exothermic welding using a remote igniter device.
- C. Tools and dies shall be approved for this purpose; dimple compressions are not acceptable. Compression connections shall be prepared in accordance with the manufacturer's instructions. Compression-type lugs shall be used in accordance with manufacturer's recommendations. Exposed ground connections to equipment shall be made by bolted clamps unless otherwise specified. No solder material shall be used in any part of the ground circuits.
- D. Embedded ground conductors and fittings shall be securely attached to concrete reinforcing steel with tie wires and prevented from displacement during concrete placement.
- E. Notify the Construction Manager two hours prior to backfilling, as each part of the grounding system installed below finished grade is complete and ready for inspection. Non-compliance shall affect the payment schedule for this work.
- F. Grounding conductors extended beyond concrete surfaces for equipment connection shall be extended a sufficient length to reach the final connection point without splicing.

Provide grounding fittings, pads, or plates as shown in the electrical details. Minimum grounding conductor extension shall be 3-feet.

- G. Grounding conductors which project from a concrete surface shall be located as close as possible to a corner of the equipment pad, protected by rigid conduit bonded to the grounding conductors, or terminated in a flush grounding plate.
- H. Exposed grounding conductors shall be supported by noncorrosive metallic hardware at 4-foot intervals or less. Grounding conductors for shown and future equipment shall be terminated using an equipment grounding plate.
- I. Ground conductors entering electrical enclosures shall be bonded to a single ground bus or terminal strip in the enclosure and to metallic raceways within or terminating at the enclosure. Direct ground connections to enclosure chassis or back plate are not acceptable. Prior to making ground connections or bonds, the metal surface at the point of connection shall be cleaned.
- J. Lightning arresters shall be directly connected to the ground grid system using lightning industry braided copper conductors, sized as specified.
- K. Metallic sheaths or shields of shielded power cable shall be terminated by a copper ground bus provided with cable connection for connection to the grounding system.

3.02 RACEWAY GROUND

- A. All service, feeder and branch circuit raceways shall contain a green insulated ground conductor sized per applicable NFPA 70 National Electrical Code (NEC) tables:
 - 1. T250.66 Grounding Electrode Conductor for Alternating Current Systems or
 - 2. T250.122 Minimum Size Equipment Grounding Conductors for Grounding Raceways and Equipment.
- B. Metallic conduits terminating at concentric knock-outs or reducing washers shall be bonded using insulated grounding bushings. Grounding bushings shall be connected to the grounding system using conductors sized in compliance with NEC.
- C. Cable trays shall have 2/0 or 4/0 bare copper ground conductor run on the outside of each tray or tray group of tiered cable tray. Conductor shall be connected to each section or fitting using an approved ground-clamp and supported at 5 foot intervals.

3.03 EQUIPMENT AND ENCLOSURE BONDING

- A. Electrical distribution and utilization equipment enclosure ground bus, motor frames, manholes, metal structures and buildings, outdoor metal enclosures, fences and gates shall be bonded to the grounding system with conductor sizes as specified.
- B. Connect the conductor to the metal enclosure using a UL listed connector, where the enclosure does not contain an internal ground bus
- C. Non-electrical equipment with metallic enclosures, that are located outdoors and without a cover or a shade, shall be connected to the grounding system.

3.04 ISOLATED GROUNDING

- A. An isolated ground system shall be installed where required by an equipment manufacturer. The isolated ground conductor shall have green insulation with a yellow stripe and shall be run in the same raceway as the power and neutral conductors. The isolated ground bus shall be kept isolated from neutral and grounding buses.
- B. Where specifically directed by the Engineer and required by an equipment manufacturer, the Contractor shall provide an additional isolated ground conductor from the service or separately derived system to an isolated ground bus bar at each associated distribution point.

3.05 SERVICE AND SEPARATELY DERIVED SYSTEM BONDING

A. A neutral bonding jumper shall be installed in only one location for each service or separately derived system. The bonding jumper shall be located at the service source or the first immediate distribution point downstream from the source. The neutral and ground buses shall be kept isolated from each other accept where the bonding jumper is installed.

3.06 GROUNDING SYSTEM TESTS

- A. The Contractor shall test the facility grounding system and the building grounding system to determine the ground resistance. The grounding test shall be IEEE Standard 81 using the NETA Fall-of-Potential procedure. A plot of ground resistance readings for each isolated ground rod, ground mat, or ground bus shall be submitted on 8-1/2 x 11 inch size graph paper. Point-to-point resistance measurements are not acceptable.
- B. The current reference rod shall be driven at least 100 feet from the ground rod or grid under test or as recommended by IEEE Standard 81. The measurements shall be made at 10-foot intervals beginning 25 feet from the test electrode and ending 75 feet from it, in direct line between the ground rod or center of grid and the current reference electrode.
- C. A grounding system that shows greater than 2 ohm resistance for the flat portion of the plotted data shall be considered inadequately grounded.
- D. The Contractor shall add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurements meet the 2 ohm requirement. Additional ground rods will be paid for as extra work where the required numbers exceed that specified when authorized and approved by the Construction Manager.
- E. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

END OF SECTION

This page intentionally left blank.

SECTION 16470

LIGHTING AND POWER DISTRIBUTION PANELBOARDS

PART 1 GENERAL

1.01 DESCRIPTION

A. 240/120V, dead front, circuit breaker type panelboard with current rating of 600amperes or less.

1.02 REFERENCES

- A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
- B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
IEEE	Institute of Electrical and Electronic Engineers
NEMA	National Electrical Manufacturing Association
NFPA 70	National Electrical Code (NEC)
UL 50	Cabinets and Boxes
UL 67	Underwriters Laboratories, Electric Panelboards
UL 489	Molded-Case Circuit Breakers and Circuit Breaker Enclosures
UL 1449	Surge Suppression Devices

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. The Owner and Construction Manager believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section. Candidate manufacturers include:
 - 1. Eaton / Cutler-Hammer:

- a. PRL1a and PRL3a
- 2. General Electric:
 - a. AQ and AD
- 3. Siemens:
 - a. S1, SE, and S3
- 4. Square D:
 - a. NQOD and NF
- 5. or equal

2.02 ARRANGEMENT AND CONSTRUCTION

- A. The front of the panel shall have concealed trim clamps and hinges. The locks shall be flush with cylinder tumbler-type with spring loaded door pulls. The fronts shall not be removable with doors in the locked position. Panelboard locks shall be keyed alike.
- B. Gutter space shall be provided on all sides of the breaker assembly to neatly connect and arrange incoming wiring.
- C. Panelboard shall be composed of individually mounted circuit breakers designed to be removable without disturbing other breakers.
- D. A directory holder with clear plastic plate and metal frame shall be mounted on the inside of the door.
- E. Panelboards shall have a NEMA 4 rating.

2.03 BUS

- A. Bus shall be tin-plated copper and shall have current ratings as shown on the panelboard schedules, sized in accordance with UL 67. Ratings shall be determined by temperature rise test.
- B. The minimum bus size shall be 100 amperes. Panel fault withstand rating shall be not less than the interrupting rating of the smallest circuit breaker in the panel. Series rating is prohibited.
- C. Panelboards shall be provided with a separate ground bus and, where specified, with a full capacity neutral bus. The neutral bus shall be mounted on insulated stand-offs.

2.04 CIRCUIT BREAKERS

- A. Circuit breakers shall be molded-case type provided for the current ratings and pole configurations specified on the panelboard schedule. Circuit breakers shall be bolt-on type. Circuit breakers shall be listed in accordance with UL 489 for the service specified. Load terminals of circuit breakers shall be solderless connectors.
- B. Circuit breakers rated 120/208 volt and 120/240 volt alternating current shall have a minimum interrupting current rating of 18,000 amperes symmetrical at 240 volt AC.

- C. Circuit breakers rated 277/480 volt alternating current shall have a minimum interrupting current rating of 25,000 amperes symmetrical at 480 volt or as specified on the panelboard schedule.
- D. Provide circuit breakers with special features such as ground fault interrupting (GFI), heating air conditioning and refrigeration (HACR) rating, or locking capability as shown on the Drawings or Schedules.

2.05 FINISH

A. Panelboard cabinet shall be fabricated from hot-dip galvanized steel in accordance with UL 50. Panelboard fronts shall have a gray, baked enamel finish.

2.06 NAMEPLATES

A. Nameplates shall be provided in accordance with the requirements of Section 16000.

2.07 PRODUCT DATA

- A. The following information shall be provided in accordance with Section 01300:
 - 1. Manufacturer's certification that bus bracing is capable of withstanding the specified short circuit condition.
 - 2. Operation and maintenance information as specified in Section 01730.
 - 3. Quantity and rating of circuit breakers provided with each panelboard.

PART 3 EXECUTION

3.01 GENERAL

- A. The Contractor shall type in the circuit description on the circuit directory as shown on the final record drawings or panelboard schedule.
- B. Provide "Circuit Directory and Circuit Identification" in accordance with NEC 408.4. Each circuit shall be of sufficient detail to allow each circuit to be distinguished from other circuits. Circuit identification shall include load location and provide equipment or instrument Tag Number and Tag Description, where shown on the drawings.

3.02 TESTING

A. Panelboards shall be tested for proper operation and function.

END OF SECTION

This page intentionally left blank.

SECTION 16617

PV BATTERY SYSTEM

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies the PV battery system that consists of a battery system, solar battery charger and inverter system, and pv array system.

1.02 SUBMITTALS

- A. The following information shall be provided in accordance with Section 01300:
 - 1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
 - A check mark (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.
 - 3. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
 - 4. Manufacturer's catalog information.
 - 5. System design drawings including single line diagrams.
 - 6. Interconnection diagrams.
 - 7. Layout drawing indicating arrangement, dimensions, and weights.
 - 8. Manufacturer's data indicating ratings.
 - 9. Mounting system structural drawings and calculations
- B. Action Submittals
 - 1. Quality Assurance (within 30 days of contract Notice to Proceed):
 - a. PV System Designer qualifications
 - b. Project personnel qualifications.

1.03 RELATED SECTIONS:

- A. Section 16000 General Requirements For Electrical Work
- B. Section 16030 Electrical Acceptance Testing
- C. Section 16110 Raceways, Boxes, And Supports
- D. Section 16120 600V Conductors, Wire, and Cable

- E. Section 16175 Miscellaneous Electrical Devices
- F. Section 16450 Grounding System

1.04 QUALITY ASSURANCE

- A. All work covered in this section shall be the responsibility of a single PV System Designer as defined within this article.
- B. The PV System Installer shall be responsible for the complete design and installation of the PV battery system as shown on the drawings and specified in this section.
- C. Provide calculations for the PV array system which indicate the following:
 - 1. Maximum Open-Circuit Voltage at minimum temperature
 - 2. Maximum Power Point (MPP) Voltage
 - 3. Short-Circuit Current
 - 4. Total Array Size (kWdc)
 - 5. Expected Annual energy yield (kWh)
- D. Demonstrate the overall system performance to the Owner for acceptance.
- E. PV System Designer qualifications:
 - 1. Evidence of Experience—Company specializing in the products and work of this section and related sections:
 - a. Minimum of 5 years of documented experience with the equipment specified as well as overall systems responsibility for systems of similar size and complexity.
 - Experience in performing five similar successful projects (equipment type, complexity, and dollar value of work performed by PV System Installer) in the last 5 years. At least one project currently in progress or completed within the last 2 years.
 - c. End-user satisfaction of projects in the past 3 to 5 years based on end-user interviews by the Owner or Engineer. Submit project descriptions of projects completed within the past 5 years with contact names, addresses, and telephone numbers from the project Owner, General Contractor, and Principal Design Firm.
 - d. Financial resources available and projected for successful completion of this project. Submit financial data for PV System Installer when subsidiary to a parent corporation. Include 2 years of financial data:
 - 1) Financial statement.
 - 2) Balance sheet.
- F. PV System Designer Personnel Qualifications: Provide qualified personnel to complete the work specified for this project. Demonstrate by including the following:
 - 1. Organization chart and resumes for proposed project personnel showing experience for the proposed roles on this project.
 - 2. Training and certification information. Completion of the following training courses or appropriate portions thereof or possession of the following certifications included with the PV System Installer's personnel experience requirements described above:
 - a. Project Manager: NABCEP PV Installation Professional (PVIP) Certification
PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. The Owner and Construction Manager believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section. Candidate manufacturers include:
 - 1. Battery System:
 - a. Simpliphi (LFP)
 - b. EnerSys (Ni-Cad)
 - c. ALCAD (Ni-Cad)
 - d. Approved Equal
 - 2. Solar Battery Charger and Inverter System
 - a. Sol-Ark
 - b. Schneider Electric
 - c. Approved Equal

2.02 BATTERY SYSTEM

- A. General:
 - 1. The stationary battery system shall be comprised of lithium ferro phosphate (LFP) or nickel-cadmium (Ni-Cad) type batteries connected in series. The individual cells shall be housed in a molded polypropylene case.
- B. The manufacturer shall size the capacity of the battery system in accordance with the following:
 - 1. System voltage:
 - a. Nominal: 48 Vdc
 - 2. Minimum ambient temperature: 0 degrees C
 - 3. Maximum ambient temperature: 50 degrees C
 - 4. Minimum Total Capacity: 45 kWh @ C100 (100 Hour Rate) & 80% Depth of Discharge
 - 5. Temperature Range:
 - a. Operating Temperature: 0C 50C
 - 6. UL 1973 Listed
- C. Warranty:
 - 1. The battery system shall have a 10 year full replacement warranty.
 - a. If the original warranty is reduced due to environmental operating conditions (temperature), provide an extended warranty to meet this requirement.
- D. Manufacturer:
 - 1. Simpliphi Ampliphi 3.5 (LFP)
 - 2. ALCAD PV Series (Ni-Cad)

- 3. EnerSys RL Series (Ni-Cad)
- 4. Or Equal
- E. Enclosure:
 - 1. The battery system shall be housed in a lockable NEMA 3R enclosure with vents and two 24Vdc powered fans. Fans shall be adequately sized to keep the enclosure environment within 3 degrees of ambient temperature.
 - 2. The batteries shall be mounted on stainless steel or fiberglass shelves.

2.03 SOLAR BATTERY CHARGER AND INVERTER SYSTEM

- A. General:
 - 1. The solar battery charger and inverter system shall be a complete pre-assembled package consisting of a solar battery charge controller, battery inverter, AC distribution assembly, DC distribution assembly, battery monitor, system display, and network switch. The assembly shall be UL9540 listed.
- B. Solar Battery Charge Controller:
 - 1. Maximum power point tracking (MPPT) type
 - 2. Maximum current rating 100Adc.
 - 3. Nominal battery voltage of 48 Vdc
 - 4. Capable of bulk, absorption, and float charging modes with programmable setpoint and durations
 - 5. Battery temperature compensation.
 - 6. UL1741 Listed
 - 7. Manufacturer:
 - a. Sol-Ark 12K-2P (LFP)
 - b. Schneider Electric, MPPT 100 600 (LFP or NiCad)
 - c. Or equal
- C. Battery Inverter:
 - 1. AC input voltage: 120/240V, 60 Hz.
 - 2. AC output voltage: 120/240V, 60 Hz
 - 3. Nominal DC Input Voltage: 48 Vdc.
 - 4. Maximum battery charging current: 200A.
 - 5. Continuous AC power: 6000 VA at 25 degrees C.
 - 6. Minimum Efficiency: 96% (CEC)
 - 7. UL1741 listed.
 - 8. Manufacturer:
 - a. Sol-Ark 12K-2P (LFP)
 - b. Schneider XW Pro (LFP or NiCad)
 - c. Or equal
- D. Accessories:
 - 1. Integrated battery and inverter overcurrent protection.

- 2. AC distribution assembly
- 3. DC distribution assembly
- 4. System Display
 - a. Capable of configuration, monitoring, and data logging
 - b. CAT6 network port.
 - c. Communication Protocol: Modbus TCP or Modbus Sunspec
- E. Enclosure
 - 1. The solar battery charger and inverter system shall be housed in a lockable NEMA 3R vented enclosure.

2.04 PV ARRAY SYSTEM

- A. A PV array shall be included to connect to the solar battery charge controller and charge the battery system during periods of grid outages. The array shall be mounted to the electrical shade structure.
- B. The PV array shall consist of multiple PV modules and shall be sized in accordance with the following:
 - 1. Maximum Array Open Circuit Voltage (Voc) at 18 deg F: 300 Vdc
 - 2. Minimum Total Array Size: 6 kW at Standard Test Conditions (STC)
- C. The PV modules shall be selected in accordance with the following:
 - 1. UL listed
 - 2. Frame: Anodized Aluminum Alloy
 - 3. Cell Type: Mono- or Poly-Crystalline, monofacial
 - 4. Operating Temperature: -40C to 85C.
 - 5. Rated maximum system voltage: 1000Vdc or 1500Vdc
 - 6. Warranty: 10 year product warranty, 25 year linear power performance warranty
- D. Mounting System:
 - 1. Electrical Shade Structure:
 - a. PV modules mounted to the electrical shade structure shall utilize the following mounting system:
 - 1) UL2703 listed
 - 2) Aluminum clamps and rails.
 - 3) Stainless steel hardware
 - 4) ASCE 7-16 rated.
 - 5) Provide bonding jumpers between mounting rails.
 - 6) Provide hardware to securely bond PV module frame to mounting system.
 - 7) Capable of attachment to standing seam metal roofs without penetration.
 - 8) Provide #8 bare copper equipment ground wire from mounting system to electrical grounding system.
 - 9) Manufacturer: Iron Ridge, or Equal

- b. The mounting system shall be stamped by a civil or structural engineer licensed in the state of California.
- E. PV Combiner Box
 - 1. The PV Combiner Box shall have the following features:
 - a. NEMA 3R Enclosure with tinted Flame-Retardant Deadfront Panel
 - b. Wall or Roof Mountable
 - c. Output Terminals Two Sets (Positive and Negative) which can accommodate $2/0 \mbox{ AWG}$ wire
 - d. Fused Inputs Minimum Four Sets (Positive and Negative) 600V Rated
- F. Bird Barrier
 - 1. The contractor shall install a bird barrier along the outside of the PV array to prevent birds and other animals from nesting under them.
 - 2. The netting shall be clipped to the underside of the PV modules at every 18 inches and extend down to the metal roof.
 - 3. Manufacturer: Bird Barrier SP-EX, or Equal

2.05 PRODUCT DATA

A. Operation and maintenance information as specified in Section 01730 shall be provided in accordance with Section 01300.

PART 3 EXECUTION

3.01 INSTALLATION

- A. General:
 - 1. Install equipment in locations that are accessible for operation and maintenance services.
 - 2. Installation, calibration, settings, and testing procedures are specified in this section, section 16030 and subsequent sections of Divisions 16 and 17.
- B. Field Equipment:
 - 1. Space instruments and cabinets from concrete walls by 5/8 inch with framing channel between instrument or cabinet and wall. Add supports to block wall to avoid damage to the wall.
 - 2. Design support systems, including panels, in accordance with Section 01900 to prevent deformation greater than 1/8 inch in any direction under the attached equipment load and under an external load of 200 pounds.
 - 3. In wet or outdoor areas, make conduit penetrations into instrument housing or panels through the bottom (preferred) or side of enclosures to minimize water entry from around or from inside of conduits. Provide conduit hubs for connections and waterproof mastic for moisture sealant.
 - 4. Provide nameplates for field-mounted equipment. Attach nameplates in a readily visible location, but such that if the field device is replaced, the nameplate will remain to identify the service.

3.02 TESTING

A. The battery system shall be given a full charge after installation. Each cell voltage shall be measured and recorded on the maintenance form provided by the manufacturer. The float, bulk, and absorption charging voltage setpoints shall also be recorded.

3.03 WARRANTY

A. The PV System Installer shall repair or replace defects in material or workmanship during the first 12 months after the PV battery system has been installed.

END OF SECTION

This page intentionally left blank.

SECTION 17000

GENERAL REQUIREMENTS FOR INSTRUMENTATION AND CONTROL

PART 1 GENERAL

1.01 SUMMARY

- A. This section specifies general requirements applicable to Division 17 of these specifications for the process control, instrumentation, communication, network, and signal systems. This work will be referenced as the Process and Instrumentation Control System (PICS) to be provided by a single Systems Integrator (SI) meeting the qualifications section of this specification.
- B. System overview. Detailed requirements are in individual related specification sections.
 - 1. Field Instrumentation:
 - a. New field instruments.
 - 2. Process Control Hardware:
 - a. Control panels with programmable logic controllers (PLC) and operator interface stations (OIS)
 - 3. Process Control Software, Programming, and Integration:
 - a. PLC and OIS programming
 - b. SCADA screen development and programming
 - 1) Inductive Automation Ignition software platform
 - 2) Coordinate all SCADA screen development with District
 - c. Integration with existing SCADA system.
 - 4. Communications and Networking
 - a. Radio and cellular communications systems
 - b. Integration with existing radio system

1.02 RELATED SECTIONS:

- A. The requirements of this section are applicable to work specified in Division 17 of these specifications.
- B. Section 17200 Schedules for Instrumentation of Process Systems.

1.03 REFERENCES

- A. Reference Standards:
 - 1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.
 - 2. Unless otherwise specified, references to documents mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids).

- 3. If referenced documents have been discontinued by the issuing organization, references to those documents mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.
- 4. Where document dates are given in the following listing, references to those documents mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

Reference	Title	
IEEE 100	Standard Dictionary of Electrical and Electronics Terms	
ISA 5.4	Instrument Loop Diagrams	
ISA 20	Specification Forms for Process Measurement and Control Instrumentation, Primary Elements, and Control Valves	
ISA 51.1	Process Instrumentation Terminology	
ISA TR20.00.01	Specification Forms for Process Measurement and Control Instruments Part 1: General Considerations	
NEMA ICS 1	General Standards for Industrial Control and Systems	

1.04 DEFINITIONS

- A. Abbreviations:
 - 1. dBm: decibel-milliwatts
 - 2. DCS: distributed control system
 - 3. DCU: distributed control unit, or digital control unit.
 - 4. HIM: human interface module
 - 5. HMI: human-machine interface
 - 6. OIS: operator interface station
 - 7. PCS: plant control system
 - 8. PICS: Process and Instrumentation Control System
 - 9. PLC: programmable logic controller
 - 10. RTU: remote terminal unit
 - 11. SCADA: supervisory control and data acquisition
 - 12. SI: Systems Integrator
- B. Definitions General:
 - General: Definitions of terminology related to Instrumentation and Industrial Electronic Systems used in the specifications as defined in IEEE 100, ISA 51.1, and NEMA ICS 1.
 - 2. Data sheets: Data sheets refer to ISA 20 or ISA TR20.00.01, as referenced within ISA-20-1981 specification.
 - 3. Two-wire transmitter: A transducer that derives operating power supply from the signal transmission circuit and requires no separate power supply connections. A two-wire transmitter produces a 4- to 20-milliampere current regulated signal in a series circuit with a 24-volt direct current (VDC) driving potential and a maximum circuit resistance of 600 ohms.

- 4. Four-wire transmitter: A transducer that derives operating power from separate power supply connections. A four-wire transmitter produces a 4- to 20-milliampere current regulated signal in a series circuit with a maximum circuit resistance of 600 ohms. Four-wire transmitters typically require 120-volt alternating current (VAC) or 24VDC input power supply.
- 5. Galvanic isolation: An electrical node having no direct current path to another electrical node. Galvanic isolation refers to a device with electrical inputs and/or outputs that are isolated from ground, the device case, the process fluid, and separate power supply terminals. Inputs and/or outputs may be externally grounded without affecting the characteristics of the devices or providing a path for circulation of ground currents.
- 6. Panel: An instrument support system that may be a flat surface, partial enclosure, or complete enclosure for instruments and other devices used in process control systems including consoles, cabinets, and racks. Panels provide mechanical protection, electrical isolation, and environmental protection from dust, dirt, moisture, and chemical contaminants that may be present in the atmosphere.
- 7. Systems Integrator: A firm engaged in the business of detailed control system design and engineering, instrumentation component purchase, system and panel assembly, control device programming, and implementing of the specified process control and industrial automation systems.
- C. Definitions–Signal Types:
 - 1. Analog, low level: Signal with full output level of 100 millivolts or less including thermocouples and resistance temperature detectors.
 - 2. Analog, high level: Signals with full output level greater than 100 millivolts but less than 30 volts, including 4 to 20 mA transmission.
 - 3. Audio signals, high level: Audio signals exceeding plus 4 dBm, including loudspeaker circuits.
 - 4. Digital code: Coded information from the output of an analog-to-digital converter or digital transmission terminal.
 - 5. Discrete control or events: Dry contact closures and signals monitored by solid-state equipment, relays, or control circuits.
 - 6. Discrete control or events, low voltage: Dry contact closures and signals monitored by solid-state equipment, relays, or control circuits operating at less than 30 volts and 250 milliamperes.
 - 7. Modulated signals: Signals from modems or low-level audio signals. Normal signal level: plus 4 dBm to minus 22 dBm. Frequency range is 300 to 10,000 hertz.
 - 8. Pulse frequency: Counting pulses emitted from speed or flow transmitters.
 - 9. Radio frequency (RF) signals: Continuous wave alternating current signals with fundamental frequency greater in a range of 310 kilohertz to 300 gigahertz.
- D. Definition—Drawing Types:
 - 1. Elementary or schematic diagram:
 - a. Use graphic symbols to indicate the electrical connections and functions of a specific circuit arrangement. The schematic diagram facilitates tracing of the circuit and its functions without regard to the actual physical size, shape, or location of the component devices or parts.

- b. Indicate connections to internal and external components connected to the panel. Note which devices are external to the panel.
- c. Depicted in ladder logic format.
- d. Indicates contact arrangement of internal and external devices such that circuits are complete and match equipment furnished.
- e. Indicates equipment designations/tag numbers to match contract drawings and P&IDs.
- 2. Block diagram: A diagram of a system, instrument, computer, or program in which selected portions are represented by annotated boxes and interconnecting lines.
- 3. Network block diagram:
 - a. A diagram of the overall control system, containing annotated boxes showing the primary network components (controllers, hubs, routers, switches, computers, displays).
 - b. Include annotated interconnecting lines showing the system communication media and communication protocols.
 - c. Indicate manufacturer and model of the primary network components and software.
 - d. Indicates functions performed by each device (e.g., Historical Data Server, Field controller, Database Server, Operator workstation, etc.)
- 4. Connection diagram:
 - a. Purpose is to show wiring requirements between internal panel components.
 - b. Show components of a control panel in an arrangement similar to the actual panel layout.
 - c. Indicate internal wiring between components.
 - d. Show terminal blocks used for internal wiring and field wiring, with identification as such.
 - e. Indicate insulation color code, signal polarities, wire numbers, and terminal block numbers.
- 5. Interconnection diagram:
 - a. Purpose is to show wiring requirements between panels, standalone devices, components, and instruments.
 - b. Indicate wire numbers, cable numbers, raceway numbers, terminal box numbers, terminal block numbers, panel numbers, and field device tag numbers.
 - c. Show external connections between terminals of equipment and outside points, such as motors and auxiliary devices.
 - d. Indicate references to connection diagrams that interface to the interconnection diagrams.
 - e. Interconnection diagrams are to be of the continuous line type. Show bundled wires as a single line with the direction of entry/exit of the individual wires clearly shown. Wireless diagrams and wire lists are not acceptable.
 - f. Show termination of each cable. Clearly mark each termination point. Show each wire's identification as actually installed. The wire identification for each end of the same wire shall be identical. Identify devices and equipment.
 - g. Depict terminal blocks as actually installed and identified in the equipment with individual terminal identification.
 - h. Indicate external jumpers, shielding, and grounding terminations.

- i. Indicate polarities for signal and DC circuit.
- j. Depict spare wires and cables installed or slated for installation.
- 6. Arrangement, layout, or outline drawings:
 - a. Show the physical space and mounting requirements of a piece of equipment.
 - b. Indicate ventilation requirements and space provided for connections or the location to which connections are to be made.
 - c. Indicate clearance requirements for ventilation and access.
 - d. Show the dimensioned external and interior control panel views with components and Bill of Material.
- 7. Loop diagrams:
 - a. Prepared per ISA 5.4.
 - b. Show device element wiring of the system. Indicate device terminations, with terminal numbers.
 - c. Show circuits for hardwired device interlocks.
 - d. Show circuit cable and wire cable numbers, signal polarities, and terminal block numbers.
 - e. Show connection to power supplies. Include alternating current (AC) and direct current (DC) power supplies and circuit information for instruments furnished under this contract.
 - f. Indicate controller or I/O card address/node, rack, slot, and point wiring terminals.
 - g. Show power supplies for signal loops. Indicate in which panel components reside and power originates with circuit numbering/name. Where new/modified loops connect to an existing power supply, show the existing power supply name, location, and circuit.
 - h. Indicate surge protection type, manufacturer, and model number (i.e., types include floating ground reference or grounded reference).
 - i. Show new and modified terminal blocks with numbering in new and existing panels.
 - j. Indicate signal loop grounding terminations.
 - k. Indicate loop numbers, wire numbers, and cable numbers used in field wiring and panel wiring.
 - I. Indicate field element being controlled or monitored (i.e., normally open contact from relay CR17, or FIT 365).

1.05 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the process and instrumentation control system for proper operation with related equipment and systems specified in other Divisions.
 - 2. Integrate equipment in conformance with the drawings, specifications, and recommendations of the equipment manufacturer and the related processes equipment manufacturers.
 - 3. Obtain manufacturer's technical information for items of equipment not provided with, but connected to, the control system. Provide the necessary coordination and components for correct signal interfaces between equipment and the control system.

- 4. Coordinate interface requirements and schedule with other project subcontractors and equipment suppliers.
- 5. Present to the Construction Manager conflicts between the plans, specifications, manufacturer/vendor drawings, and installation instructions, etc. for resolution before proceeding.

1.06 SUBMITTALS

- A. General:
 - 1. Procedures: Section 01300.
 - 2. This article indicates general requirements applicable to all PICS submittals. Additional information to be submitted with each section will be listed under Action Submittals or Closeout Submittals in this and each related section.
 - a. Submit all information for sections covered by a submittal as a complete package in one submittal. Partial submittals of a section from multiple vendors showing contractor's division of equipment, labor, or portions of the work are not acceptable.
 - b. Include a table of contents in each submittal divided by specification section and content of each section such as drawings and components. Clearly indicate the article or paragraph to which each table of content item applies.
 - c. Related sections indicate additional detail for each submittal.
 - d. Bookmark PDF submittals to match the table of contents of each submittal. Submitted information is to conform to the following:
 - e. Shop Drawings: Prepare drawings in AutoCAD with borders and title blocks identifying the project, system, revisions to the drawing, and type of drawing. Include a date and description for each revision of a drawing including the date and description of the revisions. Drawing prints shall be 11" by 17" with a minimum lettering size of 1/8".
 - f. Product Literature: Provide manufacturer's specifications, data sheets, and catalog literature for the equipment and components that clearly and unambiguously show what is being provided and that it meets the requirements specified. Indicate provided and available options, materials of construction, environmental characteristics, electrical characteristics, and connection requirements. Include only applicable information.
 - g. Conformance with Contract Documents:
 - 1) Provide a copy of sections applicable to the submittal group with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
 - 2) Check-marks (✓) denote full compliance with a paragraph as a whole. Underline deviations and denote them with a number in the margin to the right of the identified paragraph. Paragraph portions not underlined signify specification compliance. Include a detailed, written justification for each deviation. Show conformance with all paragraphs in a section. Failure to include a copy of the marked-up specification sections and justification(s) for requested deviations is cause for rejection of the entire submittal with no further consideration.

- 3) Mark a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, mark the drawing or drawings "no changes required." Failure to include copies of the relevant drawings with the submittal is cause for rejection of the entire submittal with no further review. Contract drawings would include the following:
 - a) Network system block diagrams
 - b) Cabinet and panel arrangement drawings
 - c) Control single-line diagrams
 - d) Process and instrumentation diagrams
 - e) Loop diagrams
- 4) Show conformance across suppliers and vendors in one submittal. Partial submittals from multiple vendors showing contractor's division of labor or portions of the work are not acceptable.
- 5) Provide a detailed written request and explanation for each deviation. Failure to include a copy of the marked-up specification sections and drawings, along with justification(s) for requested deviations to the contract requirements, with the submittal, is cause for rejection of the entire submittal with no further consideration.
- B. Closeout submittal general requirements.
 - 1. Procedures: Section 01730.
 - 2. Provide record drawing prints of drawings and schedules following project startup, but prior to acceptance of the work, showing the final constructed state of the process instrumentation and control systems.
 - 3. Include the following in each operation and maintenance manual:
 - a. Final reviewed submittals, including revised as-built record drawings.
 - b. Manufacturer's operation and maintenance instructions, edited for this project.
 - c. Written record of menu configuration, jumpers, switch settings, and other configurable parameters for each instrument.
 - d. Final application software configurations, in the software native format. Include a comprehensive report print-out from each controller CPU in full color. Provide in Adobe PDF format.
 - e. Final network equipment software configurations.
 - 4. Markup of existing O&M documentation that show modifications to existing panels, communications, and loops/wiring.
 - 5. Maintenance Material Submittals
 - a. Provide one listing of spare parts that is divided by specification section.
 - b. Include list prices for spare parts, expendable supplies, and tools.
 - c. Indicate spare parts packaging and storage methods.
 - d. Indicate spare parts or components that could be deleted or reduced based on manufacturer's recommendations.
 - e. Indicate where manufacturer's recommendations exceed the spare parts specified.

- f. Obtain spare parts from the equipment manufacturer. Do not provide third-party equivalent replacements.
- g. Packaging, Testing, and Storage:
 - 1) Provide protective toolboxes for special tools.
 - 2) Test spare boards, circuit cards, power supplies, and similar spare electronic assemblies on site prior to acceptance.
 - 3) Carefully repackage operable parts. Immediately remove inoperable parts from the site and order replacement parts. Test replacement parts prior to acceptance.
 - 4) Package spare parts for protection against dirt and moisture. Label each package as to its contents with a description and part number.
 - 5) Do not place spare parts for different equipment items in the same package.
- C. Action Submittals
 - 1. Quality Assurance (within 30 days of contract Notice to Proceed):
 - a. Systems Integrator qualifications
 - b. Project personnel qualifications.
 - 2. Interconnection Diagrams per paragraph 1.02.
 - a. Between all System Integrator furnished equipment and all other connected equipment. Include terminal numbers for all other connected equipment.
- D. Closeout Submittals
 - 1. Provide record drawing prints of drawings and schedules following project startup, but prior to acceptance of the work, showing the final constructed state of the process instrumentation and control systems.

1.07 QUALITY ASSURANCE

- A. All work covered by Division 17 shall be the responsibility of a single Systems Integrator as defined within this article.
- B. The instrumentation and control system functions are shown on the drawings and specified in subsequent sections of Division 17. The Systems Integrator drawings and integration practices shall be as defined in IEEE 100, ISA 51.1, and NEMA ICS 1.
- C. Demonstrate the overall system performance to the Owner for acceptance.
- D. Systems Integrator qualifications:
 - 1. The following Systems Integrators are pre-qualified to perform the work specified in Division 17 without the need to provide Evidence of Experience:
 - a. Tesco Controls
 - 2. Evidence of Experience–Company specializing in the products and work of this section and related sections:
 - a. Minimum of 3 years of documented experience with the equipment specified as well as overall systems responsibility for systems of similar size and complexity.
 - b. Experience in performing three similar successful projects (equipment type, software type, Systems Integrator responsibilities, complexity, and dollar value of

work performed by Systems Integrator) in the last 5 years. At least one project currently in progress or completed within the last 2 years.

- c. End-user satisfaction of projects in the past 3 to 5 years based on end-user interviews by the Owner or Engineer. Submit project descriptions of projects completed within the past 5 years with contact names, addresses, and telephone numbers from the project Owner, General Contractor, and Principal Design Firm.
- d. Panel fabrication and staging facilities adequate to provide services for this project. Demonstrate by including the following:
 - 1) Minimum 10,000 square feet of dedicated space for panel fabrication and testing.
 - Panel shop shall be UL 508 recognized to produce panels to UL 508 and UL 698 standards and labeling.
- e. Financial resources available and projected for successful completion of this project. Submit financial data for Systems Integrator division when subsidiary to a parent corporation. Include 2 years of financial data:
 - 1) Financial statement.
 - 2) Balance sheet.
 - 3) Dun & Bradstreet Report.
- E. Systems Integrator Personnel Qualifications: Provide qualified personnel to complete the work specified for this project. Demonstrate by including the following:
 - 1. Organization chart and resumes for proposed project personnel showing experience for the proposed roles on this project.
 - 2. Training and certification information. Completion of the following training courses or appropriate portions thereof or possession of the following certifications included with the Systems Integrator's personnel experience requirements described above:
 - a. Project manager: Control System Engineer (CSE) registration, Professional Engineer (PE) registration, or Project Management Professional (PMP) certification.
 - b. Systems engineer: Control System Engineer (CSE) registration, Professional Engineer (PE) registration, or completion of the relevant core courses in the Engineering Skills Training program as certified by ISA.
 - c. Programmer: Certified by the software/hardware manufacturer for the software and hardware being used on the project, or Control System Engineer (CSE), or Professional Engineer (PE) registration.
 - d. Field instrument technician: Certified Control Systems Technician (CCST) registration or completion of the relevant core courses in the Technical Skills Training program as certified by ISA.

1.08 ENVIRONMENTAL CONDITIONS

- A. Ambient conditions: Per Division 16.
- B. Corrosive locations: Per Division 16.
- C. Seismic:
 - 1. Brace equipment and supports per Section 01900.

PART 2 PRODUCTS

2.01 EQUIPMENT/MATERIALS

- A. General requirements:
 - 1. New.
 - 2. Free from defects.
 - 3. Rated for the installed environment.
- B. Similar control system components, instrument, instrument accessory, and devices used throughout the work shall be manufactured by one firm, where possible.
- C. The components, modules, devices, and control system equipment shall be recognized industrial-quality products. Recognized commercial- or office-grade products are prohibited.
- D. Use electronic equipment of solid-state construction with printed or etched circuit boards of glass epoxy of sufficient thickness to prevent warping.

2.02 ENCLOSURES

A. Table A specifies the instrument and control panel enclosure material and minimum NEMA rating for the location and application where not identified in other specification sections.

TABLE A

Location	Enclosure Material and NEMA Rating
Outdoor: corrosive area	NEMA 4X: 316 stainless steel
Outdoor: non-corrosive areas	NEMA 4X: 316 stainless steel

2.03 NAMEPLATES

- A. Provide nameplates for field-mounted instrument, analyzer, or equipment covered by this section with the following requirements:
 - 1. Include the equipment or instrument loop title and the instrument or equipment tag number, where nameplate engraving is not specified or shown.
 - 2. white phenolic with black 5/32-inch-high lettering, as minimum, unless otherwise specified or shown.
- B. Nameplate wording may be changed without additional cost or time, if changes are made prior to commencement of engraving.
- C. Attach nameplates to support hardware with a minimum of two self-tapping type 316 stainless steel screws in a readily visible location so the nameplate will remain to identify the service when the device is removed. Attach field instrument nameplates with braided stainless steel straps where not stand-mounted.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify field measurements prior to fabrication.

3.02 INSTALLATION

- A. General:
 - 1. Install equipment in locations that are accessible for operation and maintenance services.
 - 2. Installation, calibration, settings, and testing procedures are specified in Section 17000, Section 17200, and subsequent sections of Divisions 16 and 17.
- B. Field Equipment:
 - 1. Space instruments and cabinets from concrete walls by 5/8 inch with framing channel between instrument or cabinet and wall. Add supports to block wall to avoid damage to the wall.
 - 2. Design support systems, including panels, in accordance with Section 01900 to prevent deformation greater than 1/8 inch in any direction under the attached equipment load and under an external load of 200 pounds.
 - 3. In wet or outdoor areas, make conduit penetrations into instrument housing or panels through the bottom (preferred) or side of enclosures to minimize water entry from around or from inside of conduits. Provide conduit hubs for connections and waterproof mastic for moisture sealant.
 - 4. Provide nameplates for field-mounted equipment. Attach nameplates in a readily visible location, but such that if the field device is replaced, the nameplate will remain to identify the service.

3.03 FIELD QUALITY CONTROL

- A. Delivery Inspection:
 - 1. Notify the Owner's Representative upon arrival of material or equipment to be incorporated into the work. Remove protective covers or otherwise provide access in order that the Owner's Representative may inspect such items.
- B. Inspection and Installed Tests:
 - 1. Refer to Section 17030.

3.04 CLEANING

- A. Execute final cleaning prior to final project assessment.
- B. Clean surfaces exposed to view, remove temporary labels, stains, and foreign substances.
- C. Replace filters of operating equipment.
- D. Remove waste and surplus materials, rubbish, and construction facilities from site.

END OF SECTION

SECTION 17030

PROCESS INSTRUMENTATION AND CONTROL TESTING

PART 1 GENERAL

1.01 SUMMARY

- A. This section specifies testing requirements applicable to Division 17 of these specifications for the process control, instrumentation, communication, network, and signal systems. This work will be referenced as the Process and Instrumentation Control System (PICS) to be provided by a PICS Testing Manager meeting the Qualifications section of this specification. Section includes:
 - 1. Testing documentation.
 - 2. Testing organization and sequencing.
 - 3. Factory Acceptance Testing (FAT)
 - 4. Performance testing.
 - 5. Loop testing.
 - 6. Functional testing.
 - 7. Operational testing.
- B. Related sections:
 - 1. Section 17200 Instrument Index
 - 2. Section 17000 General Requirements for Instrumentation And Control
 - 3. Section 17900 Process Control Descriptions

1.02 REFERENCES

- A. Definitions:
 - 1. The term "instrumentation" covers field and panel instruments, analyzers, primary sensing elements, transmitters, power supplies, and monitoring devices.
- B. Reference Standards:
 - 1. This section contains references to the following documents with additional references listed in Section 17000.
 - a. References are part of this section as specified and modified. In case of conflict between the requirements of this section and those of the referenced documents, the requirements of this section prevail.
 - b. Version: Latest documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no bids) unless noted otherwise.
 - c. If referenced documents have been discontinued by the issuing organization, use the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.
 - d. Where document dates are given in the following listing, reference to those documents means the specific document version associated with that date,

whether the document has been superseded by a version with a later date, discontinued, or replaced.

Reference	Title
ISA RP7.1	Pneumatic Control Circuit Pressure Test
ISA S51.1	Process Instrumentation Terminology

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate testing with Section 01660.
 - 2. Provide notice to the Construction Manager prior to conducting a test.
 - 3. Provide a detailed step-by-step test procedure, between 60 and 70 days before the commencement of testing activity, complete with forms for the recording of test results, testing equipment used, and a place for identification of the individuals performing and witnessing the test.
 - 4. Provide detail assistance to the Contractor in generating Section 01660-Form A, customized for this project. Submit detailed form prior to testing per the requirements of Section 01660.
 - 5. Equipment and System Performance and Operational Testing: Section 01660 specifies testing of the mechanical, electrical, instrumentation, and HVAC systems. Coordinate, manage, and supervise the work with the quality assurance program including:
 - a. Testing plan with the sequence for the test work.
 - b. Calibration program for instruments and analyzers.
 - c. Documentation program that records tests results.
 - d. Performance testing program systems.

1.04 SUBMITTALS

- A. Procedures: Section 01300.
- B. Action Submittals:
 - 1. Quality Assurance submittal:
 - a. PICS Testing Manager Qualifications.
 - b. Testing Technician Qualifications.
 - 2. Testing submittal:
 - a. Submit detailed testing plan and proposed testing documentation after review of the Quality Assurance submittal showing conformance with Part 2 of this specification. Obtain approved submittal prior to testing:
 - 1) Control descriptions.
 - 2) Input/Output (I/O) interface.
 - 3) Testing status spreadsheets.
 - 4) Test procedures.
 - 5) Proposed test forms per this section, detailed for each test for this project.

- 6) List of Certified Factory Calibration Reports for flow and temperature transmitters.
- 3. FAT:
 - a. FAT schedule and location.
 - b. FAT procedures and test forms.
- C. Closeout Submittals
 - 1. Final Test Report assembled in a three-ring binder and submitted at the completion of the inspection and testing activities for a process area.
 - a. Label the binder cover and spine to identify the project name and process area. Include in the test report the applicable test procedures for the process area and the completed inspection and test report forms associated with the equipment and systems of that area.
 - b. Organize test results by equipment item or system with individual, labeled tab dividers to identify each. The responsible testing entity is to acknowledge system deficiencies and noncompliant test results identified in the final test report as corrected.
 - c. Documentation of network data communication nodes for network-type instruments, devices, and variable-frequency drives.
 - d. Test equipment and test equipment calibration date.
 - e. Certified factory calibration reports for flow and temperature transmitters.
 - f. Performance test results.
 - g. Loop test results.
 - h. Functional test results.
 - i. Operational test results.

1.05 QUALITY ASSURANCE

- A. Appoint a startup engineer or qualified specialist as PICS Testing Manager to manage, coordinate, and supervise the testing work.
- B. The quality assurance program includes:
 - 1. Definition of process areas and systems, with testing executed on an area-by-area basis, based on the P&ID drawings.
 - 2. Testing for each process area executed in sequential tasks.
 - 3. Regularly updated testing status tracking by process area, system, and task.
 - 4. Regularly updated separate testing documentation for each process system.
- C. PICS Testing Manager Qualifications:
 - 1. The PICS Testing Manager shall have at least 5 years of total experience, or experience on at least five separate projects, in managing the testing and startup of similar electrical and instrumentation control systems.
- D. Testing Technician Qualifications:
 - 1. Employ technicians who are qualified by completion and certification from training courses offered by the International Society of Automation (ISA), the instrumentation

and analyzer manufacturer's training courses, or technician training courses at a recognized trade school that specializes in instrumentation calibration.

PART 2 PRODUCTS

2.01 GENERAL

- A. Test forms: Conform to the requirements of Reference Forms 17000-A through 17000-K included in Section 01999. Develop additional or detailed forms as necessary to suit complex instrumentation. Use terms on test forms that comply with ISA S51.1.
- B. Project Labeling:
 - 1. The items specifying project labeling herein include the following as a minimum: Owner's name, facility name, project name, and project number.

2.02 TESTING DOCUMENTATION

- A. Documentation Records:
 - 1. Develop a record-keeping system to document progress and completion for each task in each process area or system. Coordinate overall organization of areas and systems with overall testing required by Section 01660, Equipment and System Performance and Operational Testing.
 - 2. Always keep documentation current and available for inspection on site in a location designated by the Construction Manager:
 - a. PICS Testing Manager's qualifications, project startup, and testing history, including resume per paragraph 1.02 PICS Testing Manager.
 - b. List of names of Contractor's and System Integrator's personnel associated with final construction and testing, and normal and emergency contact telephone numbers
 - c. Testing Status spreadsheet with breakdown for each process area and process system, with percentage complete on each testing sequence task.
 - d. Testing status specific to pre-loop test and loop testing status spreadsheet to include the I/O list organized by area and system and loop number. Percent complete of the PICS system will be based on percentage of I/O points tested.
 - e. Test Report Volumes.
- B. Test Report Volumes:
 - 1. Develop and maintain testing documentation for each process area or system in separate volumes. Always keep each volume current and available for inspection on site in a location designated by the Construction Manager. Include the following as a minimum:
 - a. Three-ring binder with front cover and spine labeled: "Testing Documentation for Process System including project labeling.
 - b. Table of Contents with same labeling as the volume cover with tabs for each section:
 - c. Section 1: Control Description
 - d. Section 2: I/O Interface
 - e. Section 3: Instrument Index

- f. Section 4: Test Procedures and Forms
- g. Section 5: Certified Factory Calibration Reports
- h. Section 6: Test Report
- C. Control Description:
 - 1. Provide a control description outlining operation for each process area's system. The Control Description Specification Section 17900 may be used as a basis.
- D. I/O Interface:
 - 1. Provide I/O spreadsheets for each process area's system. Spreadsheets are to include the following for each I/O point:
 - a. Signal number/tag.
 - b. Annotation description that may be logically abbreviated and that is subject to approval.
 - c. Complete physical I/O channel designation and addressing or communication I/O register designation.
 - d. True/false status designations for digital I/O.
 - e. Process range; engineering units and multipliers; and raw signal range count for analog I/O.
 - f. Signals: Fixed point and scaled at the controller with minimum four significant implied digits of scaling; e.g., 0 to 1,400 at controller for a pH range of 0 to 14 at operator interface.
 - g. Provide operator interface scaling to display decimal digits required.
 - h. Indicate pass/fail for each point for both pre-loop test and loop tests.
 - i. Indicate date of tests and comment for failed points.
- E. Instrument Index:
 - 1. Provide a detailed Instrument Index. The Instrument Index from Section 17200 may be used as a basis. Indicate actual calibration ranges, set points, and deadbands.
- F. Field Test Procedure Documentation:
 - 1. Organize and assemble test procedures for each analog and discrete loop in the process control system in separate volumes for each process area or test group. Organize by I/O point. Submit final test records in electronic form by scanning and converting the records and files to Adobe PDF format, to preserve actual signatures and signoffs.
 - 2. Include a detailed, step-by-step description of the required test procedure, panel and terminal block numbers for points of measurement, input test values, expected resultant values, test equipment required, process setup requirements, and safety precautions.
 - 3. Include test report forms for each loop, including forms for wiring, piping, and individual component tests, with the test procedure documentation. Record the actual test results on these forms and assemble them into final test reports.
 - 4. Preprint and populate information in the test report forms to the extent possible prior to commencing testing.
 - 5. Include on the test report forms:
 - a. Project name.

- b. Process area associated with the equipment under test.
- c. Instrument loop description.
- d. Instrument loop identification number.
- e. Instrument nameplate data.
- f. Instrument setup and configuration parameters.
- g. Time and date of test.
- h. Inspection checklist and results.
- i. Reference to applicable test procedure.
- j. Expected and actual test results for each test point in the loop including programmable controller data table or register values.
- k. Test equipment used.
- I. Space for remarks regarding test procedure or results, observations, etc.
- m. Name, date, and signature of testing personnel.
- n. Test witness's name and signature.

2.03 SOURCE QUALITY CONTROL

- A. Factory Acceptance Test (FAT):
 - 1. Provide a FAT with the test and subsequent retests witnessed by the Construction Manager and Owner.
 - 2. Load software and configuration for control system panels, controllers, network components, operator interfaces, servers, and the programming and graphic configuration application at the control system equipment supplier's factory prior to the FAT.
 - 3. Inspect equipment, panel instruments, panels, or cabinets with factory testing performed.
 - 4. Provide written notice to the Construction Manager 30 working days before the commencement of the FAT activity and include:
 - a. Schedule for the FAT.
 - b. Location of the FAT.
 - c. Testing equipment used.
 - d. Detailed test procedure with forms for the recording of test results.
 - e. Sign-off spaces for the individuals performing and witnessing the tests.
 - 5. Network and interwire equipment and panels as applicable. Operate and check out equipment prior to the FAT. Submit certification indicating that the panels are ready for the FAT. Include the following:
 - a. Visual inspection of equipment, instruments, control panels, and graphic displays.
 - b. Validation of each input loop and output loop by simulated signals for analog inputs and by shorting discrete inputs.
 - c. Validation includes:
 - 1) Monitoring state changes on operator interface screens based on the inputs state change.
 - 2) Observation of online controller programming application software with the associated outputs state change.

- 3) Outputs triggered by operator interface software devices (pushbuttons, sliders, manually entered values, etc.)
- 4) Calibration and operation of instruments on or in the control panels.
- d. Repair of loops that do not pass validation.
- e. Retest of the FAT at no additional cost.

PART 3 EXECUTION

3.01 GENERAL

- A. General Requirements:
 - 1. Provide the labor, tools, material, power, and services necessary to provide the process instrumentation and control system inspection and testing specified herein.
 - 2. Inspect materials, equipment, and construction included under this specification in accordance with this section and subsequent sections of this division. Perform testing in accordance with this and subsequent sections of this division.
 - 3. Have a certified instrument technician qualified to calibrate the instrumentation calibrate and set up field instruments and analyzers.
- B. Test Equipment and Materials:
 - 1. Provide test equipment to conduct the specified tests that simulate inputs and read outputs with a rated accuracy at the point of measurement at least three times greater than the component under test.
 - 2. Provide a calibration sticker on test instruments showing date of calibration, deviation from standard, name of calibration laboratory and technician, and date recalibration is required. Include certified calibration reports traceable to the National Institute of Standards and Technology with the final test report.
 - 3. Provide a documenting calibration system to conduct process instrumentation calibration activities that consist of a documenting process calibrator and an instrumentation data management software system that captures the calibration results and electronically document instrument data, date of calibration, calibration procedures, and as-found and as-left instrument calibration data.
 - 4. Provide an instrument calibration system such as Fluke 743B with Fluke DPC/Track Instrumentation Management software or similar system. Submit calibration files with the final test report in hard-copy and electronic formats that does not require specialized equipment or software to read and print the files.
 - 5. Provide buffer solutions and reference fluids for tests of analytical equipment.
 - 6. Provide a communications and software package to record final configuration parameters and settings for variable-frequency drives with the parameters acquired by connection to the network that record the configuration settings without manual data entry or transcription of values.
 - 7. Vendor software tools may document the systems where a licensed copy of the identical software including connectors, cables, keys, interface cards, and devices required for operation is submitted with the final documentation files.
- C. Performance Deviation Tolerances:
 - 1. Tolerances are specified in individual sections. Where tolerances are not specified, refer to the manufacturer's published performance specifications.

- 2. Calculate overall accuracy requirements for loops consisting of two or more components, by the root-summation-square (RSS) of the component accuracy specifications. Calculate and record tolerances for each required calibration point on the associated test report form.
- D. Witnessing:
 - 1. The Owner reserves the right to observe factory and field instrumentation testing and calibration procedures. Notify the owner prior to testing, as specified herein.

3.02 TESTING SEQUENCE

- A. Perform tests for each area or system in the following sequence:
 - 1. Performance testing
 - 2. Loop testing
 - 3. Functional testing
 - 4. Operational testing
- B. Group equipment and I/O based on the relationship of the equipment to operate safely as specified, including full automatic and manual control and monitoring through the control system. Equipment and I/O in a given area or system shall pass testing prior to proceeding to the next set of tests in the sequence above.

3.03 PERFORMANCE TESTING

- A. Perform tests in the order below.
- B. Wiring Tests:
 - 1. Verify that electrical power and signal cable ring-out and resistance testing has been performed as specified in Sections 16000 and 16030. Conduct wiring tests after cables have been properly terminated, tagged, and inspected.
 - a. Power and Control: Section 16030.
 - b. Signal: Section 17000-Form A.
 - 2. Pre-Active Testing: Inspect and test cables prior to energizing to verify the following:
 - a. Media type and specifications.
 - b. Physical routing and project-specific cable identification tagging.
 - c. Correct termination installation and connection of conductors to pins at terminations.
 - d. Record cable run length and compare to the manufacturer or industry standards to verify that lengths are within specifications.
 - e. Locations and values of network termination resistance.
 - f. Integrity and grounding of cable shields.
 - g. Values of transient protection (surge) elements.
 - h. Firmware revision level of network devices available prior to energization.
 - i. Settings of dip switches and configuration parameters.
 - 3. Active System Testing: After the cable or network system has been activated for testing, provide diagnostic monitoring and signal analysis for the bus network system

to evaluate network and bus integrity and data transfer quality. Measure, verify, and record the following parameters:

- a. Node addressing.
- b. Signal attenuation before and after a repeater device and at the farthest point in the network.
- c. Total network trunk voltage and current loading as applicable.
- d. Baud rate, message traffic rate, percent bandwidth used, error rate, and lost packet count.
- e. Firmware revision level of the network devices.
- f. Pre-active and active testing: within the specified range of values established by the referenced standards.
- g. Correct the functionality of networks and devices connected to the network.
- C. Piping Tests:
 - 1. Pneumatic Piping Systems: Tested for leaks in compliance with Section 17140. Test pneumatic piping systems for leaks in compliance with ISA RP7.1, except performed at 10 times the normal system operating pressure. Test Section 17000-Form B.
 - 2. Liquid Piping Systems: Tested for leaks.
- D. Instrument and Component Inspection:
 - 1. PICS components inspection activities include the following:
 - a. Compare and validate instrument type and nameplate data with the drawings, specifications, and data sheet.
 - b. Validate instrument identification tag.
 - c. Confirm that instrument installation conforms to drawings, specifications, and manufacturer's instructions.
 - d. Verify proper conductor termination and tagging.
 - e. Visually check for physical damage, dirt accumulation, and corrosion.
 - f. Verify that isolation amplifiers, surge protection, and safety barriers are properly installed.
 - g. Report deficiencies identified within 24 hours of discovery. No instrument or system component shall be tested until deficiencies are addressed.
- E. Instrumentation Calibration:
 - 1. Calibrate instruments and final elements in accordance with the manufacturer's recommended procedures and tested in accordance with the Contractor's test procedure.
 - 2. Complete and document instruments and component inspections to the satisfaction of the Owner prior to individual component calibration and testing.
 - 3. Calibrate analog instrument at 0, 10, 50, 90, and 100 percent of the specified fullscale range. Adjust each signal sensing trip and process sensing switch to the required setting. Verify instrument readout matches loop signal. Test data recorded on test forms as specified herein.
 - 4. Test and adjust final element alignment to verify that each final element operates smoothly over the full range in response to the specified process control signals.

- 5. Enter test data on the applicable test forms at the time of testing: set alarm trips, control trips, and switches to initial values specified in Section 17200 Instrument Index at this time. Check final elements for range, deadband, and speed of response.
- 6. Have any component repaired or replaced by the manufacturer where the component fails to meet the required tolerances. Repeat the specified tests until the component is within tolerance.
- 7. Install a calibration sticker on each instrument following successful calibration that indicates the date of calibration, the name of the testing company, and personnel who calibrated the instrument.
- 8. Test forms Section 17000-Form C through I.
- 9. Certified Test Reports: Field test and inspection activities include verification of instrument parameter setup, verification of instrument zero, and performance at three operating points within the instrument range. Return each instrument that fails to demonstrate proper performance for recalibration or replaced as agreed depending on the impact to the project as determined by the Construction Manager.
 - a. Where instrument field calibration is not feasible, certified factory calibration reports may be submitted that include the name and address of the laboratory that conducts the calibration testing. Certified factory test reports may be submitted for the following instrument types in lieu of field calibration:

Table A. Factory Calibration Instrument List

Instrument Identification	Instrument Section	Description
FM	17212-A	Magnetic flow metering system

- F. Pre-Loop Testing:
 - 1. Test every I/O point from the field device to the termination on the I/O card in the panel.
 - 2. Perform tests with loop wiring complete and terminated for each point being tested between initial field device and I/O termination point.
 - 3. For each discrete I/O point, verify and document contact status value for both the opened and closed positions of the contact.
 - 4. For analog points, verify analog value matches local display. Confirm calibration at 0, 25, 75, and 100 percent of value.

3.04 LOOP TESTING

- A. Provide a request to perform loop testing at least 2 weeks prior to the requested loop test date. Include the following with the request:
 - 1. Area/system for which request is being made.
 - 2. Written certification that performance testing has been completed, documented, and passed for the area/system for which loop testing is being requested.
 - 3. Submittal numbers that define the tests and data points for the I/O to be tested. Provide updates to the I/O list or instrument calibration as an outcome of the performance testing.
- B. Commence loop testing after the performance testing has been completed and documented to the satisfaction of the Construction Manager.

- C. Test each instrument loop as an integrated system. Check operation from field instruments to transmitter to receiving components to the vendor panel or the Plant Control System Operator Interface Station. Inject test signals at the process impulse line connection where the measuring technique permits, and otherwise at the most primary signal access point.
- D. For each discrete I/O point, verify and document field contact status value for both the opened and closed position of the contact.
- E. For analog points, verify that analog value matches local display. Confirm calibration at 0, 25, 75, and 100 percent of value.
- F. Where loops are interfaced to a controller, verify the controller I/O assignment and operation of the input/output system and processor. Inspect the data table or register in the PLC memory to verify proper operation.
- G. If the output control or monitoring device fails to indicate properly, make corrections to the loop circuitry or device. Repeat the test until devices and instruments operate as required.
- H. Correct loop circuitry and repeat the test until the instruments operate properly.
- I. Test Section 17000-Form J.

3.05 FUNCTIONAL TESTING

- A. Process Control Strategy/Functional Testing:
 - 1. Commence control strategy testing after loop testing has been completed and documented to the satisfaction of the Owner.
 - Control strategy testing, performed by the Programmer, consists of installing and debugging the PLC control logic program, verifying the interface points between the controller I/O cards and field devices and equipment, and exercising the control strategies. Perform control strategy testing on one PLC at a time.
 - 3. Provide qualified personnel to immediately correct deficiencies in the work that may be encountered during control strategy testing. Failure of the Contractor to provide such personnel in a timely manner may prolong the time allotted to complete control strategy testing.
- B. Control System Closed-Loop Testing:
 - 1. Commence closed-loop commissioning after the control strategy testing has been successfully completed and documented to the satisfaction of the Owner.
 - 2. Demonstrate stable operation of each loop under operating conditions. Adjust loop tuning parameters as part of the test.
 - 3. Tuning parameters: gain (or proportional band), integral time constant, and derivative time constant for each control loop, adjusted to provide 1/4-amplitude damping, unless otherwise specified.
 - 4. Provide the loop response to a step disturbance for each loop. Provide two graphs for cascaded control loops, one showing the secondary loop response with its set point in manual, and the second showing overall loop response.

- 5. Adjust control loops with "batch" features to provide optimum response following startup from an integral action saturation condition.
- 6. Provide graph recording showing the response and made at sufficient speed and amplitude to show 1/4 amplitude damping. Label to show loop number and title, and settings of parameters and set point.
- 7. Where a loop is controlled under the direction of a PLC, the Programmer will perform the necessary adjustment of loop tuning parameters and set points, record the loop response, adjusting final elements, and ensuring total integrated loop performance as specified.
- C. Functional Checkout:
 - Conduct to verify the operation of discrete and hardwired control devices, refer to Section 01660. Exercise the operable devices and energize the control circuit. Operate control element, alarm device, and interlocks to verify that the specified action occurs.

3.06 OPERATIONAL TESTING

- A. Perform the Operational Tests after component and subsystem tests have been completed. Perform the test of the completed system in full operation and demonstrate that functional requirements of this specification have been met. Demonstrate the following:
 - 1. Each component of the system operates correctly with other components of the system.
 - 2. Analog control loops operate in a stable manner.
 - 3. Hard-wired and software equipment interlocks perform correctly.
 - 4. Process control sequences perform correctly.
 - 5. Application program performs monitoring and control functions correctly.
 - 6. Operator interface graphics represent the monitoring and control functions correctly.

END OF SECTION

SECTION 17110

INSTRUMENT AND CONTROL PANELS

PART 1 GENERAL

1.01 DESCRIPTION

- A. Scope:
 - 1. This section specifies requirements for control panels and PLC cabinets.
 - 2. This section specifies requirements for power supply and conditioning equipment required to support the instrumentation and communication systems specified.
 - 3. Provide the instrument, control, and monitoring features indicated on the P&ID and electrical drawings. Panels shall be arranged to separate control and instrument devices from power wiring. Panel shall be arranged for dedicated field wiring terminations rated for 600 Vac or less for power, control, and instrument signal wiring, in accordance with NEC Article 409. It shall be fabricated by a UL-508A recognized facility and shall bear the appropriate UL 508A Industrial Control Panel label. Panels for Hazardous (Classified) Locations shall bear the appropriate UL 698A label. Panels shall be labeled in accordance with Article 409 of the National Electrical Code.
 - 4. Transmitters, Analyzers, signal conditioning modules and other equipment or devices as specified in other Division 17 sections.
 - 5. Panels that contain programmable logic controllers (PLC) and operator interface stations (OIS) units shall be as indicated in the Panel Schedule. Specific panel devices are specified herein and in Section 16175.
 - 6. PLC and OIS shall comply with the specified in Division 17. Panels that do not comply with the specified products and specified logic method, hardwired or PLC logic, shall not be accepted. Cost to retrofit the panel as specified shall be borne by the panel supplier. Corrections or modifications to UL 508A Industrial Control Panels shall be transported to the panel supplier's facility for corrections, testing, relabeling and inspection.
 - 7. Field modifications require a UL inspector site inspection for approval of panel corrections and to re-label the panel after the field modifications are completed.
 - 8. Vendor and Manufacturer panels specification Sections are referenced in the Panel Schedule and specify specific requirement for these panel. Contractor custom panels are specified herein and shown on the drawings.
 - 9. The Vendor / Manufacturer package equipment and Contractor custom field panels shall adhere to the requirements in specifications Section 16175 for motor starters, controllers, and devices and the circuits shall be arranged for Fail-Safe wiring and electrical operation, as defined hereinafter.
- B. Panel Design:
 - 1. General:
 - a. Panel hardware and software is specified in other Sections within Division 16 and 17.
 - 2. Control Power Distribution:

- a. Panel containing 120-volt powered equipment shall use the din-rail power distribution method with fuses and blown fuse indication. Power is restricted to 120 Vac and 24 Vdc.
- 3. Panels containing voltages greater than 480 Vac shall be separated from the control section by physical barrier.
- 4. Power Supplies:
 - a. Panel containing direct current powered instruments or serving as the termination point for transmission loop powered field instruments shall contain direct current power supply system as specified herein.
- 5. Air Supplies:
 - a. Each panel containing pneumatically operated instruments shall be provided with a dual service regulator and distribution manifold, and all other devices necessary to perform the functions specified. Air distribution and control devices shall be provided as specified in Section 17140.
- 6. Electrical Control Devices:
 - a. Pushbuttons, indicating lights, relays, and similar equipment located in panels specified in this section shall comply with the requirements of Section 16175.
- 7. Uninterruptible Power Supplies:
 - a. Panel mounted 120 Vac input and 120 Vac output are specified herein.
- C. Control Panel Schedule:
 - 1. PLC-100:
 - a. Programmable Logic Controller (PLC)
 - b. Panel mounted Operator Interface Station (OIS)
 - c. Windowed lockable outer door and inner door for displays.
 - d. Heating
 - e. Air Conditioning
 - f. Radio Modem and Antenna
 - g. Cellular Modem
 - h. Managed Network Switch

1.02 QUALITY ASSURANCE

- A. References:
 - 1. This section contains references to the following documents that are part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
 - 2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid or on the effective date of the Agreement if there were no Bids. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

3. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title	
EIA RS-310C	Racks, Panels, and Associated Equipment	
NEMA 250	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances	
UL 94	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances	
UL 508A	Industrial Control Panels	
UL 698A	Industrial Control Panels Relating to Hazardous (Classified) Locations	
NFPA 79	Electrical Standard for Industrial Machinery	
NFPA 70	National Electrical Code (NEC)	
NEMA ICS 6	Industrial Control and Systems: Enclosures	
ANSI/UL 497-1995	Standard for Protectors for Paired Conductor Communications Circuits	
UL 1012	Power Supplies	
EIA RS-310C	Racks, Panels, and Associated Equipment	
UL 1449	UL Standard for Safety for Surge Protective Devices	

- 4. This Section references other sections with associated work specified therein:
 - a. Section 01660 specifies Equipment and System Performance and Operational Testing with reference to Contractor's Quality Assurance Manager that is responsible for startup commissioning of system including mechanical, HVAC, electrical, and instrumentation system.
 - b. Section 16000 specifies raceways, conductors, and device requirements.
 - c. Section 17030 Process Instrumentation And Control Testing.
 - d. Section 17310 Programmable Logic Controllers.
 - e. Section 17900 Process Control Descriptions.
 - f. Section 17315 Process Control System Development And Programming.
 - g. Section 17800 Network And Communication Equipment.
 - h. Section 17710 SCADA Radio Communication Systems.
- B. Listed Products:
 - 1. Equipment and components shall be Underwriters Laboratory (UL) listed for the purpose or UL recognized.
 - 2. The control panels shall have factory applied UL 508A labels. Where intrinsic safety barriers are used within a control panel, provide UL 698A factory applied label as required by UL.
 - 3. All panels shall be labeled in accordance with NEC Article 409.
- C. Factory Testing:
 - 1. Prior to shipment, the manufacturer shall test the functional operation of the control panel as described in the control description Section 17900.
- D. Shipment, Protection and Storage:
 - 1. Equipment shipment, protection and storage shall conform to the requirements specified in Section 01605.

1.03 SUBMITTALS

A. General:

- Submittals and transmittal procedures for submittals are defined in Section 01300. Submit In accordance with the procedures set forth in the General Conditions of the Contract Documents and Section 01300 that include drawings, information and technical data for equipment and as required in Section 17000. Submittal information shall be included in one complete submittal.
 - a. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
 - 1) A <u>check mark</u> shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.
 - 2) The Owners Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications.
 - 3) Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
 - b. A marked copy of specification Section 17000.
 - c. A marked copy of specification Section 17030.
 - d. A marked copy of specification Section 17900.
 - e. A marked copy of specification Section 17310.
 - f. A marked copy of specification Section 17800.
 - g. A marked copy of specification Section 17710.
 - h. A marked copy of specification Section 01660.
 - i. A marked copy of specification Section 16175.
 - j. A copy of the contract document Process and Instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
 - k. Marked contract document Control Schematic diagrams related to the submitted equipment.
 - I. Marked contract document Control Single Line diagrams related to the submitted equipment.
 - m. Marked product literature of all the enclosure electrical devices and components mounted on or within the control panel.

- n. List of miscellaneous items, cables, spare and replenishment parts, and chemicals to be provided, including MSDS information.
- o. Dimensioned drawings:
 - 1) Exterior panel and layout
 - 2) Interior devices and layout
 - 3) Door-in-door construction devices, where required
- p. Panel assembly drawings including sections showing clearances between face and rear mounted equipment.
- q. Nameplate engraving schedule:
 - 1) Indicate engraving by line
 - 2) Character size
 - 3) Nameplate size
 - 4) Panel and equipment tag number and description
- r. Heat load calculations for each cabinet based on the highest ambient temperature listed in Section 17000 for the area in which the subject panel will be located.
- s. Wiring drawings:
 - 1) Schematic diagrams
 - 2) internal wiring diagrams
 - 3) Connection diagrams
 - 4) Power and control single line diagrams to comply with NEC Article 409.

1.04 ENVIRONMENTAL CONDITIONS

A. Refer to Section 17000.

PART 2 PRODUCTS

2.01 FABRICATION

- A. General:
 - 1. Panels shall be designed for the seismic requirements of Section 17000. Structures, equipment, and devices shall be braced to prevent damage from specified forces. Equipment panels shall be capable of operation following a disturbance.
 - 2. Nameplates with tag number and equipment description shall identify face-mounted instruments. Instruments shall be mounted for access to components and ease of removal. Cutouts for future equipment shall be blanked off with suitable covers. Instrument tag numbers shall be identified on the panel rear.
 - 3. Face-mounted equipment shall be flush or semi-flush with flat-black escutcheons. Face-mounted instruments that are more than 6 inches deep, weigh more than 10 pounds, or exert more than a 4 ft-lb moment force on the face of the panel shall be supported underneath at the rear by a 1-inch x 1/8-inch thick steel angle.
 - 4. Panels less than 60 inches high shall be provided with floor stands to raise the top of the panel to 60 inches above the floor or work platform. Panels that weigh less than 100 pounds may be wall mounted.

- 5. Panels with specified requirements including stainless steel or aluminum mounting requirements that are indicated on the project drawings or on the project details take precedence over the panel types or panel features indicated herein.
- B. Panel Layout:
 - 1. Provide 20 percent spare contiguous sub-panel area for future expansion.
 - 2. Provide minimum of 20 percent spare terminal blocks, with a minimum of 5 analog, discrete, power.
 - 3. Provide minimum of 12 inches clear space from the bottom of the panel to the bottom of the subpanel.
 - 4. Separation between the power components (over 120Vac) and the control / instrument components (120Vac and less) by locating the power components and the control / instrument components in separate sections of the cabinet enclosure.
 - 5. Power cabinet section and the control / instrument cabinet section with separate door handles.
 - 6. Separation between the power components and the control / instrument components using barriers.
 - 7. External lockable circuit breaker handle for the main panel disconnect.
 - 8. Individual power and control components with internal circuit breakers, as required.
 - 9. Motor controllers, as required by the equipment specifications.
 - 10. Displays with door-in-door construction accessible by opening the cabinet outer door.
 - 11. Face-mounted equipment flush or semi-flush with flat-black escutcheons.
 - 12. Panel tops of wall-mounted panels: mounted at the same elevation.
 - 13. Panel inner door contains a copy of the record elementary and wiring diagrams, or reference as allowed per NEC Article 409.
 - 14. Panel inner door contains a drawing holder.
 - 15. Panel drawings enclosed in a transparent, protective jacket.
 - 16. Panel functions as specified.
 - 17. Panels with floor stands, to raise the top of the panel to 60 inches above the floor or work platform.
 - 18. Wall mounting of panel weighs less than 100 pounds, where wall space is available,
- C. Enclosures:
 - 1. Panel enclosures shall comply with the requirements of NEC Article 409 and NEMA 250.
 - 2. Manufacturer:
 - a. Hoffmann Enclosures, Inc.
 - b. Rittal.
 - c. or equal.

2.02 ENVIRONMENTAL CONTROL

A. Environmental controls shall be provided as required to maintain the environmental ratings of the enclosed components and shall maintain the NEMA enclosure rating as required by its location.
- B. Heating: Panels located in unconditioned areas or outddors shall be provided with thermostatically controlled space heaters as required to maintain the panel temperature 10 degrees F above abient to prevent condensation within the panel. Space heaters with surface temperatures that exceed 120 degrees F require an expanded metal guard. Thermostats shall be Honeywell T631 series, Johnson Controls A28AA-4, or equal.
- C. Ventilation: Fans shall be equipped with UL-approved washable filters and provide at least 240 cubic feet per minute (CFM). Fans shall be thermostatically controlled. Noise level at 3 feet from exterior wall and 30 degrees off axis shall not exceed 60 NC units.
- D. Air Conditioning: Systems shall not exchange cabinet interior air with ambient air.
 - 1. The cooling system shall be either a closed glycol loop heat exchange system or a CFC-free refrigeration system as required for heat load and ambient temperature conditions.
 - 2. Panel air conditioner coils shall be Heresite, or equal coated and protected from corrosion.

2.03 PROTECTION COATING AND FINISH

A. Panels located outdoors or located in corrosive areas shall be bottom coated with waterproof coatings.

2.04 NAMEPLATES

- A. External door-mounted components and the panel description shall be identified with plastic nameplates. Machine embossed metallic adhesive labels shall identify tag number of instruments inside panels. Nameplates shall be attached to panel surfaces, not to instruments.
- B. The machine engraved laminated white phenolic nameplates with black lettering shall be provided for panel-mounted equipment. Nameplate engraving shall include the instrument tag number and description in 3/32-inch minimum size lettering.
- C. The machine embossed metallic adhesive labels shall identify tag number of instruments inside panels. Nameplates shall be attached to panel surfaces, not to instruments.
- D. The nameplates shall be attached to the panel with a minimum of two self-tapping 316 stainless steel screws. Provide RTV sealant for nameplates for NEMA-4X stainless steel panels.
- E. The nameplate wording may be changed without additional cost or time prior to commencement of engraving. Submit nameplate legend with the panel submittal.

2.05 PANEL FEATURES

- A. Interconnection Wiring: Panel Interconnecting Wiring:
 - 1. Panel control wiring: Single conductor stranded copper NEC rated Type MTW No. 16 AWG minimum(rated 10 A per NFPA 79, Table 12.5.1), with an exception for factory supplied PLC wiring harnesses that are U.L. approved.
 - 2. Panel instrument wiring: Twisted No. 16 AWG shielded pair or tri conductors.

- 3. Panel power wiring: Conductors specified in Division 16 and meet the NEC requirements for power including phase, grounded, and grounding conductors.
- 4. Wiring shall be supported independently of terminations by lacing to panel support structure or by slotted flame retardant plastic wiring channels.
- 5. Wiring channels shall comply with UL 94, Type V.
- 6. Plastic wireway with covers shall be used to route groups of wires. Wireway fill shall be sized to provide 50% maximum fill.
- 7. Plastic spiral wrap shall be used for exposed wires. Wires that cross door hinges shall be enclosed in plastic spiral wrap.
- B. Conductor Identification:
 - 1. Wiring shall be tagged at every termination with machine printed plastic sleevesor pre-printed self-sticking labels as manufactured by W.H. Brady, 3M, or approved equal. No hand-written labels are permitted.
 - 2. Three-part wire numbers for instrument and control panel internal conductors:
 - a. Part-1: Prefix of the wire number shall be the instrument loop number or equipment tag number.
 - b. Part-2: Code letter and wire colors per the following tables.
 - c. Part-3: Number that identifies individual circuit conductor Terminal Number.

Code	120 Vac Conductor Color			
L	Power	Black		
С	Control	Red		
Ν	Neutral	White		
PG	Ground	Green		
Code	V dc Conductor	Color		
PS	24 Vdc Power	Blue		
PS	12 Vdc Power	Violet		
S+	Signal (+)	Black		
SG	Signal Ground	White		
EG	Equipment Ground Green			
FV	Panel Foreign Voltage Yellow			

- C. Conductor Installation And Protection:
 - 1. Power and control wiring shall be carried in covered channels separate from low voltage signal circuits. An interior steel barrier shall be provided between AC control devices and the electronic equipment.
 - 2. Terminal blocks shall be strap screw type rated for 600 volts. Each terminal trip shall have a unique identifying alphanumeric code at one end and a vinyl-marking strip running the entire length of the terminal strip with a unique number for each terminal. Numbers shall be machine printed and 1/8 inch high.
 - 3. No more than two connections shall be made to one terminal.
 - 4. Wire connectors shall be locking fork tongue or ring tongue insulated crimp type terminals.
 - 5. Terminal blocks shall be;

- a. Buchanan 0621-1
- b. Allen-Bradley 1492-HM1 600 V 30-amperes, finger-safe terminal block.
- c. Allen-Bradley 1492-CD3 600 V 35-amperes with #8 screw terminal block for ring or spade terminals.
- d. Phoenix Contact or Weidmuller, or equal products. Phoenix Contact or Weidmuller, or equal products.
- D. Field Wiring:
 - 1. Field wiring shall be connected to separate dedicated terminal blocks in a dedicated part of the panel where the field cables enter the panel. Provide a dedicated raceway on the field side of the terminal block for field wiring use only.
- E. Fuse And Fuse Holders:
 - 1. Fuses for 120 Vac circuits shall have a minimum of 12,000-amperes interrupting capacity and blown fuse indicators.
 - 2. Fuses for 24 Vdc circuits shall be fast acting glass tube type rated 1/8 or 1/10 amp for 4-20 mA loops.
 - 3. Fuses for 24 Vdc circuits shall be 1/2 amp for the power supply to individual instruments.
 - 4. Fuse holders shall be tip-out or draw-out type.
 - 5. Provide Phoenix Contact or equal products.
- F. Control Power:
 - 1. 120 Vac control power source: Single power source for all control and DC power.
 - a. Provide control power transformers, as required for the load.
 - b. Provide direct current power supplies, as required for the load.
 - c. Provide UPS for PLC and derived loop power as defined above, as required for the load.
- G. Panel Power: Panel power source:
 - 1. Provide a 120 Vac circuit for the panel light, receptacle, heating, fan, heat exchanger, or air conditioner cooling load as required.
 - 2. Provide a 208 Vac circuit for air conditioning load as required.
- H. Accessories:
 - 1. Panels greater than 24" high x 24" wide shall include GFCI convenience receptacles and LED utility lights.
 - 2. Receptacles and utility lights shall not be powered by the UPS, where included.
 - 3. Print pocket.
 - 4. Fold-up shelf of sufficient size, sufficient weight capacity, and the proper angle for supporting a laptop computer mounted to the [inside][outside of the enclosure.
- I. Fail-Safe Wiring:
 - 1. Fail-safe wiring of control relay or other on/off device or instrument provides the condition that will occur upon loss-of-power or internal failure in the device such that the relay is de-energized in the failure or loss-of-power condition such that the control relay contact operation provides for equipment failing in a safe mode.

2.06 PROGRAMMABLE LOGIC CONTROLLERS

A. Programmable Logic Controllers shall comply with Section 17310.

2.07 RADIO AND CELLULAR COMMUNICATION EQUIPMENT

A. Radio and cellular communication equipment shall comply with Section 17710.

2.08 MANAGED NETWORK SWITCHES

A. Managed network switches shall comply with Section 17800.

2.09 OPERATOR INTERFACE STATIONS

- A. Operator Interface Stations shall be have the following features:
 - 1. Display: 15 inch XGA Color Widescreen touchscreen (1024 x 768)
 - 2. Ports:
 - a. 1 10/100 Base-TX Ethernet Port
 - b. 1 USB Type B Port
 - c. 2 High-Retention USB Host Ports
 - d. 3 Fully Isolated Serial Communication Ports (2 RS-232 / 1 RS-422/485)
 - 3. Manufacturer: Red Lion Graphite Series

2.10 CONTROL DEVICES

A. Control devices shall comply with Section 16175.

2.11 INDICATING LIGHTS

A. Indicating lights shall be equipped with colored lenses as specified in Section 16175.

2.12 POWER SUPPLY AND CONDITIONING EQUIPMENT

- A. Except for power supply units which form an integral part of an individual piece of equipment, all power supply and conditioning equipment shall comply with UL 1012 and shall be approved by UL, CSA, or FM for the application.
- B. All power supply equipment shall be provided in redundant configurations such that failure of a single unit will not disable all or any part of the instrumentation and communication systems.
- C. Direct-Current Power Supplies:
 - 1. Redundancy step-diode isolation shall be provided for redundant direct current supply units and the power supply negative output terminal shall be grounded. Shall be Phoenix Contact, Model STEP-DIODE/5-24DC/2X5/1X10 or equal.
 - 2. Nominal 24-volt direct-current instrumentation and control power supply:
 - a. Convection-cooled linear type or switching type.
 - b. Line regulation: 0.4 percent for line variations from 105 to 132 volts
 - c. Load regulation: 0.4 percent for load variations from 0 to full load.

- d. Ripple and noise: Not exceed 100 mV peak-to-peak.
- e. Hold-up time at maximum load: Not less than 16 milliseconds.
- f. Continuous duty from 0 to 50 degrees C at rated load.
- g. Output electronically current limited.
- h. Over-voltage crowbar shutdown.
- i. Output voltage:
 - 1) Rated 28 Vdc
 - 2) Adjustable plus or minus 5 percent
 - 3) Set to provide 26.4 volts to the panel direct current bus.
- j. Power Supply: TDK-Lambda, or equal.
- k. Provide dry contact for failure alarm. Dry contact to be wired as an input to the PLC

2.13 SURGE PROTECTION

- A. General: Surge protection shall be provided to protect the electronic instrumentation systems from surges propagating along the signal and power supply lines. The protection systems shall be such that the protection level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level, be maintenance free, and self restoring.
 - 1. Provide lightning and surge protection devices at all antennas, as well as signal lines, communication networks, and power feeds for all lines that originate or are routed outside a building on any part of the existing or proposed circuits.
 - 2. Lightning and surge protection devices shall provide full protection from line to line and from line to ground. Units shall be DIN-rail mounted, rated for a minimum of 10kA maximum surge current and voltage suitable for the type of circuit being protected. Reaction time shall be on the order of nanoseconds.
- B. Surge protectors shall be listed per. Surge protectors shall be removable without changing the impedance of the circuit. Surge protectors product manufactures shall be:
 - 1. AC power lines shall comply with all requirements of UL1449 3rd edition with listed devices having a minimum 18kA surge protection and RFI filtering.
 - a. MTL MA30
 - b. Joslyn Model 1663-08
 - c. Taylor 1020FA
 - d. Phoenix Contact
 - e. Telematic
 - f. Edco
 - g. Liebert
 - h. Powerware
 - i. Or equal.
 - 2. For analog signal lines use ANSI/UL497 listed device with minimum 15kA protection SD Series, as manufactured by MTL, or approved equal.
 - 3. For Ethernet BaseT communications use UL497A & UL497B listed ZoneBarrier Model ZB24540IE, Category 6 Universal LAN Protector as manufactured by MTL, or approved equal.

2.14 PANEL GROUNDING

- A. Each panel shall be provided with two copper ground bars.
 - 1. One bar (NEC required) shall be bonded to the panel or panel frame or back-plate and to the facility grounding system.
 - 2. Second (signal) ground bar shall be mounted on insulated stand-offs and shall be bonded to the panel ground bar only at one point.
- B. Signal circuits, signal cable shields, and low-voltage DC power supply commons shall be bonded to the signal ground bar.
- C. Field analog wiring shields shall only be grounded at the signal ground bar. Test to verify that single ground point at panel signal ground bar.
- D. Surge protectors and separately derived AC power supplies shall be bonded to the frame ground bar.
- E. Panels exceeding 36-inches width shall contain ground bars shall be 1/4- by 1-inch copper bars extending the entire length of the panel interior at the bottom of the panel.

2.15 PANEL DRAWING PROTECTION

A. Provide wiring diagrams in accordance with Section 01300. Provide a panel-wiring diagram and schematic for each panel in a plastic bag or plastic container to avoid water damage and aging.

2.16 SPARE PARTS

- A. The following spare parts shall be provided:
 - 1. Ten each of each type of light bulb used in the panels.
 - 2. Five each of each type and rating of fuse used in the panels.
 - 3. Five each of each type primary protector surge suppressor used in the panels.
 - 4. Two each of each type of surge protective device used in the panels.

2.17 PRODUCT DATA

- A. The following data shall be provided in accordance with Section 01300:
 - Manufacturer's operation and maintenance information as specified in Section 01730. Manual shall include final reviewed submittal and separate record of all final configuration, jumper, and switch settings.
 - 2. Test results as specified in Section 17030-2.02.
 - 3. Installation and training forms

PART 3 EXECUTION

3.01 GENERAL

A. Floor mounted cabinets shall be mounted and shimmed to precise alignment so doors operate without binding. Sealant shall be provided for conduit entering the panels.

- B. Floor-mounted panels except in dry control rooms or electrical equipment rooms shall be mounted on 3-1/2-inch minimum height concrete pads or grouted bases as specified. Coating shall be provided for outdoor panels in contact on concrete. Field panels and cabinets shall be mounted in compliance with Section 17000-3.01 Field Equipment.
- C. Provide panels with the Record As-built schematic, connection, and interconnection diagrams mounted behind plexiglass holder on the inside of the door. Place documentation in a water proof clear bag in the panel document holder.
- D. Verify that all panels have been labeled with Arc Flash warning labels per NEC 110.16. Provide labels, with Arc Flash protection boundary and PPE levels, in accordance with Section16431.

3.02 MOUNTING

- A. Control panels supported directly by concrete or concrete block walls shall be spaced out not less than 5/8 inch by framing channel between instrument and wall. Sills shall be leveled so panel structures will not be distorted. Panels shall be shimmed to precise alignment so doors operate without binding and mounted where shock or vibration will impair its operation.
- B. Support systems shall not be attached to handrails, process piping or mechanical equipment. Control panels supported directly by concrete or concrete block walls shall be spaced out from the wall to provide for air circulation around the panels.
- C. Steel used for support of equipment shall be 316 stainless steel. Support systems including panels shall be designed to prevent deformation greater than 1/8 inch under the attached equipment load and an external load of 200 pounds in any direction.
- D. Floor-mounted cabinets, except in dry control rooms or electrical equipment rooms, shall be mounted on 3-1/2-inch minimum height concrete pads or grouted bases as specified.
- E. Panels shall be shimmed to precise alignment so doors operate without binding. Sealant shall be provided under panels not located in dry control or electrical equipment rooms.
- F. Center-line of wall-mounted panels shall be 48 inches above the floor.
- G. Panel tops of wall-mounted panels shall be mounted at the same elevation.

3.03 OUTDOOR PANEL SHADE COVERS

A. Fabricate the custom aluminum panel shade cover and mount the panels facing away from the prevailing sun or wind.

3.04 PANEL POWER SUPPLY

- A. Power supply and conditioning equipment shall be mounted and connected in compliance with the manufacturer's instructions.
- B. Line side disconnect switches shall be provided for power supply and conditioning equipment. Line and load side overcurrent protection shall be provided for power supply

and conditioning equipment in compliance with NFPA 70. Disconnect switches shall comply with Section 16175.

- C. Small power supply and conditioning equipment may be mounted in the panel served. Larger units shall be mounted adjacent to the equipment served. Where unconditioned power is brought into control panels, it shall be enclosed in metallic raceways within the panel.
- D. Power supply and conditioning equipment larger than 5 kVA load capacity supported from surfaces other than concrete shall be provided with sound isolators.
- E. Final raceway connections shall be a flexible conduit in compliance with Division 16.

3.05 FACTORY TESTING

A. The control panel shall be assembled, interconnected, and functionally tested at the assembly shop prior to shipment. The Owner/Engineer shall have the option of witnessing the functional shop test. The Contractor shall notify the Owner/Engineer at least two (2) weeks in advance prior of the scheduled functional shop test.

3.06 FIELD TESTING

- A. Field verify the following for Instrument and Control Panels:
 - 1. Control circuits grounded with one terminal of each load device connected to the grounded conductor.
 - 2. Control contacts installed in the ungrounded side of the circuit.
 - 3. Panel signal and control wiring separated and installed in separate wireways with barriers between the power wiring and the signal and control wiring.
 - 4. Barriers between the power wiring and the signal and control wiring.
 - 5. Connected to the plant grounding system, as specified.
 - 6. Inner door contains a copy of the Record elementary and wiring diagrams, in a protected drawing holder. Drawings shall be enclosed in a transparent, protective jacket.
 - 7. Panel Functions as specified.
 - 8. Mounted with stainless steel unistrut, fittings, and fasteners.
 - 9. Tested in accordance with Section 16030 and Section 17030.

END OF SECTION

SECTION 17140

MISCELLANEOUS INSTRUMENT VALVES AND FITTINGS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies requirements for instrument air supply equipment and pneumatic signal transmission systems and accessories. Additional requirements for mechanical equipment and piping are specified in Divisions 17.

1.02 REFERENCES

- A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
- B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASME SECTION VIII	Boiler and Pressure Code, Pressure Vessels
ASTM B68	Seamless Copper Tube, Bright Annealed
ASTM D883	Definition of Terms Relating to Plastics
ASTM D1248	Polyethylene Plastics Molding and Extrusion Materials
ISA S7.3	Quality Standard for Instrument Air

1.03 SUBMITTALS:

- A. The following information shall be submitted in accordance with Section 01300:
 - 1. Catalog and technical data for instrument air compressor system.
 - 2. Outline dimensions, weight, and foundation requirements for instrument air compressor system.

PART 2 PRODUCTS

2.01 VALVES

- A. Isolation Valves:
 - 1. Valves shall be full port ball valves with ASTM A276, Type 316 stainless steel trim and body and with Teflon seats and packing. Valves shall be Parker CPI, Whitey, Hoke, or equal.
- B. Gage Valves:
 - 1. Gage valves shall be machined from ASTM A276, Type 316 stainless steel bar stock and shall be provided with 1/2-inch NPT connections and integral bleed plug. Valves shall be Anderson, Greenwood & Company M9 VIS-44, Hoke 6801L8Y, or equal.
- C. Root Valves:
 - Root valves shall be ASTM A276, Type 316 stainless steel bar stock with 1/2-inch NPT male process connection and three 1/2-inch NPT female instrument connections. One instrument connection shall be provided with an ASTM A276, Type 316 stainless steel bleed valve. ASTM A276, Type 316 stainless steel plugs shall be provided for unused ports.
 - 2. Lagging type units shall be provided for insulated vessels and pipes.
 - 3. Root valve manufactures: Anderson, Greenwood & Company M5 VIS-44, Hoke 6802L8Y, or equal.
- D. Manifolds:
 - Manifolds shall be three-valve bar-stock type. Manifold body shall be machined from ASTM Type 316 stainless steel bar stock. Valves shall be globe configuration with 316 stainless steel ball seats and Teflon stem packing.
 - 2. Manifolds shall be designed for direct mounting to differential pressure transmitters in place of the flanges normally furnished. Fabricated manifolds or manifolds employing needle or soft seat valves are not acceptable. Purge taps, 1/8-inch NPT shall be furnished on manifolds where water purge is specified.
 - 3. Manifold manufacturers: Anderson Greenwood AX3T VIS-4, Hoke GP831211F8YL, or equal.

2.02 CHEMICAL SEALS

- A. Diaphragm Seals Chemical Service:
 - 1. Seal shall be the diaphragm type with flushing connection, Type 316 stainless steel body and Type 316L diaphragm unless otherwise specified. Wetted materials shall be submitted with proof of compatibility with the chemical service.
 - 2. Diaphragm seal manufactures: Ametek U.S. Gauge/Mansfield and Green Type SG, Ashcroft Type 101, or equal.
- B. Diaphragm Seals Pressure Service 15 psig and Lower:
 - 1. Seal shall be the diaphragm type with flushing connection, Type 316 stainless steel body and Elastomer diaphragm unless otherwise specified. Wetted materials shall be submitted to be compatible with the chemical service.

- 2. Diaphragm seal manufactures: Ametek U.S. Gauge/Mansfield and Green Type L, Ashcroft Type 741, or equal.
- C. Diaphragm Seals Chlorine or Sodium Hypochlorite Service:
 - 1. Seal shall be the diaphragm type with flushing connection, Hastelloy C, Monel, or Tantalum body and diaphragm unless otherwise specified.
 - 2. Diaphragm seal manufactures: Ametek U.S. Gauge/Mansfield and Green Type SG, Type L for low pressure, Ashcroft Type 201, Type 741 for low pressure, or equal.
- D. Diaphragm Seals General:
 - 1. Provide ¹/₂" process and instrument connections. Provide 316 stainless steel reducer for instrument connection if required.
 - 2. Provide seal flushing connection Type 316 stainless steel interconnecting fitting, and flush valve.
- E. Annular Seals:
 - Seal shall be the in-line full stream captive sensing liquid type. Metallic wetted parts shall be Type 316 stainless steel. Flexible cylinder shall be Buna-N unless otherwise specified. Seals shall be rated 200 psig with not more than 5-inch water column (WC) hysteresis.
 - 2. Annular seal manufactures: OPW Engineered Systems/Ronningen-Petter Iso-Ring, Red Valve series 40, or equal.
- F. Fill Fluid:
 - 1. Chemical seals and associated instruments shall be factory filled as follows:
 - a. Instrument side of seal, capillary tubing, and instrument shall be evacuated to an absolute pressure of 1.0 Torr or less; filled; and sealed. Provide silicone oil fill fluid, halocarbon fill fluid for chlorine applications, unless otherwise recommended by the seal manufacturer.
 - b. Chemical seal manufacture: Dow Corning DC200, Syltherm 800, or equal.

2.03 PRODUCT DATA

A. Applicable operating and maintenance information shall be provided in accordance with Section 01300 as specified in Section 01730.

PART 3 EXECUTION

3.01 NOT USED

END OF SECTION

This page intentionally left blank.

INSTRUMENT INDEX

Tag No	Device Function	Operating Range	Min Calibration or Setpoint	Max Calibration or Deadband	Units	Signal Type	Power Requirements	Specification Number	Device Type, Instruspec	P&ID Number	Comments
LIT-100	Well Level Transmitter	0-300			in	4-20 mA	24 Vdc	17212-В	LT	I-003	
LIT-101	Fuel Tank Level Transmitter	0-100			in	4-20 mA	-	17212-B	LPT	1-003	
PI-121	Injection Tube 1 Pressure Gauge	(-)30-0; 0-60			in. Hg; psi	-	-	17212-C	PG	1-003	
PI-122	Injection Tube 2 Pressure Gauge	(-)30-0; 0-60			in. Hg; psi	-	-	17212-C	PG	1-003	
PI-123	Injection Tube 3 Pressure Gauge	(-)30-0; 0-60			in. Hg; psi	-	-	17212-C	PG	1-003	
PI-124	Injection Tube 4 Pressure Gauge	(-)30-0; 0-60			in. Hg; psi	-	-	17212-C	PG	1-003	
PI-120	Injection Pressure Gauge	0-100			psi	-	-	17212-C	PG	1-003	
PIT-120	Injection Pressure Transmitter	0-100			psi	4-20 mA	-	17212-C	PGT	1-003	
FIT-120	Injection Tubes Flow	0-2000			gpm	4-20 mA	120 Vac	17212-A	FM	1-003	
PSH-110	Well High Pressure Switch		80		psi	Discrete	-	17212-C	PS	1-003	
PIT-110	Well Raw Water Pressure Transmitter	(-)15-100			psi	4-20 mA	-	17212-C	PGT	1-003	
FIT-150	Pump To Waste Flow Transmitter	0 - 3000			gpm	4-20 mA	120 Vac	17212-A	FM	1-003	
AIT-165	Electrical Conductivity Analyzer	0 - 2000			umhos/cm	4-20 mA	120 Vac	17212-D	AC	1-003	
AIT-166	Turbidity Analyzer	0 - 100			NTU	4-20 mA	120 Vac	17212-D	ATI	1-003	
PIT-167	Well Junction Pressure Transmitter	0-100			psi	4-20 mA	-	17212-C	PGT	1-003	
FIT-170	System Supply/Return Flow Transmitter	(-)3000 - 3000			gpm	4-20 mA	120 Vac	17212-A	FM	1-002	
PI-230	Media Filter Pressure Gauge	0-100			psi	-	-	17212-C	PG	1-002	
PIT-230	Media Filter Pressure Transmitter	0-100			psi	4-20 mA	-	17212-C	PG	1-002	
PIT-211	Main Inlet/Outlut Pressure Transmitter	0-100			psi	4-20 mA	-	17212-C	PGT	1-002	

This page intentionally left blank.

SECTION 17212-A

FLOW MEASUREMENT

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Requirements for instrumentation elements that quantitatively convert the measured variable energy into a form suitable for measurement and process measurement accessories.
 - 2. Requirements for process flow measurement instruments including meters, transmitters, switches, associated indication devices, and accessories.
 - 3. Requirements for instrumentation elements which form a part of the process control systems specified in Section 17000 and Section 17200. Application requirements are specified in the instrument schedule, Section 17200.
- B. Equipment List:
 - 1. Equipment listed in the instrument schedule, Section 17200.

1.02 RELATED SECTIONS

- A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
 - 1. Section 17200 Instrument Index
 - 2. Section 17000 General Requirements For Instrumentation And Control

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
API RP 551	American Petroleum Institute Recommended Practice Process Measurement
NEMA 250	National Electrical Manufacturers Association Enclosures for Electrical Equipment (1000 Volts Maximum)

B. References are also listed in Section 17000 and are a part of this section as specified and modified.

1.04 DEFINITIONS

A. Impulse line: A small-gauge pipe that is used to connect a point in a pipe in which the pressure is measured at an instrument. In flow measurement using a primary device such as an orifice plate, nozzle or Venturi meter, impulse lines are used to connect

upstream and downstream (or throat) points of the meter to a secondary device for measuring the differential pressure.

B. Definitions are listed in Section 17000 and are a part of this section as specified and modified.

1.05 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate as specified in Section 17000.

1.06 SUBMITTALS

- A. Action Submittals:
 - 1. Procedures: Sections 01300
 - 2. Submittal requirements: Section 17000.
- B. Action Submittals:
 - 1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Referenced and applicable sections to be marked up and submitted include:
 - a. Section 01664 Demonstration and Training
 - b. Section 01730 Operating and Maintenance Data
 - c. Section 17000 General Requirements For Instrumentation And Control
 - d. Section 17200 Instrument Index
 - 2. A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
 - 3. A copy of the contract document Control Diagrams and Process and Instrumentation Diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
 - 4. Marked Contract Document Mechanical and/or Electrical Plan drawings, sections, and details showing sensor installation locations and details. Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

- 5. Marked product literature of all equipment and features to be provided.
 - a. Installation drawings for only the transmitters, sensors, and mounting accessories to be provided.
 - b. Electrical and signal connection drawings for only the transmitters and sensors to be provided.
- 6. List of miscellaneous items, cables, spare parts, that will be provided in accordance with INSTRUSPEC sheet requirements.
- 7. Marked product literature for surge protectors.
- C. Informational Submittals:
 - 1. Procedures: Section 01300.
 - 2. Factory calibration certificates.
 - 3. Head verses flow charts (required for open channel flow meters).
 - 4. Differential pressure verses flow charts (required for differential pressure flowmeters like orifice plate, venturi tube, pitot tube, annubar).
- D. Closeout Submittals:
 - 1. Procedures: Section 01730.
 - 2. Operating and maintenance submittals: Section 01730.
 - a. Final Reviewed Submittals.
 - b. Manufacturer's operation and maintainance instruction, edited for this project.
 - c. Record of menu configurations, jumpers, settings (range, set point, deadband) and other configurable parameters for each instrument in electrone form using Microsoft Excel or Word.
 - d. Hardcopy and electronic copy of final configuration files used for configuation and communication set up of programmable electronic based instruments (or smart instruments. If instrument uses HART programmer, provide the most current HART configuration files.
 - 3. Spare parts:
 - a. Procedures: Section 01300

1.07 QUALITY ASSURANCE

- A. Manufacturer: Equipment furnished under this section shall be the products of firms regularly engaged in the design and manufacture of such equipment for a minimum of five years.
- B. Identification of Listed Products: Provide process measurement devices listed for the purpose for which they are to be used and the installation environment, by an independent testing laboratory. Three such organizations are Underwriters Laboratories (UL), Canadian Standards Association (CSA), and Factory Mutual (FM). Independent testing laboratory need be acceptable to the inspection authority having jurisdiction.
- C. Installer: Installation, calibration and testing of equipment furnished under this section shall be performed by qualified, skilled, Certified Technicians specified in Section 17000, who are regularly engaged in such activities involving systems of similar complexity.

1.08 DELIVERY, STORAGE AND HANDLING

A. Procedures: Section 01605.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Candidate manufacturers are specified on the INSTRUSPEC sheets in Part 4 of this section. Candiate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. The manufacturer's standard product may require modification to conform to specified requirements:

2.02 TYPE

A. INSTRUSPEC sheets in Part 4 of this section represent different types of flow measurment instruments. The flow measurement instrument are listed in the instrument schedule, Section 17200 with required INSTRUSPEC symbol specified.

2.03 PERFORMANCE/ DESIGN CRITERIA

- A. General:
 - 1. Performance and features required are specified in the INSTRUSPEC.
- B. Environmental conditions:
 - 1. Equipment provided under this section shall be suitable for operation under environmental conditions described in Section 17000.
- C. Operating conditions:
 - 1. Operating setpoints and ranges are specified in the instrument schedule, Section 17200, in the INSTRUSPEC, and/or on the drawings.
- D. Process switch:
 - 1. Contact outputs used for alarm actuation to be normally-closed or normally-opened as required by the process condition to open to initiate the alarm.
 - 2. Contact outputs used to control equipment to be normally-opened, and close to start the equipment.
 - 3. Contacts monitored by solid state equipment such as programmable controllers or annunciators to be hermetically sealed and rated for switching currents from 20 to 100 mA at 24 volts DC.
 - 4. Contacts, monitored by electromagnetic devices such as mechanical relays, to be rated as NEMA ICS 2, designation B300.
 - 5. Double barriers provided between switch elements and process fluids such that failure of one barrier will not permit process fluids into electrical enclosures.
 - 6. Switch electrical enclosures rated as NEMA 250, Type 4X minimum.
 - 7. Provide intrinsic safety barrier with switch located in a facility area classified as hazardous per the NFPA and the NEC when instrument is not available as explosion proof (Class I, Division 1) or an alternative protection method recognized by NEC

(Class I, Division 2). Intrinsic safety barrier to be dual type to prevent grounding circuit at the barrier; MTL 787, or approved equal.

- 8. Select switch range so that the specified set point is at least 30 percent but not more than 70 percent of the span, between the upper range limit and the lower range limit.
- E. Process transmitter:
 - Any transmitter that does not include an integral indicator, provide output indicators. Configure indicator display readout, whether integral or separate, in US process measuring units over the calibrated range of the transmitter. Display process measurement as a digital LED or LCD readout with process measuring units on the face of the indicator.
 - a. Analog output indicators shall be 2.5-inch milli-ammeter with 90-degree movement enclosed in a NEMA rated meter case meeting the installation environment requirement. Provide indicators with accuracy within two percent of span. Provide a diode to maintain loop continuity for indicator removal.
 - 2. Provide two-wire, three-wire and four-wire transmitters with 4 to 20 milliampere (mA) output signal. Derive operating power for two-wire transmitter from the current output signal. Require an external 24 V DC power supply for three-wire transmitter; the power supply common and the current output return share the same wire. Require an external 24 V DC or 120 V AC power supply for four-wire transmitter; there shall be no electrical connection between the current output signal and the power supply.
 - 3. Provide load variations within the range of 0 to 500 ohms with the power supply at a nominal 24 volts DC or 120 volts AC with the default range of 0 to 100% corresponding to 4 to 20 mAdc for the transmitter output.
 - 4. Configure transmitter output to increase with increasing measurement except where specified as "reverse action" in the Instrument Index.
 - 5. Provide adjustable time constant from 0.5 to 5.0 seconds for transmitters used for flow, level transmitters used for flow measurement, or pressure measurement.
 - 6. Galvanically isolate via electro-mechanical or optical technology the transmitter output. If transmitter is not galvanically isolated then provide transmitter output with a loop-powered signal current isolator.
 - a. Provide galvanic isolation of milliampere transmission signals from transmitters. Locate isolator inside panel and DIN rail mount. Derive operating power from the signal input circuit or as specified on the drawings.
 - Input and output signals 4 to 20 milli¬amperes with error not exceeding 0.1 percent of span. Input resistance not to exceed 550 ohms with an output load of 250 ohms.
 - c. Manufacturer: Phoenix Contact or approved equal.
 - 7. Provide transmitter enclosures as rated NEMA 250, Type 4X, unless otherwise specified.
 - 8. Surge protect power and output signals for transmitters located outdoors:
 - a. Signal: Provide internal surge protector as a product option. If transmitter does not include an internal surge protector then provide an external surge protector: Emerson/Rosemount Model 470 D, Emerson/EDC0 SS64-036-2, CCI SPN-42 FS28 Series, or approved equal.

- b. AC Power: Provide internal surge protector as a product option. If transmitter does not include an internal surge protector then provide an external surge protector. External surge protector UL 1449, LED indicator, screw terminal connections, NEMA 4X, EDCO HSP121A or approved equal.
- c. Provide a terminal junction box for housing external surge protector. Box to match NEMA rating of the transmitter.
- 9. Provide intrinsic safety barrier with two-wire transmitter located in a facility area classified as hazardous per the NFPA and the NEC when instrument is not available as explosion proof (Class I, Division 1) or an alternative protection method recognized by NEC (Class I, Division 2). Require the two-wire transmitter product manufacturer to list intrinsic safety barriers as an acceptable method for installation in a hazardous classified area.
 - a. Intrinsic safety barriers for two-wire transmitters to be of the active, isolating, loop powered type. Barrier shall be as recommended by the two-wire transmitter product manufacturer, or accepted equal.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Provide receipt verification prior to installation. Check:
 - 1. Instrument received is instrument ordered.
 - 2. Instrument meets specified requirements.
 - 3. Instrument has correct manufacturer manuals.
 - 4. Instrument has been factory calibrated, bench calibrated or has method for field calibration.
- B. Flushed and hydrostatically test the process line before installing an inline flow measurement instrument to avoid debris in the process line damaging the instrument.

3.02 INSTALLATION

- A. General:
 - 1. Installation requirements specified in INSTRUSPEC sheets are applicable to this section.
 - 2. Installation requirements specified in Section 17000 are applicable to this section.
- B. Process Connections:
 - 1. Install the instrument in the manufacturer's recommended position.
 - 2. In liquid flow measurement installation, ensure there is no air or vapor in the liquid.
 - 3. In gas flow measurement, ensure there are no liquid droplets in the gas.
 - 4. Support the process connection piping to minimize the effect of vibration.
 - 5. When specified, provide filtration upstream to knock out solids from the flow stream.
 - 6. When specified, provide flow conditioners or straighteners to meet required straight pipe run for the instrument.
 - 7. Provide sufficient clearance for installation and maintenance work.

- 8. When flow measurment is based on differential pressure measurement, ensure impulse line taps are per manufacturer's recommended location, diameter size, orientation, include valves for block, bleed, flushing, zeroing, and calibrating such as 5 valve manifold. Ensure all valve connections are label to function.
 - a. Impulse Lines:
 - 1) Match piping diameter of impulse line to the instrument connection size and process line taps.
 - 2) Install impulse lines between the flow element to the transmitter within 3 feet if possible. Do not exceed 20 feet. Slope impulse lines as required by type of process fluid.
 - 3) Support impulse lines every 18 inches to a channel frame system secured to wall or floor with clamps to prevent vibration. Do not support impulse lines using other process piping or conduit.
 - 4) Square-cut and de-burr impulse line before installation in fittings. Fittings shall be used for splices, connections, and turns near final connections. Bulkhead fittings shall be used when impulse lines enters a panel.
 - b. Wetted material to be 316 stainless steel piping, unless the piping specification requires a polymer type material to be chemically compatible with process fluid being measured.
- C. Electrical Connections:
 - 1. Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of 2 feet.
- D. Outdoor:
 - 1. Transmitters mounted outdoors shall be provided with rain/sun hood.

3.03 FIELD QUALITY CONTROL

A. Testing requirements are specified in Section 17030.

3.04 TRAINING

A. Training requirements are specified in Sections 01664. Provide two training sessions, each with one-half hour for each type of flow measurement instrument.

PART 4 APPENDIX - INSTRUSPECS

4.01 INSTRUSPECS

A. General requirements for instruments specified in this section are listed on INSTRUSPEC sheets herein. Application requirements are specified in the Instrument Index, and/or on the drawings.

Table A

INSTRUSPEC Symbol	Instrument description	Instrument function	
FM	Magnetic Flow Transmitter	Flow Measurement	

4.02 INSTRUMENT IDENTIFICATION: FM

- A. Instrument Description: Magnetic Flow Metering System
- B. Manufacturer:
 - 1. McCrometer Ultra Mag
 - 2. Approved equal.
- C. Features:
 - 1. Instrument Function: Flow Measurement
 - 2. Signal Input: Process
 - 3. Signal Output: 4-20 mA
 - 4. Power Supply: 120Vac
 - 5. Process Connection:
 - a. Flow tubes of less than 4 inch diameter may be wafer-style ductile-iron or fullbody flanged construction.
 - b. Flow tubes larger than above shall be flanged, ANSI B16.5, Class 150, raised face.
 - 6. Magnetic flow meter provided as a system consisting of a flow tube with separate indicating transmitter complete with interconnecting cables of sufficient length between the flow tube and the transmitter.
 - a. Indicating transmitter for full-scale flow rates from 1.0 to 30 feet per second. System error shall not exceed the greater of 0.5 percent of flowrate or 0.1 foot per second from 3 to 30 feet per second. Mount transmitter on a stand with a rain/sunhood.
 - b. Flow Tube: Shall be rated NEMA 6P for continuous submergence up to 20 feet.
 - c. Grounding Rings: Provide up-stream and downstream 316L stainless steel grounding rings shall be fabricated from the same metal as for the electrodes below.
 - d. Electrodes: Shall have conical shaped probes that are cleaned by the velocity of the flow stream. Probes shall be manufactured of 316L stainless steel unless otherwise specified in Section 17200.
 - e. Liner: As follows unless otherwise specified in Section 17200.
 - 1) Fusion boned epoxy

- f. Transmitter: Contain electronics associated with the magnetic flow meter system. Enclosure rating NEMA-4X, cast aluminum or metal compartment for power, field connections and calibration adjustments separate from digital circuitry.
 - 1) Means to calibrate the metering system without use of external calibration units. Transmitter self-diagnostics. Traceability certificate of actual flow lab certification provided with each flowtube.
 - 2) 4-digit LCD flow indication calibrated in process units. Data retained in non-volatile memory.

END OF SECTION

This page intentionally left blank.

SECTION 17212-B

LEVEL MEASUREMENT

PART 1 GENERAL

1.01 DESCRIPTION

- A. This section specifies requirements for instrumentation elements that quantitatively convert the measured variable energy into a form suitable for measurement and process measurement accessories. Application requirements are specified in Section 17200.
- B. This section specifies requirements for process level transmitters, associated indication devices, and accessories.
- C. This section specifies requirements for process level activated switches, devices, and accessories.
- D. Scope:
 - This section specifies requirements for instrumentation elements which form a part of the process control systems specified in Section 17000 and Section 17200-3.03. Application requirements are specified in the instrument schedule, Section 17200-3.03.

1.02 QUALITY ASSURANCE

- A. Equipment furnished under this section shall be the products of firms regularly engaged in the design and manufacture of such equipment for a minimum of five years.
- B. Installation, calibration and testing of equipment furnished under this section shall be performed by qualified, skilled, Certified Technicians specified in Section 17000, who are regularly engaged in such activities involving systems of similar complexity.
- C. References are listed in Section 17000 and are a part of this section as specified and modified.

1.03 ENVIRONMENTAL CONDITIONS

A. Equipment provided under this section shall be suitable for operation under ambient conditions described in Section 17000-1.03.

1.04 SUBMITTALS

- A. Submittals shall be provided as specified in Section 17200-1.03.
- B. Submittals shall be provided as specified in Sections 01300 and 17000, including:
 - 1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Referenced and applicable sections to be marked up and submitted include:

- a. Section 01664 Training
- b. Section 01730 Operating and Maintenance Information
- c. Section 17000 General Requirements For Instrumentation And Control
- d. Section 17200 Instrument Index

A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

- 2. A copy of the contract document Control Diagrams and Process and Instrumentation Diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
- 3. Marked Contract Document Mechanical and/or Electrical Plan drawings, sections, and details showing sensor installation locations and details. Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
- 4. Marked product literature of all equipment and features to be provided.
 - a. Installation drawings for only the transmitters, sensors, and mounting accessories to be provided.
 - b. Electrical and signal connection drawings for only the transmitters and sensors to be provided.
- 5. List of miscellaneous items, cables, spare parts, that will be provided in accordance with INSTRUSPEC sheet requirements.
- 6. Marked product literature for surge protectors.

PART 2 PRODUCTS

2.01 INSTRUMENTATION SPECIFICATION SHEETS (INSTRUSPEC)

- A. General requirements for instruments specified in this section are specified on the INSTRUSPEC sheets in the Appendix at the end of this section.
- B. Application requirements are specified in the Instrument Index, and/or on the drawings.

2.02 PRODUCT DATA

- A. General:
 - 1. In accordance with Section 01300, the General Conditions of the Contract Documents, drawings, information, and technical data for all equipment as, required

in Section 17000 and this section shall be provided. All required product data for this section shall be included in one complete package.

- B. Process switches and devices shall comply with the following requirements:
 - 1. Contact outputs used for alarm actuation shall be normally-closed or normallyopened as required by the process condition to open to initiate the alarm.
 - 2. Contact outputs used to control equipment shall be normally-opened and shall close to start the equipment.
 - 3. Contacts monitored by solid state equipment such as programmable controllers or annunciators shall be hermetically sealed and rated for switching currents from 20 to 100 mA at 24 volts DC.
 - 4. Contacts, monitored by electromagnetic devices such as mechanical relays, shall be rated as NEMA ICS 2, designation B300.
 - 5. Double barriers provided between switch elements and process fluids such that failure of one barrier will not permit process fluids into electrical enclosures.
 - 6. Switch electrical enclosures rated as NEMA 250, Type 4 minimum.
 - 7. Switch range shall be selected so that the specified set point is at least 30 percent but not more than 70 percent of the span, between the upper range limit and the lower range limit.
- C. Measuring elements and transmitters shall comply with the following requirements:
 - 1. Measured parameter output indicators complying with paragraph 2.02 shall be provided with any transmitter that does not include an integral indicator. Indicators, whether integral or separate, shall be calibrated in process units, and engraved on the indicator scale plate.
 - 2. The two-wire type transmitters shall have operating power derived from the signal transmission circuit.
 - 3. Transmitters shall meet specified performance requirements with load variations within the range of 0 to 600 ohms with the power supply at a nominal 24 volts DC with the default range of 0 to 100% linearly corresponding to 4 to 20 mAdc.
 - 4. Transmitter output shall increase with increasing measurement.
 - 5. Time constant shall be adjustable from 0.5 to 5.0 seconds for transmitters used for flow, level transmitters used for flow measurement, or pressure measurement.
 - 6. Transmitter output shall be galvanically isolated via electro-mechanical or optical technology.
 - 7. Transmitter enclosures shall be rated NEMA 250, Type 4, unless otherwise specified.
 - 8. Transmitters located outdoors shall be provided with surge protectors:
 - a. Signal: Emerson/Rosemount Model 470 D, Emerson/EDCO SS64-036-2, CCI SPN-42 FS28 Series, or accepted equal.
 - b. AC Power: UL 1449, LED indicator, screw terminal connections, NEMA 4X. EDCO HSP121A or accepted equal.
 - 9. Two-wire transmitter located in a facility area classified as hazardous per the NFPA and the NEC shall be made safe by means of an intrinsic safety barrier as specified in paragraph 2.04.
 - 10. Four-wire transmitters shall be isolated from the process and power or provided with a loop-powered signal current isolator as specified in paragraph 2.05 connected in the output signal circuit.

2.03 PROCESS PARAMETER OUTPUT INDICATOR

- A. Provide digital LED or LCD indicators that integral to the instrument housing where available from the manufacturer. Displays shall be scaled in engineering units, over the calibrated range of the instrument. Calibrate the indicator scale in process units.
- B. Analog output indicators shall be 2.5-inch milli-ammeter with 90-degree movement enclosed in a NEMA 7/9 rated meter case. Provide indicators with accuracy within two percent of span. Provide a diode to maintain loop continuity for indicator removal.

2.04 SIGNAL CURRENT ISOLATOR

- A. Isolator shall provide galvanic isolation of milliampere transmission signals from transmitters. Isolator shall be housed in a NEMA 250, Type 4/7 conduit body and derive operating power from the signal input circuit.
- B. Input and output signals shall be 4 to 20 milliamperes, and error shall not exceed 0.1 percent of span. Input resistance shall not exceed 550 ohms with an output load of 250 ohms.

2.05 PRODUCT DATA

- A. Additional Information: The following product data shall be provided:
 - 1. Flow calculation for each differential-type flow element.
 - 2. Record documentation shall include the data sheets specified in this section.
- B. The following data provided in accordance with Section 01300:
 - 1. Operating and maintenance information as specified in Section 17000-2.03. Include final reviewed submittal and separate record of all final configuration, jumper, and switch settings for each instrument.
 - 2. Test results as specified in Section 17030-2.02.

PART 3 EXECUTION

3.01 INSTALLATION

- A. General:
 - 1. General requirements for the installation of primary elements specified in this section are listed on INSTRUSPEC sheets.
 - 2. Installation requirements are specified in Section 17000-3.01.
- B. Process Connections:
 - 1. General: Process connections shall be arranged such that instruments may be readily removed for maintenance without disruption of process units or draining of large tanks or vessels. Unions or flange connections shall be provided as necessary to permit removal without rotating equipment.
 - a. Where process taps are not readily accessible from instrument locations, an isolation valve shall be provided at the instrument.
 - b. Isolation valves shall be provided for each instrument where multiple instruments are connected to one process tap.

- c. Pipe between the process connection and instruments shall be 1/2-inch stainless steel with treatment material for easy removal, as specified herein.
- 2. Safety Instruments: No valves shall be installed at pressure taps for safety instruments. Safety instruments shall not be connected to the same process tap as instruments used for control, indication, or recording except when annular chemical seals are used.
- 3. Root Valves: Root valves shall be provided at all process taps, except as follows:
 - a. Temperature taps, where valves are unnecessary.
 - b. Pump discharge pressure taps where no instrument is permanently installed. Isolation valves shall be provided.
 - c. Process taps for safety instruments.
 - d. Where gauge valves are provided.
 - e. Where chemical seals are used.
- 4. Gauge Valves: Gauge valves shall be provided for each pressure gauge tap except where chemical seals are used.
- C. Tubing:
 - 1. Tubing shall be installed on supports spaced not more than 3 feet apart and shall run parallel of perpendicular to walls structural members, or intersections of vertical planes and the ceiling. Unless otherwise shown, tubing shall follow building surfaces closely or shall be carried in trays or conduit.
 - 2. Tubing shall not be supported from piping or equipment except at process taps or connections to the device served. Tubes supported directly on concrete surfaces shall be spaced at least 1/8 inch from the concrete. Tubing support shall be one-hole malleable iron clamps with clamp backs as required. Bends shall be formed to uniform radii without flattening.
 - 3. Ends of tubing shall be square-cut and de-burred before installation in fittings. Fittings shall be used for splices, connections, and turns near final connections. Bulkhead fittings shall be used when tubing enters a panel.
- D. Electrical Connections:
 - 1. Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of 2 feet.

3.02 TESTING

- A. Applicable testing requirements are specified in Section 17200.
- B. Testing requirements are specified in Section 17030.

3.03 TRAINING

A. Training requirements are specified in Sections 01664. Provide one training sessions, each with one-half hour for each type of level transmitter.

PART 4 APPENDIX - INSTRUSPECS

4.01 INSTRUSPECS

A. General requirements for instruments specified in this section are listed on INSTRUSPEC sheets herein. Application requirements are specified in the Instrument Index, and/or on the drawings.

Table A

INSTRUSPEC Symbol Instrument description		Instrument function			
LT	Water Level Transmitter	Well Level Measurement			
LPT	Tank Level Transmitter	Tank Level Measurement			

4.02 INSTRUMENT IDENTIFICATION: LT

- A. Instrument Function: Well Level Measurement
- B. Instrument Description: Water Level Transmitter
- C. Power Supply: 24Vdc.
- D. Signal Output: 4-20 mA.
- E. Sensor: Piezoresistive type with Titanium body and Delrin nose cone.
- F. Product Requirements:
 - 1. Temperature Range: -5 to 50 degC.
 - 2. Accuracy: 0.05 percent of span.
 - 3. Resolution: 0.005 perecent full-scale
 - 4. Manufacturer: In-Situ Level TROLL 500 Series, or equal
- G. Execution:
 - 1. Installation: Install in accordance with manufacturer's instructions as specified on the drawings.
 - 2. Calibration: Switch set point and reset point adjusted as specified.

4.03 INSTRUMENT IDENTIFICATION: LPT

- A. Instrument Function: Level Measurement
- B. Instrument Description: Tank Level Transmitter
- C. Power Supply: Loop-Powered
- D. Signal Input: Process
- E. Signal Output: 4-20 mA
- F. Process Connection: Tank fittings
- G. Product Requirements:

- 1. Pressure Transmitter: Capacitance or piezoresistive type.
- 2. Wetted Parts: Type 316 stainless steel or as specified in Section 17200-3.03.
- 3. Range: 100:1.
- 4. Accuracy: 0.075 percent of calibrated span.
- 5. Static Pressure Rating: 2,000 psi.
- 6. Indicator: LCD display.
- 7. HART standard data communication protocol
- 8. Acceptable Manufacturer:
 - a. Rosemount 3051.
 - b. Accepted equal.
- H. Execution:
 - 1. Installation: Install in accordance with manufacturer's instructions as specified on the drawings.
 - 2. Calibration: Switch set point and reset point adjusted as specified.

END OF SECTION

This page intentionally left blank.

SECTION 17212-C

PRESSURE MEASUREMENT

PART 1 GENERAL

1.01 DESCRIPTION

- A. This section specifies requirements for instrumentation elements that quantitatively convert the measured variable energy into a form suitable for measurement and process measurement accessories. Application requirements are specified in Section 17200.
- B. This section specifies requirements for process pressure transmitters, associated indication devices, and accessories.
- C. This section specifies requirements for process pressure activated switches, devices, and accessories.
- D. This section specifies requirements for instrumentation elements which form a part of the process control systems specified in Section 17000 and Section 17200-3.03. Application requirements are specified in the instrument schedule, Section 17200-3.03.

1.02 QUALITY ASSURANCE

- A. Equipment furnished under this section shall be the products of firms regularly engaged in the design and manufacture of such equipment for a minimum of five years.
- B. Installation, calibration and testing of equipment furnished under this section shall be performed by qualified, skilled, Certified Technicians specified in Section 17000, who are regularly engaged in such activities involving systems of similar complexity.
- C. References are listed in Section 17000 and are a part of this section as specified and modified.

1.03 ENVIRONMENTAL CONDITIONS

A. Equipment provided under this section shall be suitable for operation under ambient conditions described in Section 17000-1.03.

1.04 SUBMITTALS

- A. Submittals shall be provided as specified in Section 17200-1.03.
- B. Submittals shall be provided as specified in Sections 01300 and 17000, including:
 - 1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Referenced and applicable sections to be marked up and submitted include:
 - a. Section 01664 Training
 - b. Section 01730 Operating and Maintenance Information

- c. Section 17000 General Requirements For Instrumentation And Control
- d. Section 17200 Instrument Index

A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.

The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications.

Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

- 2. A copy of the contract document Control Diagrams and Process and Instrumentation Diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
- 3. Marked Contract Document Mechanical and/or Electrical Plan drawings, sections, and details showing sensor installation locations and details. Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
- 4. Marked product literature of all equipment and features to be provided.
 - a. Installation drawings for only the transmitters, sensors, and mounting accessories to be provided.
 - b. Electrical and signal connection drawings for only the transmitters and sensors to be provided.
- 5. List of miscellaneous items, cables, spare parts, that will be provided in accordance with INSTRUSPEC sheet requirements.
- 6. Marked product literature for surge protectors.

PART 2 PRODUCTS

2.01 INSTRUMENTATION SPECIFICATION SHEETS (INSTRUSPEC)

- A. General requirements for instruments specified in this section are specified on the INSTRUSPEC sheets in the Appendix at the end of this section.
- B. Application requirements are specified in the Instrument Index, and/or on the drawings.

2.02 EQUIPMENT

- A. General:
 - 1. In accordance with Section 01300 the General Conditions of the Contract Documents, drawings, information, and technical data for all equipment as, required

in Section 17000 and this section shall be provided. All required product data for this section shall be included in one complete package.

- B. Process switches and devices shall comply with the following requirements:
 - 1. Contact outputs used for alarm actuation shall be normally-closed or normallyopened as required by the process condition to open to initiate the alarm.
 - 2. Contact outputs used to control equipment shall be normally-opened and shall close to start the equipment.
 - 3. Contacts monitored by solid state equipment such as programmable controllers or annunciators shall be hermetically sealed and rated for switching currents from 20 to 100 mA at 24 volts DC.
 - 4. Contacts, monitored by electromagnetic devices such as mechanical relays, shall be rated as NEMA ICS 2, designation B300.
 - 5. Double barriers provided between switch elements and process fluids such that failure of one barrier will not permit process fluids into electrical enclosures.
 - 6. Switch electrical enclosures rated as NEMA 250, Type 4 minimum.
 - 7. Switch range shall be selected so that the specified set point is at least 30 percent but not more than 70 percent of the span, between the upper range limit and the lower range limit.
- C. Measuring elements and transmitters shall comply with the following requirements:
 - 1. Measured parameter output indicators complying with paragraph 2.02 shall be provided with any transmitter that does not include an integral indicator. Indicators, whether integral or separate, shall be calibrated in process units, and engraved on the indicator scale plate.
 - 2. The two-wire type transmitters shall have operating power derived from the signal transmission circuit.
 - 3. Transmitters shall meet specified performance requirements with load variations within the range of 0 to 600 ohms with the power supply at a nominal 24 volts DC with the default range of 0 to 100% linearly corresponding to 4 to 20 mAdc.
 - 4. Transmitter output shall increase with increasing measurement.
 - 5. Time constant shall be adjustable from 0.5 to 5.0 seconds for transmitters used for flow, level transmitters used for flow measurement, or pressure measurement.
 - 6. Transmitter output shall be galvanically isolated via electro-mechanical or optical technology.
 - 7. Transmitter enclosures shall be rated NEMA 250, Type 4, unless otherwise specified.
 - 8. Transmitters located outdoors shall be provided with surge protectors:
 - a. Signal: Emerson/Rosemount Model 470 D, Emerson/EDCO SS64-036-2, CCI SPN-42 FS28 Series, or accepted equal.
 - b. AC Power: UL 1449, LED indicator, screw terminal connections, NEMA 4X. EDCO HSP121A or accepted equal.
 - 9. Two-wire transmitter located in a facility area classified as hazardous per the NFPA and the NEC shall be made safe by means of an intrinsic safety barrier as specified in paragraph 2.04.

10. Four-wire transmitters shall be isolated from the process and power or provided with a loop-powered signal current isolator as specified in paragraph 2.05 connected in the output signal circuit.

2.03 PROCESS PARAMETER OUTPUT INDICATOR

- A. Provide digital LED or LCD indicators that integral to the instrument housing where available from the manufacturer. Displays shall be scaled in engineering units, over the calibrated range of the instrument. Calibrate the indicator scale in process units.
- B. Analog output indicators shall be 2.5-inch milli-ammeter with 90-degree movement enclosed in a NEMA 7/9 rated meter case. Provide indicators with accuracy within two percent of span. Provide a diode to maintain loop continuity for indicator removal.

2.04 SIGNAL CURRENT ISOLATOR

- A. Isolator shall provide galvanic isolation of milliampere transmission signals from transmitters. Isolator shall be housed in a NEMA 250, Type 4/7 conduit body and derive operating power from the signal input circuit.
- B. Input and output signals shall be 4 to 20 milliamperes, and error shall not exceed 0.1 percent of span. Input resistance shall not exceed 550 ohms with an output load of 250 ohms.

2.05 PRODUCT DATA

- A. Additional Information: The following product data shall be provided:
 - 1. Flow calculation for each differential-type flow element.
 - 2. Record documentation shall include the data sheets specified in this section.
- B. The following data provided in accordance with Section 01300:
 - 1. Operating and maintenance information as specified in Section 17000-2.03. Include final reviewed submittal and separate record of all final configuration, jumper, and switch settings for each instrument.
 - 2. Test results as specified in Section 17030-2.02.

PART 3 EXECUTION

3.01 INSTALLATION

- A. General:
 - 1. General requirements for the installation of primary elements specified in this section are listed on INSTRUSPEC sheets.
 - 2. Installation requirements are specified in Section 17000-3.01.
- B. Process Connections:
 - 1. General: Unless otherwise specified, process taps shall comply with Section 15050. Process connections shall be arranged such that instruments may be readily removed for maintenance without disruption of process units or draining of large
tanks or vessels. Unions or flange connections shall be provided as necessary to permit removal without rotating equipment.

- a. Where process taps are not readily accessible from instrument locations, an isolation valve shall be provided at the instrument.
- b. Isolation valves shall be provided for each instrument where multiple instruments are connected to one process tap.
- c. Pipe between the process connection and instruments shall be 1/2-inch stainless steel with treatment material for easy removal, as specified herein.
- 2. Safety Instruments: No valves shall be installed at pressure taps for safety instruments. Safety instruments shall not be connected to the same process tap as instruments used for control, indication, or recording except when annular chemical seals are used.
- 3. Root Valves: Root valves shall be provided at all process taps, except as follows:
 - a. Temperature taps, where valves are unnecessary.
 - b. Pump discharge pressure taps where no instrument is permanently installed. Isolation valves shall be provided.
 - c. Process taps for safety instruments.
 - d. Where gauge valves are provided.
 - e. Where chemical seals are used.
- 4. Gauge Valves: Gauge valves shall be provided for each pressure gauge tap except where chemical seals are used.
- C. Tubing:
 - 1. Tubing shall be installed on supports spaced not more than 3 feet apart and shall run parallel of perpendicular to walls structural members, or intersections of vertical planes and the ceiling. Unless otherwise shown, tubing shall follow building surfaces closely or shall be carried in trays or conduit.
 - 2. Tubing shall not be supported from piping or equipment except at process taps or connections to the device served. Tubes supported directly on concrete surfaces shall be spaced at least 1/8 inch from the concrete. Tubing support shall be one-hole malleable iron clamps with clamp backs as required. Bends shall be formed to uniform radii without flattening.
 - 3. Ends of tubing shall be square-cut and de-burred before installation in fittings. Fittings shall be used for splices, connections, and turns near final connections. Bulkhead fittings shall be used when tubing enters a panel.
- D. Electrical Connections:
 - 1. Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of 2 feet.

3.02 TESTING

- A. Applicable testing requirements are specified in Section 17200.
- B. Testing requirements are specified in Section 17030.

3.03 TRAINING

A. Training requirements are specified in Sections 01664. Provide one training sessions, each with one-half hour for each type of level transmitter.

PART 4 APPENDIX - INSTRUSPECS

4.01 INSTRUSPECS

A. General requirements for instruments specified in this section are listed on INSTRUSPEC sheets herein. Application requirements are specified in the Instrument Index, and/or on the drawings.

Table A

INSTRUSPEC Symbol	Instrument description	Instrument function
PG	Pressure gage	Pressure measurement
PGT	Gage Pressure Transmitter	Pressure Measurement
PS	Pressure Switch	Pressure Measurement

4.02 INSTRUMENT IDENTIFICATION: PG

- A. Instrument Function: Pressure measurement
- B. Instrument Description: Pressure gage
- C. Power Supply: N/A
- D. Signal Input: N/A
- E. Signal Output: N/A
- F. Process Connection: 1/2-inch male NPT
- G. Product Requirements: Pressure gages shall be 4-1/2-inch premium grade, glycerin filled units with bourdon tube element, 270-degree milled stainless steel movement, phenolic case, and shatterproof glass window. Accuracy shall be 1 percent of span or better. All exposed metal parts shall be stainless steel. Pressure gage manufactures:
 - 1. Ashcroft Duraguage Figure 1279
 - 2. Ametek 1981L
 - 3. or equal.
- H. Execution:
 - 1. Installation: Install in accordance with manufacturer's instructions and the recommendations of API RP551 to the specified requirements.

Root valves shall be provided at all process pressure taps except taps made for safety instruments. Gage valves shall be provided at the instrument where the instrument is not within sight of the root valve or where two or more instruments are connected to a single tap.

Safety instruments shall not be connected to the same process tap as instruments used for control, indication, or recording. Unless otherwise specified, pressure instruments shall be located as close as practical to the process tap but shall be positioned to permit observation and maintenance. Pressure gages may be supported from the process tap if this location permits observation from the floor or a permanent work platform. Pressure instruments shall be installed in such a manner that blowout discs are not obstructed.

2. Application/Calibration: Application, calibration, and set points shall be as specified in Section 17200-3.03.

4.03 INSTRUMENT IDENTIFICATION: PGT

- A. Instrument Function: Pressure Measurement
- B. Instrument Description: Gage Pressure Transmitter
- C. Power Supply: Loop-Powered
- D. Signal Input: Process
- E. Signal Output: 4-20 mA
- F. Process Connection: 1/2-inch female NPT flange adapter
- G. Product Requirements:
 - 1. Pressure Transmitter: Capacitance or piezoresistive type.
 - 2. Wetted Parts: Type 316 stainless steel or as specified in Section 17200-3.03.
 - 3. Range: 100:1.
 - 4. Accuracy: 0.075 percent of calibrated span.
 - 5. Static Pressure Rating: 2,000 psi.
 - 6. Indicator: LCD display.
 - 7. HART standard data communication protocol
 - 8. Acceptable Manufacturer:
 - a. Emerson Rosemount 2051
 - b. Accepted equal.
- H. Execution:
 - 1. Installation: Install in accordance with manufacturer's instructions and the Engineer's installation detail.
 - 2. Root valves provided at all process pressure taps.
 - 3. Gauge valves provided at the instrument where the instrument is not within sight of the root valve or where two or more instruments are connected to a single tap.
 - 4. Safety instruments shall not be connected to the same process tap as instruments used for control, indication, or recording.
 - 5. Pressure instruments located as close as practical to the process tap and be positioned to permit observation and maintenance.
 - 6. Pressure instruments shall not be supported from process piping.

4.04 INSTRUMENT IDENTIFICATION: PS

- A. Instrument Function: Pressure Measurement
- B. Instrument Description: Pressure Switch
- C. Signal Input: Process
- D. Signal Output: As specified in paragraph 2.02
- E. Process Connection: 1/2-inch female NPT
- F. Product Requirements:
 - 1. Pressure switch shall consist of a pressure transducer and a precision switch. Pressure transducer shall be the diaphragm piston type with wetted materials as recommended by the switch manufacturer. Piston backed by a cylinder disc to permit 10 times over-range pressure without affecting calibration.
 - 2. Range spring and piston shall be isolated from process fluids by the diaphragm. Switch provided with two 3/4-inch conduit connections. Switch assembly housing shall be cast aluminum rated types 3, 4, and 7D per NEMA ICS6. Contractor shall select pressure transducer so that set point falls between 30 and 70 percent of maximum range.
 - 3. Approximate set point and, if applicable, reset point indicated on calibrated scales. Repeatability and sensitivity shall be 1.0 percent of operating range. Unless otherwise specified, switches nonadjustable deadband type.
- G. Approved Manufacturers: SOR Inc. Static-O-Ring, Mercoid Series 1000, or equal.
- H. Execution:
 - 1. Installation: Install in accordance with manufacturer's instructions and to the specified requirements.
 - 2. Application/Calibration: Application, calibration, and set points as specified in Section 17200-3.03.

END OF SECTION

SECTION 17212-D

PROCESS LIQUID ANALYTICAL MEASUREMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies requirements for process fluid analyzer indicating transmitters.

1.02 REFERENCES

A. References shall be as specified in Section 17000.

1.03 SUBMITTALS

- A. Submittals shall be provided as specified in Sections 01300 and 17000, including:
 - 1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Referenced and applicable sections to be marked up and submitted include:
 - a. Section 01664 Training
 - b. Section 01730 Operating and Maintenance Information
 - c. Section 17000 General Requirements For Instrumentation And Control
 - d. Section 17200 Instrument Index

A <u>check mark</u> shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.

The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. *Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.*

2. A copy of the contract document Control Diagrams and Process and Instrumentation Diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal.

If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

- 3. Marked Contract Document Mechanical and/or Electrical Plan drawings, sections, and details showing sensor installation locations and details. *Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.*
- 4. Marked product literature of all equipment and features to be provided.

- a. Installation drawings for only the analyzers, sensors, and mounting accessories to be provided.
- b. Electrical and signal connection drawings for only the analyzers and sensors to be provided.
- 5. List of miscellaneous items, cables, spare parts, replenishment parts, and chemicals that will be provided in accordance with INSTRUSPEC sheet requirements.
- 6. Marked product literature for surge protectors.

1.04 ENVIRONMENTAL CONDITIONS

A. Refer to Section 17000.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The Owner and Construction Manager believe the candidate manufacturers listed in the INSTRUSPEC sheets included in this Section are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section.

2.02 GENERAL

- A. Process fluid analyzers shall comply with the following requirements:
 - 1. Measured parameter output indicators shall be calibrated in process engineering units.
 - 2. Two wire Analyzers shall be 4 to 20 milliampere output with operating power derived from the signal transmission circuit.
 - 3. Transmitter shall support an external load of 0 to 500 ohms with the power supply at a nominal 24 volts DC with the range of 0 to 100% corresponding to 4 to 20 madc.
 - 4. Transmitter output shall be galvanically isolated from the process and the analyzer case.
 - 5. Analyzers located outdoors shall be provided with surge protectors.
 - a. Signal: Emerson/Rosemount Model 470 D, Emerson/EDC0 SS64-036-2, CCI SPN-42 FS28 Series, or accepted equal.
 - b. AC Power: UL 1449, LED indicator, screw terminal connections, NEMA 4X. EDCO HSP121A or accepted equal.
 - 6. Transmitter output shall increase with increasing process measurement, except where specified as "reverse action" in the Instrument Index.
 - 7. Electrical parts of analyzer transmitter and/or primary element mechanisms shall housed in enclosures meeting NEMA 250, Type 4 requirements.
 - 8. Electrical equipment and analyzer transmitters located outdoors or in areas specified as corrosive shall have enclosures meeting NEMA 250, Type 4X requirements.
 - 9. Four-wire transmitters shall be isolated from the process and power or be provided with a loop-powered signal current isolator and shall be connected in the output signal circuit.

10. One analyzer transmitter shall be provided for each sensor. Dual sensor analyzer capability shall not be utilized.

2.03 PRODUCT DATA

- A. The following data shall be provided in accordance with Section 01300:
 - 1. Operating and maintenance information as specified in Section 17000-2.03. Include final reviewed submittal and separate record of all final configuration, jumper, and switch settings for each analyzer.
 - 2. Test results as specified in Section 17030-2.02.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Installation requirements are specified in Section 17000-3.01.
- B. Outdoor:
 - 1. Transmitters mounted outdoors shall be provided with rain/sun hood.

3.02 TESTING

A. Testing requirements are specified in Section 17030.

3.03 TRAINING

A. Training requirements are specified in Sections 01664 and 17000. Provide one training session, each with one hour per type of Analyzer.

3.04 INSTRUMENTATION SPECIFICATION (INSTRUSPEC) SHEETS

- A. General requirements for instruments specified in this section are listed on INSTRUSPEC sheets herein. Application requirements are specified in the Instrument Index, Section 17200, and/or on the drawings.
- B. INSTRUSPEC sheets for the analyzers listed in the following Table A are included in this paragraph:

Table A: List of Process Fluid Analyzer Indicating Transmitters

INSTRUSPEC Symbol	Analyzer Description	Instrument Function
AC	Conductivity Analyzer	Analyzer Indicating Transmitter
ATI	Optical Turbidimeter Analyzer	Analyzer Indicating Transmitter

3.05 AC INSTRUMENT SPECIFICATION SHEET-INSTRUSPEC

- A. Instrument Identification: AC
- B. Instrument Description: Conductivity Analyzer
- C. Power Supply: 120 volts AC

- D. Signal Output:
 - 1. 4 to 20 mA into 0 to 500 ohms, isolated
 - 2. Two Form C relay outputs
- E. Process Connection: Insertion
- F. Product Requirements:
 - 1. Analyzer: Analyzer transmitter shall be pipe/surface mount, NEMA 4X with integral keypad/display and self-diagnostics system. Unit shall be Hach SC200, or equal.
 - 2. Sensor: Conductivity measurement shall be made with an titanium electrode sensor with integral Pt 1000 RTD temperature sensor designed for immersion service water quality monitoring. Sensor shall be Hach 3422, or equal.
 - 3. Calibration Buffers: Two sets of two different conductivity buffers. Use one set for testing/calibration and training, second set for Owner.
 - 4. Insertion Mounting: Accessories as required for insertion mounting the sensor, provided by sensor Manufacturer.
- G. Execution:
 - 1. Installation: Insertion assemblies shall be installed per Manufacturer instructions.
 - 2. Outdoor transmitters shall be installed with a rain/sun hood.
 - 3. Application/Calibration: In accordance with Section 17200-3.03.

3.06 ATI INSTRUMENT SPECIFICATION SHEET-INSTRUSPEC

- A. Instrument Identification: ATI
- B. Instrument Description: Optical Indicating Turbidimeter
- C. Power Supply: 120 volts AC
- D. Signal Output:
 - 1. 4 to 20 mA into 0 to 500 ohms, isolated
 - 2. Three Form C relay outputs
- E. Process Connection: Sample
- F. Product Requirements:
 - 1. Analyzer: Analyzer transmitter shall be pipe/surface mount, NEMA 4X with integral keypad/display and self-diagnostics, and shall be Hach SC200.
 - 2. Sensor: All optical and hydraulic components shall be housed in the turbidimeter body which shall incorporate a built-in bubble trap. 0 to 700 NTU range. Turbidimeter shall be Hach TU5300; Engineer knows of no equal.
 - 3. Replacement Parts: One lamp assembly for each sensor/analyzer
 - 4. Junction Box: Hach.
 - 5. Calibration Standard: A Formazin Calibration Kit shall be provided consisting of a 1-liter calibration cylinder simulating the turbidimeter body, a Ten Sette Pipet and a pint bottle of 4000 NTU Formazin Primary Standard.

G. Execution:

- 1. Installation: Installation shall be in accordance with the manufacturer's recommendations.
- 2. Outdoor transmitters shall be installed with a rain/sun hood.
- 3. Application/Calibration: Application, calibration, and set points shall be as specified in Section 17200-3.03.
- 4. Manufacturer Services: Two hours per analyzer on-site, minimum one day.

END OF SECTION

This page intentionally left blank.

SECTION 17110

PROGRAMMABLE LOGIC CONTROLLERS

PART 1 GENERAL

1.01 DESCRIPTION

- A. Scope
 - This Section specifies requirements for programmable logic controllers (PLC) designed to execute discrete and continuous control logic with high reliability in industrial applications. Enclosures and components are specified in Section 17110.
 - 2. All PLCs provided for this project shall comply with the requirements of this Section.
- B. General Requirements
 - 1. General requirements shall be as specified in Sections 17000 and 17110. PLC assemblies provided by Equipment Manufacturers may be provided by firms other than the Systems Integrator.

1.02 QUALITY ASSURANCE

- A. References
 - This Section contains references to the following documents or documents listed in Sections 16000, 17000, and 17110. They are a part of this Section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this Section as if referenced directly. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.
 - 2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids).
 - 3. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.
 - 4. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
IEC 61131-3	Programmable Controllers – Part 3: Programming Languages
NEMA IA 2.2	Programmable Controllers - Equipment Requirements and Tests
NEMA IA 2.3	Programmable Controllers – Programming Languages

- B. Systems Integrator
 - 1. Responsibilities and qualifications shall be as specified in Section 17000.

- C. Factory Acceptance Tests:
 - 1. Factory Acceptance Tests are specified in Section 17030.
 - a. Submit factory test forms for approval prior to tests.
 - b. Provide all expenses for one Owner staff member and one Engineer staff member to witness factory testing. Travel shall be during business hours on weekdays.

1.03 SUBMITTALS

- A. The following information shall be provided in accordance with Sections 01300 and 17000:
- B. Shop Drawings:
 - 1. Submit under Section 17110, including:
 - a. A copy of this Specification Section, with addendum updates included, and all referenced and applicable Sections, with addendum updates included, with each paragraph check-marked to indicate Specification compliance or marked to indicate requested deviations from Specification requirements. A <u>check mark</u> shall denote full compliance with a paragraph as a whole.
 - b. If deviations from the Specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.
 - c. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the Specifications.
 - d. Failure to include a copy of the marked-up Specification Sections, along with justification(s) for any requested deviations to the Specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
 - 2. Submittal requirements per Section 17110 for the equipment specified herein.
 - 3. PLC Input/Output (I/O) loop diagram drawings.
 - 4. Internal power distribution schematic diagram drawings.
 - 5. PLC power supply loading calculations.
 - 6. List of spare parts to be provided.
- C. Factory Acceptance Test Schedule And Forms
 - 1. Submit under Section 17030 and per the requirements of this Section.
- D. Operating and Maintenance Information:
 - 1. Operating and maintenance information shall be provided in accordance with Section 01730, including the following for the PLC system:
 - a. Manufacturer, Representative, and Supplier contact information.
 - b. Manufacturer instruction manuals shall include only the following as applicable to the PLC system:
 - 1) Safety Precautions.
 - 2) Environmental Conditions.

- 3) Troubleshooting guides and diagnostic techniques.
- 4) Component connection diagrams.
- 5) Removal and replacement instructions.
- c. Warranty information.
- d. Final reviewed submittal.
- e. As-built drawings with record of switch and jumper settings for all components.
- f. List of spare parts provided.

PART 2 PRODUCTS

2.01 GENERAL

- A. Manufacturer
 - The Owner and Construction Manager require the specified Manufacturer to provide the equipment and/or products to be furnished under this Section. The Owner and Construction Manager believe the Manufacturer is capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed to mean that the named Manufacturer's standard product will comply with the requirements of this Section.
 - 2. Manufacturers and models shall be as specified for the purpose of compatible and efficient utilization of existing equipment, supplies, and personnel training and experience, no substitutions are permitted.
- B. Materials
 - 1. Equipment and/or products shall be new and unused at the time of system assembly.
- C. Controller conforming to NEMA IA 2.2, and with required memory and functional capacity to perform specified sequence of operation with scheduled input and output points.
 - 1. RFI/EMI Susceptibility: MIL STD 461B CS02.
 - 2. Showering Arc Test: NEMA Pub No ICS2-230.42.
 - 3. Surge Withstand: ANSI C37.90a.
 - 4. RFI Immunity: IEC 801-3.
 - 5. Ground Continuity: IEC 801-5.
 - 6. Electrostatic Discharge: IEC 801-2.
 - 7. Electromagnetic Field: IEC 61000-4-3.
 - 8. Fast transients: IEC 61000-4-4.

2.02 PROGRAMMABLE LOGIC CONTROLLER

- A. Manufacturer:
 - 1. Allen-Bradley CompactLogix 1769-L33R
- B. NEMA IA 2.3 and IEC 61131-3 compliant program editor with program written in Function Block or Sequential Function Language. Confirm the Language type required with the District before beginning programming. Program to be written using the same type of software as is specified below.

- C. Networking Connections: Provide all communication interfaces, network cables, taps, terminators, power supplies, and accessories for a complete operating network.
 - 1. Ethernet/IP.
- D. Processor:
 - 1. Serial port dedicated solely for programming use, and battery-backed solid-state RAM memory for storage of the control program. Provide additional serial communications adapters required for other serial interfacing. RAM memory size shall be provided so that 50% is available after program is tested.
- E. Input and Output Modules:
 - 1. Discrete Inputs: 120 Vac, 16 channel.
 - 2. Discrete Outputs: 120 Vac, 16 channel with interposing relays.
 - 3. Analog Inputs: 4-20 mAdc/1-5 Vdc, isolated channel-to-channel, 8 channel.
 - 4. Analog Outputs: 4-20 mAdc, isolated channel-to-channel, 4 channel.
 - 5. Spare Input/Outputs: The greater of a minimum one channel or 15 percent of each type provided per control panel.
 - 6. I/O Chassis spare slots: Minimum 1 per chassis.
- F. Power Supplies:
 - 1. Processor and I/O Chassis:
 - a. Single, 120 Vac input.
 - 2. I/O only Chassis: Single, 120 Vac input.
- G. Miscellaneous:
 - 1. Provide all cables, taps, terminators, power supplies, and accessories for a complete operating PLC system.

2.03 PROGRAMMING SOFTWARE

- A. The following software shall be provided by the Systems Integrator for this project.
 - 1. Programmable Logic Controller
 - a. Manufacturer:
 - 1) Allen-Bradley RSLogix 5000, RSLinx, and network module software
 - b. Licenses: Owner has licensed copy for their use
 - 2. SCADA Screens
 - a. Manufacturer:
 - 1) Inductive Automation Ignition
 - b. Licenses: Owner has licensed copy for their use

2.04 SPARE PARTS

- A. The following spare parts shall be provided
- B. Programmable Logic Controller
 - 1. One of each unique processor card.
 - 2. One of each unique communication card.

- 3. One for each ten, minimum of one for each unique I/O card.
- 4. One of each unique power supply.
- 5. One of each unique pre-fabricated cable.

2.05 CONTROL PANEL FABRICATION

- A. Refer to Section 17110.
- B. Detail shop drawings showing field connections and any terminal block jumpering required.
- C. Terminate all used and spare I/O wiring to terminal blocks.
- D. Create wire markers with "to-from" component name, PLC slot/base, or terminal column number and terminal number information identical at each end.
- E. Provide terminal Blocks for field connections to PLC Discrete Inputs:
 - 1. One fused terminal with LED for each group of 8 inputs, connected to control power.
 - 2. Fused terminal connected to eight terminal blocks to provide power to each field input circuit.
 - 3. One terminal per PLC input.
 - 4. One common terminal for each group of 8 inputs, connected to control power common.
 - 5. Surge protecting terminals for each field mounted instrument or equipment input signal, grounded to the frame ground bus.
- F. Provide terminal Blocks for field connections to PLC Discrete Outputs:
 - 1. One fused terminal with LED for each output, connected to control power.
 - 2. Provide interposing relay for each solid-state PLC output. Connect output and control power common to relay coil. Provide two terminals for relay contact, normally opened unless otherwise noted.
 - 3. One common terminal for each output, connected to control power common.
- G. Provide terminal Blocks for field connections to PLC Analog Inputs:
 - 1. One fused terminal with LED for each input, connected to +24 Vdc.
 - 2. Two terminals per PLC input.
 - 3. One common terminal for each input, connected to 24 Vdc common.
 - 4. One ground terminal for each input shield, connected to signal ground bus.
 - 5. Two surge protecting terminals for each field mounted instrument or equipment, grounded to the frame ground bus.
- H. Provide terminal Blocks for field connections to PLC Analog Outputs:
 - 1. One fused terminal with LED for each output, connected to +24 Vdc.
 - 2. Two terminals per PLC output.
 - 3. One common terminal for each output, connected to 24 Vdc common.
 - 4. One ground terminal for each output shield, connected to signal ground bus.

5. Two surge protecting terminals for field mounted equipment, grounded to the frame ground bus.

2.06 PRODUCT DATA

- A. The following Product Data shall be provided in accordance with Section 01300.
- B. Factory Acceptance Test Results:
 - 1. Submit under Section 17030 and per the requirements of this Section.
- C. Operating and Maintenance Information:
 - 1. Operating and maintenance information shall be provided in accordance with Section 01730, including the following.
 - a. Manufacturer, Representative, and Supplier contact information.
 - b. Manufacturer instruction manuals shall include only the following as applicable to the PLC system:
 - 1) Safety Precautions.
 - 2) Environmental Conditions.
 - 3) Troubleshooting guides and diagnostic techniques.
 - 4) Component connection diagrams.
 - 5) Removal and replacement instructions.
 - c. Warranty information.
 - d. Final reviewed submittal.
 - e. As-built drawings with record of switch and jumper settings for all components.
 - f. List of spare parts provided.
- D. PLC Program Systems Integrator
 - 1. Provide the as-built programmable controller program prepared using the software type specified in Part 2 and per Section 17315.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Refer to Section 17110.
- B. Connect input and output devices to the PLC via control panel terminal blocks, not directly to the PLC.

3.02 FIELD INSPECTION AND TESTING

- A. Refer to Section 17110.
- B. Equipment Manufacturer and Systems Integrator: The supplier of each PLC system shall provide a qualified service representative to perform the following:
 - 1. Inspect the PLC installation including I/O and network systems, hardware configuration switch and jumper settings.

- 2. Monitor all PLC system diagnostic indicators, both hardware and software, and certify that the PLC system performance meets or exceeds the Manufacturer's published specifications.
- 3. Assist in all testing. The Systems Integrator will provide a minimum of two man-weeks on-site for each PLC I/O rack.
- 4. Modify PLC programs as required.
- 5. Certify in writing to the Construction Manager that the PLC system has been installed and configured in accordance with the Manufacturer's published guidelines.
- C. Contractor
 - 1. Fault or trouble conditions shall be investigated and resolved by the Contractor to the satisfaction of the PLC supplier.

END OF SECTION

This page intentionally left blank

SECTION 17315

PROCESS CONTROL SYSTEM DEVELOPMENT AND PROGRAMMING

PART 1 GENERAL

1.01 DESCRIPTION

- A. Scope:
 - 1. This section specifies the general requirements applicable to the development and programming of the process control systems, graphical operator interface, historical data management system, and process control logic.

1.02 QUALITY ASSURANCE

- A. Implementation Plan Meetings:
 - 1. The Systems Integrator shall include as work of this section of the specifications the requirement for two (2) meetings to be held online. The primary function of the meetings shall be to solicit input from the Owner regarding the implementation of the process control system and to facilitate preparation of the Process Control System Implementation Plan specified herein.
 - 2. The Systems Integrator shall have in attendance at each meeting a representative who is responsible for the preparation of the Process Control System Implementation Plan. The preliminary schedule and agenda for each of the meetings shall be as described below. The specific dates for each of the meetings shall be scheduled by the Systems Integrator and approved by the Construction Manager.
 - 3. The Construction Manager shall be provided with two (2) weeks minimum advanced written notice of proposed scheduled meeting dates. The System Integrator shall prepare a detailed meeting agenda and submit it to the Construction Manager with the notice of proposed scheduled meeting dates.
 - a. Meeting-1 shall be held within sixty (60) days of receipt of Notice to Proceed. The purpose of this meeting shall be to begin preparation of the Process Control System Implementation Plan. The System Integrator shall be prepared to present the capabilities of the proposed process control system software and the alternatives available for each of the major areas of implementation described by the Process Control System Implementation Plan.
 - b. Meeting-2 shall be held within thirty (30) days of completion of the Engineer's review of the Process Control System Implementation Plan submittal. The purpose of this meeting shall be to discuss the submittal review comments and resolve any related issues.

1.03 SUBMITTALS

- A. The following information shall be provided in accordance with Section 01300:
 - 1. Process Control System Implementation Plan

PART 2 PRODUCTS

2.01 PRODUCT DATA

- A. The following data shall be provided in accordance with Section 01300:
 - Process Control System Developer's Guidelines: The Process Control System Implementation Plan shall be modified and updated during the course of development of the process control system control logic and graphical operator interface to reflect the conventions and standards used in the final system development. Upon final acceptance of the work, the updated implementation plan shall be re-published and submitted as the Process Control System Developer's Guidelines.
 - 2. Process Control System Configuration Report:
 - a. Report documenting the final configuration of the process control system including the following:
 - 1) Hardware Configuration: Final switch settings and jumper positions shall be documented for all process control system components including processors, communications adapter modules, motor controllers and adjustable frequency drives, power metering systems, etc.
 - Process Control Logic: Bound hard copy of the annotated process controller program listing. The program listing for each processor shall be separately bound and shall have tab dividers for each program file listing. Program listing shall include cross references.

PART 3 EXECUTION

3.01 PROCESS CONTROL SYSTEM IMPLEMENTATION PLAN

- A. General:
 - The Systems Integrator shall prepare an implementation plan for the process control system development and programming work. The implementation plan shall establish guidelines for development of the graphical operator interface, the historical data management system and the programmable logic controller (PLC) process control logic and shall insure the consistent application of conventions and methods through the course of development. The implementation plan shall specifically address the following:
 - a. Tag database structure and configuration.
 - b. Tag naming conventions.
 - c. Graphical operator interface standards.
 - d. Process control system configuration.
 - e. PLC program file organization.
 - f. PLC data file organization.
 - g. List and description of graphic displays.
- B. Tag Database Structure and Configuration:
 - 1. The implementation plan shall define how the tag database will be organized to logically associate tags with specific input/output types, functions, or process areas.

In addition, the plan shall prescribe guidelines for configuration of tag alarm handling and annunciation and tag data logging.

- C. Tag Naming Conventions:
 - A tag naming convention shall be established which provides a structured organization to the tag database facilitating tag searches and substitutions during system development and provide for effective and efficient design, management and operation of the process control system. The tag naming convention shall be developed to take full advantage of the capabilities of the process control system software and not impose any artificial constraints in the operation or management of the process control system. Tag names shall minimally be comprised of the following information:
 - a. Equipment type designation.
 - b. Equipment loop number.
 - c. Signal type designation.
- D. Graphical Operator Interface Standards:
 - 1. The configuration and development of the graphical operator interface shall be based on standards prepared specifically for this application. The interface standards shall be consistently applied to the development of the interface to insure optimum usability.
 - 2. All HMI development including tag naming scheme, screen navigation methods, use of pop-ups, etc. shall be implemented in a manner that is consistent with HMI systems in use elsewhere in the Owner's existing operations at other facilities. Graphic screens shall utilize the same colors, symbols, fonts, and features to provide an interface to operators that is uniform and consistent with existing HMI screens serving Owner's other facilities.
 - 3. The interface standards shall specifically address the following topics:
 - a. Graphical Display Type: The user interface will be comprised of various types of graphic displays including schematic overviews, control panels, faceplates, utility displays, and trend displays. The content and layout of each type of interface including navigational and utility features shall be defined by the standard. The standard shall also define the naming conventions for graphic display files.
 - b. Symbology: The symbology used in the preparation of the graphical interface shall be defined by this standard. The symbology standard shall address the following symbol types:
 - 1) Symbols representing process equipment, structures, piping, and systems.
 - 2) Navigational and utility system icons.
 - 3) Dynamic data display objects including numeric displays, bargraphs, indicating lights, text labels, etc.
 - 4) Control objects including pushbuttons, selector switches, slider bars, setpoint entry, etc.
 - c. Colors: The color standard shall define the foreground, background, and border colors used to indicate dynamic conditions (run, stop, alarm, trouble, ready, etc.), process-specific applications (raw water, settled water, finished water, chemicals, etc.), graphic display backgrounds, dynamic data objects, text, control objects, etc.

- d. Visibility: The visibility standard shall define the following:
 - 1) Application of blinking to graphic objects.
 - 2) Application of font styles and sizes.
 - 3) Manipulation of graphic object color to represent different conditions.
- e. Terminology: All terminology used to annotate the graphical interface shall be defined by these standards. The terminology standards shall define the following:
 - 1) Descriptive names used to identify the treatment processes, systems, structures, equipment, process variables, etc.
 - 2) Units of measurement for all process variables.
 - 3) Alarm condition descriptors.
 - 4) Abbreviations.
- f. Navigation: The navigation standard shall define the organization of the user interface and the features of the navigational system. This standard shall address all techniques used to implement the navigation system and where and how the navigation system is accessed including button bars, shortcut icons, hot links, continuation labels, and graphic menus.
- E. Process Control Logic Configuration:
 - 1. Guidelines shall be developed which define the organization and structure of the process control logic and data memory within the process controller. These guidelines shall address the following:
 - a. Structure of the control logic including the use of subroutines and the allocation of memory to accommodate modifications and expansion of the control logic.
 - b. Methodology for handling common control functions shall be standardized such that similar functions are implemented in a consistent manner across the entire project. Standardized routines for motor control, VFD control, instrument data handling, alarm management, etc. shall be developed and reviewed by the Owner prior to final programming.
 - c. Assignment of data storage memory including data formats and method of documenting memory mapping..
 - d. Methodology for implementing peer to peer communications including allocation of memory or register addresses is such a way as to organize data for optimum efficiency of data exchanges between peer processors.
- F. Process Control Strategies:
 - 1. Process control strategies shall be reviewed with the Owner and refinements made as agreed to by the Systems Integrator. Modifications to the control strategies that are determined to be a change in scope will be addressed by change order. The final process control strategies shall be incorporated into the Implementation Plan.

3.02 TAG DATABASE DEVELOPMENT

- A. General:
 - 1. The process control system tag database development shall include the definition of all device, derived and soft tags and the required alarm processing and data logging and archiving definitions for each tag. Conventions used in the development of the tag database shall be as defined in Process Control System Implementation Plan.

- B. Tag Definition:
 - 1. The definition of tags in the tag database shall comply with the following guidelines except as otherwise modified by the Process Control System Implementation Plan:
 - a. Tag Naming Conventions:
 - Tag names shall minimally consist of two distinct components. The leading component shall represent the tag equipment number. The trailing component (tag descriptor) shall be an abbreviated description of the associated process variable or the function of the tag. Each component shall be assigned a fixed maximum length which shall be dependent on the available tag name length supported by the process control system software.
 - 2) The tag equipment number shall be derived from the primary item of process equipment or instrumentation most closely associated with the process variable and shall be comprised of an equipment type prefix followed by process loop number. The equipment numbers shall be as defined by the Contract Documents.
 - 3) The tag descriptor shall provide a description of the process variable referenced by the tag name or a description of the function associated with the tag. Tag descriptors shall be based on ANSI/ISA-S5.1 and Appendix B of ISA-RP60.6. The tag descriptor may be comprised of several parts to clearly define the tag function. The following typographical convention shall be used to create the tag descriptor:
 - a) Symbol identification letters (ANSI/ISA-S5.1) shall be all upper case.
 - b) The first letter of an abbreviation (ISA-RP60.6) shall be upper case. The remainder of the abbreviation shall be lower case.
 - 4) Examples of the tag names are provided in Table 3.02.B.1:

Table 3.02.B.1

Tag Name	Tag Function
P1121PSH	Pump P1121 pressure switch high
FIT1101	Flow transmitter 1101
P1121Run	Pump P1121 run status

- 2. Tag Descriptions:
 - a. Describe the tag in terminology consistent with this application. Abbreviations and equipment numbers shall be not be used in the tag description without prior approval of the Owner. Tag descriptions shall not include any wording which implies the state or condition of the tag. For example, the tag description for P1121PSH shall read "Backwash Water Pump 1 Discharge Pressure" in lieu of "Backwash Water Pump 1 Discharge Pressure High."
- 3. ON/OFF and Alarm State Labels:
 - a. The ON/OFF and alarm state labels shall consist of words which describe the state of the tag. For digital tags, the logic TRUE state of the tag will generally be the state labeled.
 - 1) Examples of ON/OFF and alarm state labels include RUN, OFF, OPEN, CLOSED, READY, ALARM, NORMAL, HIGH, LOW, HIGH-HIGH, LOW-LOW, etc. Abbreviations shall not be used in ON/OFF or alarm state labels.

- C. Tag Types:
 - Tags shall be classified as either device tags, derived tags or soft tags. Device tags shall be those tags which have a physical device as the data source. Derived tags are those tags whose value is calculated or otherwise derived from another tag. Derived tags have no data source address. Soft tags are those tags whose value is obtained from another process software application. Tags shall be defined for each of the following tag data sources:
 - a. Physical input/output process variables derived from the process control input/output subsystems. Refer to the Input/Output Summary, Section 17310.
 - b. Control and status data derived from the process control logic required to fully implement the process control strategies specified in Section 17900. This data shall include the following types of information:
 - 1) Operating setpoints.
 - 2) Process operations setup and control parameters including start/stop, lead/lag, auto/manual, enable, etc.
 - 3) Operating status and fault data including ready, fail-to-run, etc.
 - 4) Timing/counting function data including preset and accumulated values.
 - c. Operating, fault and diagnostic data derived from the external systems, such as chlorine generator, metering pump systems, including the following:
 - 1) Process variable transmitters and analyzers.
 - 2) Operating status of all system equipment including run and ready status.
 - 3) Power parameters.
 - 4) System trouble and alarm conditions.
 - 5) Process control system diagnostic data.
 - 6) System status, control and configuration parameters including lead/lag selection, operating setpoints, etc.
 - Refer to the particular equipment specification section in Division 16 or 17 for specific data to be produced, consumed and transmitted by external systems.
 - d. Operating data derived from electronic power metering systems including the following power parameters:
 - 1) Kilowatts
 - 2) Kilowatt-hours
 - 3) Kilowatt demand
 - 4) Kilovars
 - 5) Kilovolt-amperes
 - 6) Kilovolt-ampere-hours
 - 7) Kilovolt-ampere demand
 - 8) Power factor
 - 9) Line currents
 - 10) Voltage (phase-to-phase and phase-to-ground)
 - 11) Line frequency.
 - e. Operating, fault and diagnostic data derived from solid-state adjustable frequency motor speed controllers including the following:

- 1) Run status
- 2) Drive fault
- 3) Start/stop control
- 4) Speed setpoint
- 5) Running speed
- 6) Running amps
- f. Diagnostic data derived from the process control system controllers, I/O subsystems, and communications controllers including the following:
 - 1) Controller operating mode
 - 2) Controller performance (e.g. Scan time)
 - 3) Controller fault status and fault code
 - 4) Controller time and date values
 - 5) Controller network address
 - 6) I/O subsystem fault status
 - 7) I/O module channel health
 - 8) Communication controller fault status
- g. Analytical, operating and diagnostic data derived from turbidity instruments including, but not limited to the following:
 - 1) Instrument operating mode
 - 2) Particle count in each of the particle size ranges configured.
 - 3) Instrument diagnostic or fault status and status code
 - 4) Instrument network address
 - 5) Communication link status or fault condition.
- h. Table 3.02.C.8 specifies the types of derived process variables and the associated real-time process variable.

Table	3.0	2.0	.8
-------	-----	-----	----

Real-time Process Variable Type	Derived Process Variable	Description
Flow	Totalized Flow	Totalized flow process variable shall be defined for all flow process variables.
Level	Volume	A process variable representing tank volume shall be defined for all chemical and fuel storage tanks and shall be based on the real-time level process variable and the geometry of the storage tank.
Run Status	Accumulated Runtime	An accumulated runtime process variable shall be defined for all rotating equipment which has an associated run status tag defined in the tag database.

- D. Data Logging:
 - 1. Tags representing the following types of process variables shall be defined in the tag database for data logging. This data shall support historical and real-time dynamic trending functions.
 - a. Flow or chemical feed rate
 - b. Process pressure
 - c. Storage tank level or volume

- d. All analytical instrument values including pH, turbidity, particle count, temperature, and chemical residual
- e. Filter loss of head
- f. Chemical storage weight
- g. Power parameters representing line current, kilowatts, kilovars, kilovolt-amperes, and power factor.
- E. Alarm Handling, Annunciation, And Logging:
 - 1. All discrete tags representing alarm or trouble conditions shall be defined in the tag database to be processed as alarms. All analog tags shall have alarm thresholds defined in the tag database. The value of the alarm thresholds shall be defined by the Owner during the preparation of the Process Control System Implementation Plan.
 - 2. The tag database shall be configured to implement alarm processing and annunciation as defined by the Process Control System Implementation Plan. Each tag's alarm definition shall prescribe whether the occurrence of the alarm condition is logged to journal, printed, or audibly annunciated or any combination thereof.

3.03 GRAPHICAL OPERATOR INTERFACE DEVELOPMENT

- A. General:
 - 1. The process control system graphical operator interface development shall include the preparation of the specified graphic displays in accordance with the Process Control System Implementation Plan and the requirements of this specification. The Systems Integrator shall prepare additional graphic displays as may be required to provide a comprehensive process and system management graphical operator interface.
- B. Development Guidelines:
 - 1. The graphical operator interface shall be developed in accordance with recognized usability practices to insure efficient and effective use of the process control system. The completed graphical operator interface shall adhere to the following three principles of usability:
 - a. Learnability: The graphical operator interface shall be easy to learn so that the user can quickly start being productive with the tools provided by the system.
 - b. Efficiency: The graphical operator interface shall be efficient to use, so that once the user has learned the system, a high level of productivity is possible.
 - c. Memorability: The graphical operator interface shall be easy to remember, so that the casual user is able to return to the system after some period of absence without the need to learn the interface over again.
 - 2. Adherence to the stated principles of usability shall be achieved through consistent application of the following development standards defined herein and as defined in the Process Control System Implementation Plan.
 - a. Graphic Design: The layout and organization of each graphic display shall be consistent among the graphic display types and shall adhere to the following standards:
 - 1) Position similar information and features of the graphical operator interface at the same location on each display.

- 2) Enclose groupings of associated data in a frame or box.
- 3) Color conventions shall be consistently applied throughout the graphical interface. Foreground colors shall be selected to provide contrast to the background color. Verify that all colors chosen can be viewed by the end-user.
- 4) Text font sizes, colors and types shall be consistently applied throughout the graphical interface.
- C. General Graphic Display Configuration:
 - 1. Graphic displays shall be configured as either full screen displays or pop-up displays. Each type of display configuration shall include the following features:
 - a. Full Screen Display
 - 1) Full screen displays shall be maximized, occupying the full, usable area of the window.
 - 2) Controls to close or minimize the window shall be disabled.
 - 3) Window exit control shall be embedded in the graphic display's navigational controls.
 - 4) Full screen displays shall remain in the background when a pop-up display is called from navigational hot links within the full screen display.
 - 5) Navigational and utility button bars shall be provided.
 - b. Pop-up Display
 - 1) Pop-up displays shall not occupy the full window and shall appear in the foreground when called from a full screen display.
 - 2) Pop-up displays shall appear at a user-defined location on the background display when called, but shall have the capability to be dragged to a different location on the screen.
 - 3) Pop-up displays shall not be resizable.
 - 4) Pop-up displays shall be provided with close control.
- D. Graphic Display Types:
 - 1. Graphic displays shall be categorized as either schematic overview, control panel, faceplate, trend or utility.
 - a. Schematic Overview: The schematic overview graphic display shall be presented as a process flow diagram and shall represent major process piping, major equipment, process variable data, and process alarm and status data.
 - b. Schematic overview displays shall be prepared in accordance with the following guidelines except as otherwise modified by the Process Control System Implementation Plan:
 - 1) Numeric display objects shall be provided to indicate the instantaneous value of all analog process data associated with the process. In addition, dynamic fill shall be used to indicate analog process data representing level.
 - 2) Dynamic equipment symbols shall be provided to indicate run, off, and fault conditions for all major equipment associated with the process.
 - 3) An alarm summary object indicating only those alarms related to the associated process shall be provided at the bottom of the display.

- 4) Continuation labels shall be provided to access associated schematic overview displays.
- 5) Hot links shall be provided on equipment symbols to provide access to an associated control panel display or faceplate.
- 6) Hot links shall be provided on numeric display objects to access associated trend displays.
- 7) Navigational and utility button bars shall be provided.
- 8) Schematic overview shall be a full screen display.
- c. Control Panel: The control panel graphic display shall be presented as a virtual control panel providing a point of operator interface for control of a specific equipment item or system.
- d. Control panel graphic displays shall be prepared in accordance with the following guidelines except as otherwise modified by the Process Control System Implementation Plan:
 - 1) Graphical control objects representing selector switches, pushbutton, slider bars, etc., shall be provided to initiate the appropriate control function.
 - 2) All pertinent operating status data associated with the equipment or system controlled by the panel shall be indicated.
 - 3) Navigational control in the form of short-cut icons or labels shall be provided to access associated graphic displays.
 - 4) Control panels shall be configured as pop-up graphic displays.
- e. PID controller Faceplate (if used): The PID controller faceplate graphic display shall represent the appearance and functionality of a typical PID controller. The PID controller faceplate graphic display shall provide a point of operator interface for control of a specific process.
- f. PID controller faceplate graphic displays shall be prepared in accordance with the following guidelines except as otherwise modified by the Process Control System Implementation Plan:
 - 1) Analog data shall be presented in numerical and bargraph format.
 - 2) PID operating status such as mode, high/low limiting, deadband in effect, etc., shall be indicated.
 - 3) Navigational control in the form of short-cut icons or labels shall be provided to access associated graphic displays.
 - 4) PID controller faceplates shall be configured as pop-up graphic displays.
- g. Trend Display: The trend graphic display shall present a graphical trend object with the associated controls to adjust the time scale and scroll the time axis.
- h. Trend graphic displays shall be prepared in accordance with the following guidelines except as otherwise modified by the Process Control System Implementation Plan:
 - 1) A pen legend shall be provided which associates the trend plot to a process variable description through the use of color.
 - 2) Y-axis shall be graduated and labeled in the appropriate engineering units.
 - 3) Controls shall be provided to adjust the time scale and to scroll the X-axis backwards and forwards.
 - 4) Navigational control in the form of short-cut icons or labels shall be provided to access associated graphic displays.

- 5) Trend graphic displays shall be configured as pop-up graphic displays.
- i. Utility Display: The utility graphic display shall present all pertinent data associated with an ancillary support system. The utility graphic display shall provide a point of operator interface for control, monitoring and management of the specified utility system.
- j. Utility graphic displays shall be prepared in accordance with the following guidelines except as otherwise modified by the Process Control System Implementation Plan:
 - 1) Provide a schematic representation of the utility system where specified.
 - 2) Numeric display objects shall be provided to indicate the instantaneous value of all analog process data associated with the utility.
 - 3) Dynamic symbols or labels shall be provided to indicate current condition of the utility and its components.
 - 4) Graphical control objects representing selector switches, pushbutton, slider bars, etc., shall be provided to initiate the appropriate control function.
 - 5) Navigational control in the form of short-cut icons or labels shall be provided to access associated graphic displays.
 - 6) Control panels shall be configured as either full screen displays or pop-up graphic displays, as specified.
- k. PLC System Status Display: The PLC system status graphic display shall present all pertinent data associated with the process PLC system itself. The PLC system status graphic display shall provide a diagnostic interface for troubleshooting, monitoring and management of the PLC system. No control is associated with the PLC system status graphic displays.
- I. PLC system status graphic displays shall be prepared in accordance with the following guidelines except as otherwise modified by the Process Control System Implementation Plan:
 - 1) Provide a schematic representation of the PLC system where specified.
 - 2) Provide detailed displays for each PLC processor showing the processor status, including diagnostic and fault codes. Display shall include communication status of Ethernet, IObus and any additional communication links associated with the processor.
 - Status of all discrete I/O points shall be indicated by dynamic text or colored graphical object. Status and raw data value of all analog I/O points shall be indicated by dynamic text.
 - 4) Dynamic symbols or labels shall be provided to indicate current condition of the processor and its components.
 - 5) Navigational control in the form of short-cut icons or labels shall be provided to access associated graphic displays.
- E. Navigation System:
 - 1. The navigation system shall be configured to provide a logical, intuitive path through the graphical operator interface and also provide the flexibility to directly access graphic displays and system utilities. The graphical operator interface shall be generally organized by process area; however, shortcuts shall be provided to navigate beyond process boundaries.

- 2. The graphical operator interface shall incorporate features to accommodate mouseoriented navigation throughout the process control system. Scrollable menus, button bars, embedded hotlinks and continuation labels shall be used to create a navigational system which provides ready-access to commonly used displays and utilities.
- 3. The navigation system shall be implemented in accordance with the following guidelines unless otherwise modified by the Process Control System Implementation Plan:
 - a. Process Overview Graphic Display: A process overview display schematically representing the overall facility shall be function as the system startup display and "home base" for conventional system navigation. Embedded hot links shall be provided on this display to permit access to all other displays.
 - b. Continuation Labels: Continuation labels shall be provided on all process schematic displays where a process line continues to another process area. These labels shall have embedded hot links to the process schematic display referenced by the label.
 - c. Graphic Menu System: A graphic menu system shall be provided where the navigational control action can result in multiple options. A graphic menu display shall be configured as a pop-up display and shall provide short cuts to associated graphic displays.
 - d. Short Cut Icons: Short cut icons shall be utilized to provide direct access to typical display types. Short cut icons shall be provided to represent schematic displays, control panels, trend displays, and PID controller faceplates. Short cut icons shall typically be applied to pop-up displays such as graphic menus, control panels, faceplates, and trend displays.
 - e. Hot Links: Hot links shall be embedded in each of the following types of display objects to provide access to an associated display or menu:

Table	3.03.E.5
IUNIC	0.00.2.0

Display Object	Hot Link
Equipment Symbol	Associated trend, PID controller faceplate, control panel or graphic menu display
Numeric Display	Associated trend display

3.04 PROCESS CONTROL LOGIC DEVELOPMENT

- A. The process control system control logic development shall include the preparation of control logic required to implement the specified control strategies and support the specified operator interface functions.
- B. Organization:
 - The control logic shall be organized in a hierarchical structure which correlates to the actual process relationships. Individual control logic program files shall be prepared for each system or equipment item and shall be organized by process area. Data table files shall be similarly organized by process area. Data types shall be consistently applied throughout the control logic in accordance with the Process Control System Implementation Plan.
 - 2. The control logic and data table organization shall facilitate the addition of future control logic.

- C. Documentation:
 - 1. All control logic shall be completely annotated down to and including the instruction level. Each rung or statement of control logic shall be provided with annotation specific to its function. Each program file shall have a title and a detailed description of the control strategy represented by the control logic. Terminology consistent with the Process Control System Implementation Plan shall be applied throughout.
- D. Control Logic Implementation:
 - 1. The project control strategies outline the general control requirements of the treatment process and associated utility systems. In addition to the requirements of the control strategies, the following control features shall be implemented in the process control logic:
 - a. Fail to operate: All automatically operated equipment shall be monitored for failure to respond to control requests from the process control system. Upon a call to start, stop, open, close, etc., a fail timer shall be initiated. If the appropriate equipment status signal (run, off, full open, full closed) is not reported back to the process control system within the time duration defined by the fail timer, an alarm shall be initiated through the process control system MMI.
 - b. Time based control: Process control logic for all equipment and processes' controlled on the basis of time duration shall provide for operator access to the preset value of the time function through the MMI and report back to the MMI the instantaneous value of the time function associated value.
 - c. PID Regulatory control: Every PID regulatory control function implemented in the process control logic shall be interfaced with the MMI to provide the following functions:
 - 1) Report to the MMI the instantaneous values of the process variable, setpoint, and control variable.
 - 2) Report to the MMI the current operating mode, high/low limiting in effect, deadband in effect, cascade mode in effect, etc.
 - 3) Provide operator control of the operating mode, setpoint value, and the control variable in manual mode.
 - 4) PID tuning parameters shall be accessible via password protected screens. Supervisor level access is required for modification of tuning parameters.
 - d. Control Setup Control functions which are described in the control strategies as operator initiated or invoked through the process control system MMI shall be interfaced with the MMI to permit operator manipulation of that control function and to report back the current status of the control configuration. Functions of this type include manual start/stop, lead/lag selection, hand/off/automatic selection, enable, setpoint adjustment, etc.
 - e. Real Time Data Server Communication: Control logic shall be implemented to facilitate and optimize the communication of data between the process control system real-time data server and the process controllers. Paragraph 3.02 of this specification defines the types of tags to be defined in the tag database. Control logic shall be implemented as required to make the specified real-time data available to the tag database. Control logic shall also be provided to support optimization of the communication between the process control system MMI real-time data server and the process controllers. Data of similar format (binary, integer, floating point, string, etc.) shall be grouped in data tables designated a

communication buffer files. All tags defined in the tag database shall be addressed to the designated communication buffer files.

3.05 HISTORICAL DATA MANAGEMENT SYSTEM

A. The historical data management system development shall include the preparation of extracts to enter the following real-time process variable types and associated attributes into the historical database.

Table 3.06

Process Variable Type	Sample Interval	Attribute			
		Total	Average	Maximum	Minimum
Flow	Hourly	Х	X	X	X
	Daily	Х			
Level	Daily		X	Х	X
Power	Daily	Х	X	х	Х
Pressure	Daily		X	Х	X
Equipment Run	Daily	Х			
Water Quality Analysis	Hourly	Х	X	Х	X
	Daily	X			

3.06 TESTING AND COMMISSIONING

A. The graphical operator interface shall be tested and commissioned in accordance with Section 17030.

END OF SECTION

SECTION 17710

SCADA RADIO COMMUNICATION SYSTEM

PART 1 GENERAL

1.01 DESCRIPTION

- A. Scope:
 - This Section specifies requirements for Supervisory Control And Data Acquisition (SCADA) radio communications equipment. Enclosures and components are specified in Section 17110.
- B. General Requirements:
 - 1. General requirements shall be as specified in Sections 17000 and 17110.
- C. Radio Path Survey:
 - 1. A radio path survey shall be provided by an experienced, qualified firm. The survey shall include:
 - a. Software terrain analysis.
 - b. Field survey using portable radio equipment and telescoping poles.
 - c. Antenna locations, heights, and directions.
 - d. Conflicts and proposed solutions.

1.02 QUALITY ASSURANCE

- A. References:
 - This Section contains references to the following documents or documents listed in Sections 16000, 17000, and 17110. They are a part of this Section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this Section as if referenced directly. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.
 - 2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.
- B. Systems Integrator:
 - 1. Responsibilities and qualifications shall be as specified in Section 17000.

1.03 SUBMITTALS

- A. The following information shall be provided in accordance with Sections 01300 and 17000:
 - 1. Radio Path Survey
 - a. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
 - 1) A <u>check mark</u> shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
 - b. Qualifications including years of experience performing surveys for both the survey firm and the person performing the survey, and survey software used.
 - c. Radio path survey for all sites shown.
 - 2. Shop Drawings
 - a. Submit under Section 17110, including:
 - 1) A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
 - a) A <u>check mark</u> shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
 - b. Submittal requirements per Section 17110 for the equipment specified herein.
 - c. List of spare parts to be provided.
 - 3. Operating And Maintenance Information
 - a. Operating and maintenance information shall be provided in accordance with Section 01730, including the following for the communication system:

- 1) Manufacturer, Representative, and Supplier contact information.
- 2) Manufacturer instruction manuals shall include only the following as applicable to the communication system:
 - a) Safety Precautions
 - b) Environmental Conditions
 - c) Troubleshooting guides and diagnostic techniques
 - d) Component connection diagrams
 - e) Removal and replacement instructions
- 3) Warranty information.
- 4) Final reviewed submittal.
- 5) As-built drawings with record of configuration, switch, and jumper settings for all components.

PART 2 PRODUCTS

2.01 GENERAL

- A. Manufacturer:
 - 1. The Owner and Construction Manager require the specified Manufacturer to provide the equipment and/or products to be furnished under this Section. The Owner and Construction Manager believe the Manufacturer is capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed to mean that the named Manufacturer's standard product will comply with the requirements of this Section.
 - 2. Manufacturers and models shall be as specified for the purpose of compatible and efficient utilization of existing equipment, supplies, and personnel training and experience, no substitutions are permitted.
- B. Materials:
 - 1. Equipment and/or components shall be new and unused.

2.02 5 GHZ CARRIER RADIO

- A. Point-To-Multi Point Remote Radio/Modem:
 - 1. AES-256 Encryption
 - 2. 2 10/100/1000 Ethernet Ports (1 Data / 1 Management)
 - 3. Frequency Range: 4.8 GHz 6.2 GHz
 - 4. Channel Bandwidth: 10/20/30/40/50/60/80/100 MHz Selectable
 - 5. Max Conducted TX Power: 29 dBm
 - 6. FCC Certified
 - 7. Manufacturer: Ubiquiti Networks airFiber 5XHD;
 - 8. Provide Antenna with radio

2.03 TRANSMISSION SYSTEM

- A. Transmission Line:
 - 1. Heliax cable only, closed-cell polyethylene foam-dielectric, 50 ohm, annular corrugated outer conductor. Air dielectric and non-heliax coaxial cables are not permitted.
 - a. Length from radio/modem to antenna less 50 than feet: Andrew LDF4-50A, 1/2".
 - b. Length from radio/modem to antenna of 50 feet or longer: Andrew LDF5-50A, 7/8".
 - c. Type N Male connectors only, UHF connectors are not permitted: Andrew.
 - d. Cold shrink connector weatherproof kit: Andrew.
 - e. Type N Female converting connector as required to connect to remote radio/modem.
 - 2. Lightning Protector: Polyphaser IS-B50LN-C1.
 - a. Install through radio/modem enclosure wall for enclosures installed outside.
 - b. Provide loose for installation at building entrance for enclosures installed inside buildings.
 - 3. For radio/modem enclosure installed outdoors, install lightning protectors in the enclosure and provide factory manufactured transmission line jumper to radio/modem. 1/2" Superflex Heliax cable with pre-attached type N Male connectors only, coaxial cable is not permitted. Andrew FSJ4-50B-NMNM, length as required.
- B. Directional Antenna:
 - 1. 4.9-5.9 GHz. 125 mph wind rated. Vertical polarization. Type N female connector.
 - 2. Gain: 23 dBi, 30 dBi, or 34 dBi; as required to meet specified bandwidth requirements.
 - 3. Manfucturer: Ubiquiti Networks AF-5G Series Slant 45
 - 4. Provide with Precision Alignment Kit

2.04 SPARE PARTS

2.05 CONTROL PANEL FABRICATION

- A. Refer to Section 17110.
- B. Detail shop drawings showing internal and antenna feedline connections.

2.06 PRODUCT DATA

- A. Product Data shall be provided in accordance with Section 01300
- B. Operating and Maintenance Information:
 - 1. Operating and maintenance information shall be provided in accordance with Section 01730, including the following for the communication system:
 - a. Manufacturer, Representative, and Supplier contact information.
 - b. Manufacturer instruction manuals shall include only the following as applicable to the communication system:
- 1) Safety Precautions.
- 2) Environmental Conditions.
- 3) Troubleshooting guides and diagnostic techniques.
- 4) Component connection diagrams.
- 5) Removal and replacement instructions.
- c. Warranty information.
- d. Final reviewed submittal.
- e. As-built drawings with record of configuration, switch, and jumper settings for all components.
- f. List of spare parts provided.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Enclosure:
 - 1. Refer to Section 17110.
- B. Transmission Line:
 - Route transmission line in conduit to protect from damage. Conduit sweeps shall be long radius bends and fittings shall not cause Manufacturer bend radius limits to be exceeded. Kinked line shall be replaced or a Manufacturer approved splice unit provided to remove the damaged section. Transition from outdoor conduit or pole to antenna shall be provided with a "CGB" weatherproof cord grip, weather-heads not permitted.
 - a. 1/2" Heliax routed in minimum 2" conduit.
 - b. 7/8" Heliax routed in minimum 3" conduit.
 - 2. Install connectors per Manufacturer instructions. Connection installation shall be witnessed by the Construction Manager. Install weatherproof cold shrink after connection to antenna or other outdoor component.
 - a. 1/2" Heliax mechanical and soldered connection.
 - b. 7/8" Heliax mechanical connection.
 - 3. Provide ground connection from ground grid / UFER to lightning protector, minimum #4 AWG.
- C. Antenna Pole:
 - 1. Fabricate antenna pole and base per details shown.
 - 2. Provide ground connection from ground grid / UFER to poles, minimum #4/0 AWG.
- D. Antenna:
 - 1. Align antennas per results of the Radio Path Survey.

3.02 FIELD INSPECTION AND TESTING

- A. Refer to Section 17110.
- B. Systems Integrator:
 - 1. Inspect the installation including transmission line and antenna installation, and radio/modem configuration, switch, and jumper settings.
 - 2. Use diagnostic software specified above to verify performance, and certify that the communication system performance meets or exceeds the Manufacturer's published specifications. Provide software for your configuration and diagnostics use if the Owner has their own copy. Perform Voltage Standing Wave Ratio (VSWR) tests, and troubleshoot readings of 2:1 ratio or higher and resolve.
 - 3. Assist in all testing. The Systems Integrator will provide a minimum of eight hours onsite. For unlicensed systems, change frequency zone for units if interference is suspected.
 - 4. Certify in writing to the Construction Manager that the communication system has been installed and configured in accordance with the component Manufacturer's published guidelines.
- C. Contractor:
 - 1. Transmission line or antenna related fault or trouble conditions shall be investigated and resolved by the Contractor to the satisfaction of the Systems Integrator.
 - 2. The Contractor shall replace damaged transmission line or related components, lightning protectors, poles, towers, or connectors that were installed improperly. Realign antennas as required for maximum signal strength.

END OF SECTION

SECTION 17715

VIDEO SURVEILLANCE

PART 1 GENERAL

1.01 DESCRIPTION

- A. Scope:
 - 1. This section specifies requirements for providing the remote security video surveillance system that interfaces with the SCADA system radio for remote monitoring from the SCADA Central Control Center operator workstation.
 - 2. The system inputs are video cameras as shown on the Communication Block Diagram.

1.02 QUALITY ASSURANCE

- A. References:
 - This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
 - 2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.
 - 3. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

lue
Standard Dictionary of Electrical and Electronics Terms
General Standards for Industrial Control and Systems
National Electrical Contractors Association – Standard Practices for Good Norkmanship in Electrical Contracting
National Electrical Code (NEC)
Enclosures for Electrical Equipment (1000 Volt Maximum)
General Requirements for Wiring Devices
Panelboards

1.03 SUBMITTALS

- A. Submittals and transmittal procedures for submittals are defined in Section 01300.
 - a. Referenced and applicable sections to be reviewed with this specification include: Sections: 01660, 01664, 16030, 17030.
 - 2. A copy of the contract documents and drawings relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
 - 3. Marked Product literature showing features, options provided, dimensions, clearances, and installation instructions.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Surveillance System Manufacturers:
 - 1. Backstreet Surveillance

2.02 SYSTEM EQUIPMENT

- A. Surveillance System Equipment:
 - 1. The security video surveillance system shall incorporate the following hardware and software:
 - a. Remote Video Engine (RVE): Integrated hardware and software unit for capturing and transmitting video streams and event data located at remote location.
 - b. The RVE system shall provide the collection, analysis, and storage of video images at a remote location without a high speed data connection to the remote site. The RVE system shall provide the following hardware characteristics.
 - 1) 8 Video Inputs
 - 2) Permanent storage of 100GB
 - 3) USB and Ethernet data communication access ports
 - c. Video Control Center (VCC):
 - 1) Software to manage configuration and monitor system.
 - d. The RVE system shall transfer video, event, and configuration information between the host VCC system and the RVE using the communications network.
 - e. The surveillance system shall provide three modes of video image collection:
 - 1) DVR Mode:
 - a) Local streaming video storage characteristics.
 - (1) 30 days local video storage
 - (2) 4k, 8mp, 6mp & 5mp resolution
 - (3) 10 frames / sec capture
 - (4) Open AVI file format with 24 hour files

- 2) Event Mode:
 - a) Event clip generation for detection of security events.
 - (1) Configurable Before and After time setting
 - (2) Associate up to 4 independent camera clips per event
 - (3) Upon activation of digital outputs
 - (4) Local store and forward of event clips
 - (5) Automatic transfer of event clips to central host (VCC) for analysis and storage when the communication link is available.
- 3) Live Mode:
 - a) On demand video streaming from the RVE to the VCC.
 - (1) Supports video streaming over low bandwidth networks beginning at 2400 baud.

2.03 CAMERA EQUIPMENT:

- A. Provide pole-mounted pan, tilt, and zoom cameras.
- B. Camera features:
 - 1. 3 Axis Motorized base for wide angles of rotation,
 - 2. 4K 8MP resolution
 - 3. 20x Optical Zoom,
 - 4. 300ft Color Night Vision,
 - 5. WDR, Day/Night,
 - 6. 512Kbps 12Mbps Video Bitrate,
 - 7. IP66 Weather Rated,
 - 8. Motion Detection,
 - 9. Image Centering,
 - 10. Remote camera positioning.
- C. Provide 15' Camera Pole With Pole Mount Bracket
- D. Manufactuer:
 - 1. Backstreet Surveillance ProPTZ-4K
 - 2. No Equal

2.04 ELECTRICAL ENCLOSURES AND AUXILIARY DEVICES:

- A. Equipment enclosures shall be in accordance with NEMA-250, NEMA-WD-1, and UL 67. Provide lockable hinged enclosure doors.
- B. Motion sensors to initiate recording when motion is detected in the area under surveillance.
- C. Network video recorder (NVR), as specified in 2.02, capable of saving camera data for ten weeks of recording with motion detection so footage is recorded when motion triggers the NVR system.
 - 1. Features shall include:

- a. Full time remote access
- b. Still images pausing
- c. Clear image copying
- d. Picture-in-picture and zoom
- e. Hard drive data storage
- 2. Manufactuer:
 - a. Backstreet Surveillance ProVue NVR Series.
 - b. No Equal

2.05 MANUFACTURER OR VENDOR SERVICES:

- A. Provide Manufacturer's or Vendor's personnel to provide on-site services to the Contractor.
- B. Provide expenses for onsite services to include:
 - 1. Installation supervision: Two man-days onsite.
 - 2. Testing: Two man-days onsite
 - 3. Commissioning: Two man-days onsite
 - 4. Training: Specified in paragraph 3.03.
- C. Provide Extended Warrantee and Support to include:
 - 1. Annual hardware and software maintenance program.
 - 2. Periodic software updates to the Video Control Center software and REV firmware.
 - 3. Factory telephone support.

2.06 SPARE PARTS:

- A. The following spare parts shall be furnished:
 - 1. 1 Camera
 - 2. Set of fuses.
- B. Spare parts shall be tagged and stored.

2.07 PRODUCT DATA

- A. Manufacturer's operation and maintenance information as specified in Section 01730. Manual shall include final reviewed submittal and separate record of all final configuration, jumper, and switch settings.
- B. Test results.
- C. Installation and training forms specified in Part 3.

PART 3 EXECUTION

3.01 INSTALLATION

- A. The equipment shall be installed and tested in accordance with the manufacturer's written recommendations by a qualified, factory trained manufacturer's representative.
- B. The equipment shall be fabricated in accordance with NEMA ICS and installed in accordance with NECA-1 procedures.

3.02 FIELD TESTING

- A. Testing shall conform to the requirements of Section 01660.
- B. Performance tests shall be conducted during field testing to measure the following characteristics: video transfer, storage, retrieval, editing, camera control, alarms etc..

3.03 TRAINING

A. A minimum of 4 hours of training conforming to the requirements of Section 01664 shall be provided. Training shall be certified as specified in Section 01730.

END OF SECTION

This page intentionally left blank.

SECTION 17800

NETWORK AND COMMUNICATION EQUIPMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies Plant Control System and SCADA System data communication network configuration verification and validation including performance testing with certified testing equipment. This section specifies the documentation of network configuration verification and data communication validation for the networks shown on the drawings.

1.02 QUALITY ASSURANCE

- A. References:
 - This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
 - 2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
EIA	Electronics Industries Alliance
TIA	Telecommunications Industry Association
NEC	National Electrical Code
NESC	National Electrical Safety Code

1.03 SUBMITTALS

- A. The following information shall be submitted in accordance with Section 01300. The submittal shall contain a cover sheet, indexed by item, and cross-referenced to the appropriate specification paragraph, and be organized in the following order:
 - 1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.

- 2. A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.
- 3. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications.
- 4. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
- 5. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

1.04 PROJECT / SITE CONDITIONS

A. The equipment shall be designed and manufactured to meet the specified requirement for environmental and seismic conditions.

PART 2 PRODUCTS

2.01 PRODUCT DATA

- A. Applicable information shall be provided in the product submittal, including:
 - 1. Test Equipment calibration certification for any testing devices used.
 - 2. Network block diagram and network routing site plan drawings.
 - 3. Testing Services Report sealed by a Registered Electrical or Control System Engineer.
- B. Industrial Managed Switch: network Ethernet switch to provide connectivity between the control system network components. Provide the switch with the following minimum features:
 - 1. Fan-less steel industrial-strength enclosure
 - 2. DIN rail mounted
 - 3. Minimum of eight (8) shielded RJ-45 ports with auto-negotitation and auto-MDI/MDIX
 - 4. Minimum of four (4) PoE/PoE+ capable ports
 - 5. Rapid Spanning Tree Protocol (RSTP) ring management
 - 6. Link Standby redundancy
 - 7. Bandwidth control
 - 8. Virtual cable test (VCT) utility
 - 9. Dual firmware, software management
 - 10. MODBUS TCP support
 - 11. 100/1000 Mbps operation
 - 12. SNMP monitoring
 - 13. Dry contact for local network health monitoring, or generation of alarm

- 14. Switch shall have a minimum of 2 spare ports after connection of all network components
- 15. Hirschmann BOBCAT series, or equal

PART 3 EXECUTION

3.01 ONSITE NETWORK INSPECTION AND VALIDATION SERVICES:

A. Coordinate the network inspection, validation and testing services with the Construction Manager.

3.02 FIELD TESTING

- A. The following items shall be tested:
 - 1. Test operation of communication ports.
 - 2. Test data communication circuit from end-to-end for each link of the network.
 - 3. Test for validation of 802.1 spanning tree to detect and eliminate bridging loops with each domain.
 - 4. Test for validation of snooping within each domain.
 - 5. Test the performance of the network.
 - 6. Test segment attenuation against segment propagation delay calculation.

3.03 FIELD VERIFICATION

- A. The network equipment shall be tested in accordance with paragraph 3.02 and the service providers' standard procedures.
 - 1. Correct node and subnet configuration.
 - 2. Proper usage of equipment i.e. switches, routers, hubs.
 - 3. Node count.
 - 4. Repeater configuration and optical power loss for fiber circuits.
 - 5. Redundant network function.
 - 6. Utilization, errors, collisions, broadcasts, protocols, stations, device detection, and connectivity for components shown on the network block and connection diagrams.
 - 7. Proper network and equipment safety grounding.

3.04 NETWORK CONFIGURATION VALIDATION REPORT

- A. Provide written verification results and recommendations.
 - 1. Operation of communication ports results.
 - 2. Data communication circuit from end-to-end for each link of the network results.
 - 3. Validation of 802.1 spanning tree to detect and eliminate bridging loops with each domain, results.
 - 4. Validation of snooping within each domain, results.
 - 5. Network performance results.

END OF SECTION

This page intentionally left blank.

SECTION 17900

PROCESS CONTROL DESCRIPTIONS

PART 1 GENERAL

1.01 SUMMARY

- A. SCOPE: These control strategies are not intended to apportion work or responsibility for work among subcontractors, suppliers and manufacturers, but are offered as a guide for programming, startup, and checkout. They describe how the system is to operate, and do not necessarily include every component required to make the system function.
 - Control strategies describe sequential and interlocking control functions, analog control functions, color-graphic video display HMI Computers and Operator Interfaces and alarm and event logging. The System Programmer will provide all necessary software and applications programming to implement the control strategies. All control functions shall be programmed in the PLCs, the Operator Interfaces and HMI computers shall perform supervisory functions.
 - 2. The System Integrator will configure Operator Interface to be high performance graphic displays for equipment status and alarming requirements for the abnormalities of the process and malfunctions of equipment.

1.02 RELATED SECTIONS

- A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
 - 1. Programming: Refer to Section 17000.

1.03 REFERENCES

- A. This Section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this Section as if referenced directly. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this section prevail.
 - 1. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI/ISA 5.06.01	Functional Requirements Documentation for Control Software
ANSI/ISA 101.01	Human Machine Interfaces for Process Automation

1.04 **DEFINITIONS**

- 1. Per ANSI/ISA 5.06.01:
 - 1. Analog Input (AI): A modulated signal received by the control system from an external device, such as a 4-20 mA or fieldbus signal from a pressure transmitter.
 - 2. Analog Output (AO): A modulated signal sent by the control system to an external control device, such as a 4-20 mA or fieldbus signal to a flow control valve.
 - 3. Discrete Input (DI): A binary signal received by the control system from an external switch, such as a 24-Vdc or fieldbus signal from a block valve's closed limit switch.
 - 4. Discrete Output (DO): A binary signal sent by the control system to an external on/off device, such as a 120-Vac or fieldbus signal to start a pump.
 - 5. Operation: A major programmed processing action or set of related actions normally consisting of one or more phases.
 - 6. Piping and Instrumentation Diagram (P&ID): A diagram showing the interconnection of process equipment and instrumentation used to control a process,
 - 7. Process Flow Diagram (PFD): A diagram showing outlines of one or more pieces of equipment and the expected flow paths for materials and utilities.
 - 8. Phase: The smallest element of procedural control that can accomplish a process-oriented task. A phase may be comprised of steps.
 - 9. Step: Sequential action of control devices within a phase.
- 2. Per ANSI/ISA 101.01:
 - 1. Control System: A system that responds to input signals from the equipment under control and/or from an operator and generates output signals that cause the equipment under control to operate in the desired manner.
 - 2. Human Machine Interface (HMI): The collection of hardware and software used by the operator or other users to monitor and interact with the control system and with the process via the control system.
 - 3. Supervisory Control and Data Acquisition (SCADA): A system for monitoring and control of process which are geographically widespread. This includes all equipment and functions for acquiring, processing, transmitting, and displaying the necessary process information.
- 3. For the purposes of this section, "Existing" refers to those structures, devices, or items of equipment which were a part of the process system prior to the work done under this Contract

1.05 ADMINISTRATIVE REQUIREMENTS

- A. The control strategies are not intended to apportion work or responsibility for work among subcontractors, suppliers and manufacturers, but are offered as a guide for programming, startup, and checkout. The control strategies describe how the system is to operate, and do not necessarily include every component required to make the system function.
- B. Coordinate with the Programmer as specified in Section 17000 for testing and commissioning.

1.06 SUBMITTALS

- A. PROCEDURES:
 - 1. Per Section 01300.
- B. ACTION SUBMITTALS:
 - 1. Conformance with specification per Section 17000.
- C. CLOSEOUT SUBMITTALS:
 - 1. Provide control strategies as record included in testing per Section 01662.

PART 2 NOT USED

PART 3 EXECUTION

3.01 CONTROL STRATEGIES

A. The following control strategies are included in this section and describe general control features for all systems.

Control Strategy Number	Title
1	Discrete Point Status
2	Analog Point Status
3	General Ready, Running and Failure Status
4	General Recording System
5	General Contact/Logic System
6	General Process Control Function (Analog) System
7	Trend Plots
8	Color Notation for Dynamic Objects on Control Graphic Display Screens
9	Discrete Alarm System
10	Discrete Status System
11	ASR Well Operation
12	Chemical Injection System

B. Refer to related sections for detailed process control system descriptions.

Control Strategy 1 Discrete Point Status

- A. Reference Drawings:
 - 1. All P&IDs.
- B. System Components:
 - 1. In accordance with P&IDs.
- C. Description:
 - 1. The status of each discrete input point shall be maintained in the SCADA system database. The status of each logical discrete point shall also be maintained in the SCADA system database. Logical points are points which depend upon the status of one or several discrete input points.
 - 2. For example, an equipment-failed logical status will result from a loss of ready status when running. Loss of ready status when NOT running will not result in a failed logical status.
- D. SCADA:
 - 1. Calculate and maintain the status of all discrete and logical discrete status points in the SCADA system database.

Control Strategy 2 Analog Point Status

- A. Reference Drawings:
 - 1. All P&IDs.
- B. System Components:
 - 1. In accordance with P&IDs.

C. Description:

- 1. Analog input points shall be checked for the following status conditions:
 - 1. Failed: Point value is less than or greater than the specified value range, typically less than 3.6 mA and greater than 21.6 mA.
 - 2. Low Alarm: Point value is equal to or less than a predetermined alarm value.
 - 3. High Alarm: Point value is equal to or greater than a predetermined alarm value.
 - 4. Normal: Point value is within the predetermined low and high alarm values.
- 2. An analog point which is in alarm status shall not be changed to normal status until the point value changes by the predetermined deadband value for the point.
- D. SCADA:
 - 1. Failed, high alarm, low alarm, and deadband values shall be maintained in the SCADA system database. These limits may be changed via the SCADA programmer.
 - 2. Point status shall be maintained in the SCADA system database. Discrete alarm outputs shall be driven from the point status.

Control Strategy 3 General Ready, Running and Failure System

- A. Each motor-driven piece of equipment shall have a RUNNING status input to the SCADA system. If the equipment is equipped with one or more HAND-OFF-AUTO switches, the equipment shall have an input for AUTO status. If a "RUNNING" input status occurs and the "AUTO" status does not occur, the SCADA system shall identify that the motor is operating in the HAND mode.
- B. The run time shall be calculated and stored for all equipment being monitored. This function shall be equivalent to a conventional elapsed time meter to include the tenth of an hour digit and shall include: Today's Total and Yesterday's total and Cumulative Total. Program a setpoint to set a flag for maintenance of equipment. Program an adjustable timer to set a flag for maintenance of equipment. A summary of equipment requiring maintenance shall be printed out upon plant operator request.
- C. The failure of driven equipment shall be monitored by the SCADA system. Equipment shall be considered failed under the following conditions:
 - 1. The equipment is in AUTO and the SCADA system attempts to operate the equipment and it does not respond within a defined time period.
 - 2. The equipment is in AUTO and running and for whatever reason other than the SCADA system requesting the equipment to "STOP," the equipment stops.
- D. In addition, specific equipment is required to provide "Fault" or other specific alarm inputs to the SCADA system. This input shall be added to the internal logic described in items 1 and 2 above so that any one of these events shall trigger a "FAIL" alarm.
- E. The SCADA system shall be used to the extent that it shall facilitate sequencing of the equipment. The plant operator shall be able to bypass the sequencing and START/STOP the equipment and OPEN/CLOSE valves and gates on a "MANUAL" procedure from the hand switches when desired. Interface to the SCADA system shall be through I/O points or workstations or laptops.

Control Strategy 4 General Recording System

- A. Reference Drawings:
 - 1. All P&IDs.
- B. Description:
 - 1. HMI workstations shall generate reports based upon process variables (pressure, flow, temperature, level and analytical) and equipment status (speed, and motor current) in real-time and from recent historical data. The exact report requirements will be determined by the Owner and shall be configured by the System Programmer during the project construction period.

Control Strategy 5 General Contact/Logic System

- A. Reference Drawings:
 - 1. All P&IDs.
- B. Description:
 - 1. All discrete/logic control functions shall be provided as required and shall include but not be limited to the following:
 - Discrete/Logic Functions: The ability to perform logic and sequencing functions shall be supported to provide control interlocks, event sequencing and other logic operations.
 - 2. Boolean Algebra requirements: AND gate, OR gate, NAND gate, NOR gate, XOR gate, and NXOR gate.
 - 3. Logic requirements: Logic switch, logic compare, bi-directional time delay, and on-off with feedback.
 - 4. Ladder Logic requirements: NO contact, NC contact, energize coil, latch/unlatch coil, retentive timer on/off delay, up/down counter, counter/timer reset, ladder execution control, immediate input, and immediate output.

Control Strategy 6 General Process Control Function (Analog) System

- A. Reference Drawings:
 - 1. All P&IDs.
- B. Description:
 - 1. All analog control functions shall be provided as required and shall include but not be limited to the following:
 - 1. Proportional-Integral-Derivative (PID) Control--Standard controller functions with balanceless, bumpless transfer from manual to automatic, manual overrides, external reset and output summing capabilities. Provision for cascade, rationing gain, bias, lead-lag, dead-time, feed forward, and feedback control shall be available.
 - 2. HMI display system shall have a common PID controller operator interface for all equipment utilizing PID control. Controller operator interface shall include alphanumeric and graphic indication of the following features as a minimum:
 - 1) ID of controlled equipment
 - 2) ID of process variable input
 - 3) Controller setpoint value
 - 4) Process variable value
 - 5) Controller output value
 - 6) Setpoint adjustment interface
 - 7) Indication if setpoint is under local or remote control
 - 8) Local/Manual control output adjustment interface
 - 9) Indication if control output is under local/manual control or under control of process controller
 - 3. Computational Functions: On-line mathematical functions shall be available to provide real-time computational capability of control variables for use in feed-forward and other advanced control functions.
 - 4. All setpoints for alarm and control shall be adjustable from password-protected HMI Computer screens. Coordinate level of security required for password protection of setpoint screens with the Owner and Engineer.
 - 5. Appropriate control action(s) shall be provided as needed.

Control Strategy 7 Trend Plots

- A. Reference Drawings:
 - 1. All P&IDs.
- B. Description:
 - 1. HMI workstations shall graphically plot trends of process variables (pressure, flow, temperature, level and analytical), controller setpoints and outputs, and equipment status (speed and motor current) in real-time and from historical data. The plant operator shall be able to select the plotting interval, within the limits of the actual data collection. Provide a minimum of four trends per display view.
 - 2. In addition to the plotted data, a trend shall include:
 - 1. Time
 - 2. Date
 - 3. Tag number
 - 4. Plotting interval
 - 5. Time at start
 - 6. Time at latest value

Control Strategy 8 Color Notation for Dynamic Objects on Control Graphic Display Screens

- A. Reference Drawings:
 - 1. All P&IDs, all control strategies.
- B. Description:
 - 1. All dynamic objects on control graphic display screens shall be provided with multiple-color display to identify status as tabulated below:

Equipment	Status	Required color
Motor	Running	Red
Motor	Ready, Stopped	Green
Valve	Open position	Green
Valve	Closed position	Red
All	Fault, Abnormal condition	Amber (Yellow)

Control Strategy 9 Discrete Alarm System

- A. Reference Drawings:
 - 1. All P&IDs, electrical control diagrams, and vendor drawings.
- B. System Components:
 - 1. In accordance with P&IDs.
- C. Description:
 - All discrete input alarms shall be provided as shown on P&IDs or listed in the instrument index (Section 17200) whether or not specific control strategies are provided. Whenever a P&ID is not shown with any On/Off, Start/Stop, Open/Close or analog modulation control, no specific control strategy will be written even if a discrete alarm system is shown on the drawing. For this condition, control strategies 1-11 shall be applicable. Discrete inputs can be from field instruments (level switches, pressure switches, etc.), local control panels (relay outputs, alarm module outputs, switches), and packaged systems (designated terminals with packaged units). A manual reset is required at the equipment control panel; Reset from SCADA is not acceptable.
 - 2. On a power failure, equipment shall return to the ready state when power is returned. Given the process condition, the lead piece of equipment shall start if called for. The lag and lag-lag, etc., starting sequence shall be staggered at 15-second intervals (adjustable) depending on the process. Operations shall designate this time during startup.

Control Strategy 10 Discrete Status System

- A. Reference Drawings:
 - 1. All P&IDs, electrical control diagrams, and vendor drawings.
- B. System Components:
 - 1. In accordance with contract drawings, P&IDs and as called out in the specifications.
- C. Description:
 - All discrete input status shall be displayed on HMI screens as required by the reference drawings and specifications regardless whether or not specific control strategies are provided. Each discrete input shall be shown in its appropriate process screen and/or equipment status screen. Discrete inputs can be originated from field instruments (motorized actuators, HVAC related air handling units, power management related contact inputs, level switches, pressure switches, etc.), local control panels (relay outputs, alarm module outputs, switches), and packaged systems (designated terminals with packaged units).
 - 2. All equipment HOA selector switch Auto mode status contact is to be monitored by the PLC. When the HOA switch is not in the Auto mode the SCADA system shall display "Not in Auto" for that respective piece of equipment.

Control Strategy 11 ASR Well Operation

- D. Reference Drawing:
 - 1. E-006, I-002, I-003
- E. System Components:
 - 1. Well Pump- PMP-101
 - 2. Well Level LIT-100
 - 3. Well Discharge Pressure PIT-110
 - 4. Well Waste Flow FIT-150
 - 5. Media Filter Flow FIT-170
 - 6. Well Column Flow FIT-290
 - 7. Well Raw Water Flow FIT-110
 - 8. Well Injection Tube Flow FIT-120
 - 9. Well Waste Valve MOV-148
 - 10. Well Column Flow Control Valve MOV-112
 - 11. Main Inlet/Outlet Valve MOV-210
 - 12. Main Inlet/Outlet Pressure PIT-211
 - 13. Well Injection Tubes Valve MOV-120
 - 14. Well Air Release Isolation Valve MOV-108
 - 15. Conductivity Analyzer AIT-165
 - 16. Conductivity Analyzer AIT-290
 - 17. Turbidity Analyzer AIT-405
 - 18. Engine Control Panel LCP-101
 - 19. Load Shedding Contactor CONT-A
- F. Description:
 - 1. The Broadview ASR well site will operate to inject or extract groundwater. The well will also be able to be periodically backflushed during the injection process. The well will have a vertical turbine pump that is diesel engine driven. Injection can be performed down the pump column with flow control at the wellhead. The well will also have one or more injection tubes next to the pump column to allow for more injection capacity. Because partial vacuum conditions will exist at the wellhead during injection down the pump column, the well will have a motorized air release isolation valve to prevent the introduction of air during injection with vacuum conditions. Other motorized valves will open, close, or modulate depending on the operation mode the system is in. Flow and pressure transmitters will monitor the system throughout injection, backflushing, and extraction.
- G. Control Descriptions:
 - 1. Operating Modes:
 - 1. Sleep:
 - 1) During periods of non-operation the system will disconnect power to the noncritical loads panel by opening the load shedding contactor (CONT-A). The

system will automatically transition to sleep mode after completing injection or extraction.

- 2) The operator will have the option to override the sleep mode and keep the non-critical loads powered for a set period of time. Once the time period has elapsed, the load-shedding contactor will open again.
- Injection: The ASR well should follow the prescribed sequence of operation for injection. There are two injection modes: Column & Tube Injection and Tube Only Injection
 - 1) Column & Tube Injection
 - a) Startup
 - (1) Close Load Shedding Contactor (CONT-A) and wait for a set period of time for non-critical loads to power up.
 - (2) Open the Well Column Valve (MOV-112).
 - (3) Open the Air Release Isolation Valve (MOV-108).
 - (4) Open the Well Waste Valve (MOV-148)
 - (5) Start the Well Pump at a moderate speed to fill the column and push out air. Water will be pumped overboard briefly.
 - (6) Open the Main Inlet/Outlet Valve (MOV-210).
 - (7) Once the air has been evacuated, close the Well Air Release Isolation Valve (MOV-108)
 - (8) Partially close the Well Column Valve (MOV-112)
 - (9) Close the Well Waste Valve (MOV-148)
 - (10) Stop the pump so that injection flow may begin.
 - (11) During injection, the Well Column Valve (MOV-112) should modulate to provide the desired flow rate, creating a vacuum downstream of the valve.
 - (12) During injection, monitor for abnormal conditions and stop the pump if there is an alarm condition.
 - (13) The Injection Tubes Valve (MOV-120) may also modulate open if tube injection is desired.
 - b) Stopping Injection
 - (1) Slowly close the Well Column Valve (MOV-112).
 - (2) Slowly open the Air Release Isolation Valve (MOV-108) to relieve the vacuum.
 - (3) Close the Main Inlet/Outlet Valve (MOV-210).
 - (4) If open, slowly close the Injection Tubes Valve (MOV-120)
 - (5) After a set period of time open the Load Shedding Contactor (CONT-A)
 - 2) Tube Only Injection
 - a) Startup
 - (1) Close Load Shedding Contactor (CONT-A) and wait for a set period of time for non-critical loads to power up.
 - (2) If not already open, open the Column Valve (MOV-112)
 - (3) Open the Waste Valve (MOV-148)
 - (4) Open the Main Inlet/Outlet Valve (MOV-210)

- (5) Close the Waste Valve (MOV-148)
- (6) Open the Well Injection Tube Valve (MOV-120)
- (7) Modulate the Well Injection Tube Valve (MOV-120) to meet desired flow
- b) Stopping Injection
 - (1) Close the Well Injection Tube Valve (MOV-120)
 - (2) Close the Main Inlet/Outlet Valve (MOV-210) if the injection season is complete
 - (3) After a set period of time open the Load Shedding Contactor (CONT-A)
- 3. Backflushing for combined Column & Tube Injection: The ASR well shall follow the prescribed sequence of operation for changing from injection mode to backflushing. The well should be backflushed and then injection restarted.
 - 1) Starting Backflushing
 - a) If not already closed, close the Load Shedding Contactor (CONT-A) and wait a set period of time for the non-critical loads to power up.
 - b) The Air Release Isolation Valve (MOV-108) should remain closed.
 - c) The Well Column Flow Control Valve (MOV-112) should be partially open at its injection setting.
 - d) Close the Injection Tubes Valve (MOV-120)
 - e) Open the Well Waste Valve (MOV-148)
 - f) Start the Well Pump at 70% speed, allowing water to discharge overboard into the border strip basins.
 - g) Fully open the Well Column Valve (MOV-112)
 - h) Close the Main Inlet/Outlet Valve (MOV-210)
 - i) After 15 minutes of operation, drop the engine speed to fast idle.
 - j) Open the Main Inlet/Outlet Valve (MOV-210)
 - k) Close the Waste Valve (MOV-148)
 - I) Wait 3 minutes
 - m) Restart the Well pump and slowly ramp up to 100% speed
 - n) Open the Waste Valve (MOV-148)
 - o) Close the Main Inlet/Outlet Valve (MOV-210)
 - p) Run the pump for an additional 20 minutes.
 - q) If injection is going to be restarted follow the steps outlined in 3.b.2 (below), otherwise stop the well pump.
 - r) After a set period of time open the Load Shedding Contactor (CONT-A)
 - 2) Restarting Injection After Backflushing:
 - a) Column & Tube Injection:
 - (1) Well pump should already be running. Reduce the pump speed until the wellhead pressure is about 20 psi.
 - (2) Open the Main Inlet/Outlet Valve (MOV-210).
 - (3) Close the Well Waste Valve (MOV-148)
 - (4) Partially close the Well Column Valve (MOV-112)
 - (5) Stop the Pump. Injection flow will begin.

- (6) Modulate the Well Column valve (MOV-112) to provide the desired flow rate down the column.
- (7) Open the Injection Tubes Valve (MOV-120)
- b) Tube Only Injection:
 - (1) Stop the Pump.
 - (2) Open the Injection Tubes Valve (MOV-120)
- 4. Extraction: The ASR wells should follow the prescribed sequence of operation for long term extraction
 - 1) Close Load Shedding Contactor (CONT-A) and wait for a set period of time for non-critical loads to power up.
 - 2) Open the Well Column Valve (MOV-112)
 - 3) Open the Well Waste Valve (MOV-148)
 - 4) Start the Well pump
 - 5) Open the Main Inlet/Outlet Valve (MOV-210)
 - 6) Gradually close the Well Waste Valve (MOV-148)
 - 7) Gradually adjust pump speed to produce the desired flow into the distribution system.
 - 8) During extraction, monitor for abnormal conditions and stop the pump if there is an alarm condition.
- H. Interlocks and Permissives:
 - 1. Hardwired Interlocks
 - 1. Engine Control Panel
 - 1) High Discharge Pressure
 - 2) Engine High Temperature
 - 3) E-Stop
 - 2. Software Interlocks
 - 1. Well Pumps A
 - 1) Low Flow
 - 2) Well High Level (During Injection)
 - 3) Well Low Level (During Extraction)

Control Strategy 12 Chemical Injection System

- A. Reference Drawing:
 - 1. I-002
- B. System Components:
 - 1. Injection System Control Panel PNL-500
 - 2. Chlorine Pump
 - 3. Chlorine Tank
- C. Description:
- D. Control Descriptions:
 - 1. Local Control:
 - 1) The Injection System Control Panel shall have a Hand-Off-Auto switch for each Chlorine and Chemical pump
 - 2) Placing the HOA switch to the Hand position will start the respective pump. The pump will stop if the HOA switch is placed in the Off position.
 - 2. Auto Control: With the HOA switch in the Auto position, the pump is started and stopped via the PLC/SCADA system.
 - 1) SCADA Manual Control:
 - a) When the software HOA switch is in the HAND position, the pump is started and will continue to run until the switch is placed in the OFF position.
 - 2) SCADA Auto Control:
 - a) When the software HOA switch is in the AUTO position, the pump is started and stopped automatically by the PLC/SCADA system. The start, stop, and speed of the pump will be depend on the operating mode selected
 - 3. Operation Modes:
 - 1) Chlorination
 - a) Intermittent chlorination should be performed once every 3 weeks or more often to prevent bioslime development in the wells. 100-300 ppm free Cl is planned as an initial target.
 - b) Chlorine injection should stop 10 minutes prior to backflushing.

Control Strategy 13 PV Battery System

- A. Reference Drawing:
 - 1. E-005 / E-006
- B. System Components:
 - 1. Battery Inverter
 - 2. Battery Charger
 - 3. Battery Bank
 - 4. PV Array
- C. Description:
 - 1. The PV Battery system consists of the PV array which charges the battery bank via a battery charger. The battery inverter converts the energy stored in the battery bank (DC) so that it can be used for the 120 VAC loads.
- D. Operation:
 - 1. During operation of the ASR Well system monitor the battery state of charge (SOC).
 - A. Battery Low Level Warning < 55%.
 - B. Battery Low Level Alarm <45%
 - 1) Stop operation of the ASR Well system and chemicial injection system is the Low Level Alarm is reachedB
 - Allow the ASR Well and chemical injection system to be operated again if the SOC goes is greater than 55%
 - C. Battery Critical Level Alarm <20%
- E. Monitoring:
 - 1. Provide the following monitoring of the PV Battery System:
 - A. Battery
 - B. State Of Charge (SOC)
 - C. Voltage (V)
 - D. Temperature
 - E. Amp-Hours In
 - F. Amp-Hours Out
 - 2. Battery Charger
 - a. Target Charge Voltage
 - b. Charging Voltage
 - c. Charging Current (A)
 - d. Charging Power (W)
 - e. Input Voltage
 - f. Input Current
 - g. Input Power (W)
 - h. Energy

- 1) Daily kWH
- 2) Total kWH
- 3. Battery Inverter
 - a. AC Output
 - 1) Voltage
 - 2) Current (A)
 - 3) Power
 - a) Real (W)
 - b) Apparent (VA)
 - 4) Energy
 - a) Daily kWH
 - b) Total kWH
 - b. DC Input
 - 1) Voltage
 - 2) Current (A)
 - 3) Power (W)

End of Control Strategy 13

END OF SECTION