



OAK HARBOR WASTEWATER TREATMENT PLANT

MBR SYSTEM EQUIPMENT PROCUREMENT

TECHNICAL SPECIFICATIONS

March 2014



PROCUREMENT DOCUMENTS REPRESENT PRELIMINARY DESIGN INFORMATION FOR THE PROPOSED CITY OF OAK HARBOR CLEAN WATER FACILITY TO SOLICIT PROPOSALS FROM EQUIPMENT MANUFACTURERS. FINAL DESIGN DOCUMENTS WILL BE DEVELOPED BASED ON AND WITH THE ASSISTANCE OF THE SELECTED EQUIPMENT MANUFACTURER. LAYOUT OF EQUIPMENT AND REQUIRED ANCILLARY COMPONENTS ARE SUBJECT TO CHANGE AS THE FINAL DESIGN IS DEVELOPED.



March 2014

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CITY OF OAK HARBOR
OAK HARBOR WASTEWATER TREATMENT PLANT
MBR SYSTEM EQUIPMENT PROCUREMENT
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SECTION 01110

SUMMARY OF WORK

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Identification and summary description of the Project, the Work, location, Owner-furnished products, activities by others, coordination, and early occupancy by Owner.
- B. Related section:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.

1.02 THE PROJECT

- A. The City plans to construct and install 2.42 million gallons per day (mgd) of average day flow production capacity (9.0 mgd peak hour production capacity, 4.98 mgd peak hour capacity), with provisions to expand the system to 4.3 mgd average day flow (12.4 mgd peak flow) in the future. The MBR system supplied by the manufacturer will include membranes and associated equipment.

1.03 THE WORK

- A. The Work consists of the pre-purchase of a membrane system equipment and appurtenant equipment including, but not limited to, equipment, related appurtenances, controls, engineering, submittal preparation, packaging factory testing, loading and freight, installation instruction and inspection, field support, start-up and testing assistance, O&M manual preparation, and Owner training, as specified herein. Controls and programming include the entire membrane system, as specified herein. Installation of the equipment will be by others.
- B. Except as specifically noted otherwise, provide and pay for:
 - 1. Insurance and bonds.
 - 2. Labor, materials, and equipment.
 - 3. Freight and insurance.
 - 4. Taxes per Bid Form.
- C. Comply with codes, ordinances, regulations, orders, and other legal requirements of public authorities having bearing on the performance of the Work.

1.04 LOCATION OF PROJECT

- A. The Work is located at the new Oak Harbor Wastewater Treatment Plant (WWTP), Oak Harbor, WA 98277.

1.05 ACTIVITIES BY OTHERS

- A. OWNER, utilities, and others may perform activities within Project area while the Work is in progress.
 - 1. Schedule the Work with Owner, utilities, and others to minimize mutual interference.
- B. Activities by others which may affect performance of work include: None.
- C. Cooperate with others to minimize interference and delays.
 - 1. When cooperation fails, submit recommendations and perform Work in coordination with work of others.

1.06 COORDINATION OF WORK

- A. Maintain overall coordination of the Work.
- B. Obtain construction schedules from each subcontractor, and require each subcontractor to maintain schedules and coordinate modifications.

1.07 EARLY OCCUPANCY OF PORTIONS OF WORK

- A. Owner's partial utilization of portions of Work prior to final acceptance of the completed Work will not be made.
- B. Certificates of Substantial Completion will be executed for each designated portion of Work prior to Owner occupancy.
 - 1. Such certificate of Substantial Completion will describe the portion of the Work to be occupied by Owner, items that may be incomplete or defective, date of occupancy by Owner, and other information required by Owner and Contractor.
- C. After Owner occupancy, allow access for Owner's personnel, access for others authorized by Owner, and Owner operation of equipment and systems.
- D. Following occupancy, Owner will:
 - 1. Provide power to operate equipment and systems.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01116

CONTRACT DOCUMENT LANGUAGE

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes: Explanation of arrangement, language, reference standards and format.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01600 - Product Requirements.

1.02 REFERENCES

- A. Construction Specifications Institute (CSI):
 - 1. MasterFormat™.
 - 2. SectionFormat™.
 - 3. PageFormat™.

1.03 PROJECT MANUAL ARRANGEMENT

- A. Document and Section numbers used in Project Manual, and Project Manual arrangement are in accordance with CSI MasterFormat™, except where departures have been deemed necessary.
- B. Sections are written in CSI SectionFormat™, Three-Part Section Format, except where departures have been deemed necessary.
- C. Page format for Sections in the Project Manual is in PageFormat™, except where departures have been deemed necessary.

1.04 CONTRACT DOCUMENT LANGUAGE

- A. Specification Section Paragraphs entitled "Section Includes" summarize briefly what is generally included in the section.
 - 1. Requirements of Contract Documents are not limited by "Section Includes" paragraphs.

- B. Specifications have been partially streamlined by intentionally omitting words and phrases, such as "the Contractor shall," "in conformity therewith," "shall be" following "as indicated," "a," "an," "the" and "all."
 - 1. Assume missing portions by inference.
- C. Phrase "by Engineer" modifies words such as "accepted," "directed," "selected," "inspected," and "permitted," when they are unmodified.
- D. Phrase "to Engineer" modifies words such as "submit," "report," and "satisfactory," when they are unmodified.
- E. Colons (:) are used to introduce a list of particulars, an appositive, an amplification, or an illustrative quotation:
 - 1. When used as an appositive after designation of product, colons are used in place of words "shall be."
- F. Word "provide" means to manufacture, fabricate, deliver, furnish, install, complete, assemble, erect in place, test, render ready for use or operation, including necessary related material, labor, appurtenances, services, and incidentals.
- G. Words "Supplier shall" are implied when direction is stated in imperative mood.
- H. Term "products" includes materials and equipment as specified in Section 01600.
- I. Owner is synonymous with the City of Oak Harbor (City).

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01300

SUBMITTALS

1. OPERATION AND MAINTENANCE DATA AND MANUALS. Adequate operation and maintenance information shall be supplied for all equipment requiring maintenance or other attention.

Operation and maintenance manuals shall include the following:

- a. Equipment function, normal operating characteristics, and limiting conditions.
- b. Assembly, installation, alignment, adjustment, and checking instructions.
- c. Operating instructions for startup, routine and normal operation, regulation and control, shutdown, and emergency conditions.
- d. Lubrication and maintenance instructions.
- e. Guide to troubleshooting.
- f. Parts lists and predicted life of parts subject to wear.
- g. Outline, cross-section, and assembly drawings; engineering data; and wiring diagrams.
- h. Test data and performance curves, where applicable.

The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered, or which may be required by Supplier.

Manuals and other data shall be printed on heavy, first quality paper, 8-1/2 by 11 inch size, with standard three-hole punching. Drawings and diagrams shall be reduced to 8-1/2 by 11 inches or 11 by 17 inches. Where reduction is not practicable, larger drawings shall be folded separately and placed in envelopes which are bound into the manuals. Each envelope shall bear suitable identification on the outside.

Three preliminary copies of each manual, temporarily bound in heavy paper covers bearing suitable identification, shall be submitted to Engineer prior to the date of shipment of the equipment. After review by Engineer, three final copies of each operation and maintenance manual shall be prepared and delivered to Engineer not later than 30 days prior to placing the equipment in operation. Final manuals and all parts lists and information shall be assembled in substantial, permanent, three-ring or three-post binders. As much as possible, material shall be assembled and bound in the same order as specified, and each volume shall have a table of contents and suitable index tabs.

All material shall be marked with project identification, and inapplicable information shall be marked out or deleted.

Shipment of equipment will not be considered complete until all required manuals and data have been received.

END OF SECTION

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SECTION 01410

REGULATORY REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Regulatory requirements:
 - 1. Building code.
 - 2. Electrical code.
 - 3. Energy code.
 - 4. Fire code.
 - 5. Mechanical code.
 - 6. Plumbing code.

1.02 REFERENCES

- A. National Fire Protection Association (NFPA):
 - 1. NFPA 70: National Electrical Code, 2011.
- B. State or Local Building Codes and Amendments.
 - 1. Washington Administrative Code (WAC)
 - a. Title 51 – Department of Commerce, Building Code Council.,
 - 1) Washington State Energy Code (Chapter 51-11).
 - 2) State Building Code - Building Code (Chapter 51-50).
 - 3) State Building Code - Mechanical Code (Chapter 51-52).
 - 4) State Building Code - Fire Code (Chapter 51-54).
 - 5) State Building Code - Plumbing Code (Chapter 51-56).
 - 6) State Building Code - Plumbing Code Standards (Chapter 51-57).

1.03 SYSTEM DESCRIPTION

- A. Design requirements:
 - 1. Building code:
 - a. Washington State Building Code – Building Code.
 - 2. Electrical code:
 - a. NFPA 70: National Electric Code.
 - 3. Energy conservation code:
 - a. Washington State Energy Code.
 - 4. Fire code:
 - a. Washington State Building Code – Fire Code.
 - 5. Mechanical codes:
 - a. Washington State Building Code – Mechanical Code.
 - 6. Plumbing code:
 - a. Washington State Building Code – Plumbing Code.
 - b. Washington State Building Code – Plumbing Code Standards.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used.

END OF SECTION

SECTION 01424

ABBREVIATIONS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Abbreviations and meanings.

1.02 INTERPRETATIONS

- A. Interpret abbreviations by context in which abbreviations are used.

1.03 ABBREVIATIONS

- A. Abbreviations used to identify reference standards:

AA	Aluminum Association
AABC	Associated Air Balance Council
AAMA	Architectural Aluminum Manufacturers Association
AAN	American Association of Nurserymen
AASHTO	American Association of State Highway and Transportation Officials
ABC	Associated Air Balance Council
AATCC	American Association of Textile Chemists and Colorists.
ABPA	Acoustical and Board Products Association
ACGIH	American Conference of Government Industrial Hygienists
ACI	American Concrete Institute
ACIL	American Council of Independent Laboratories
ADC	Air Diffusion Council
ABMA	American Bearing Manufacturers' Association (formerly AFBMA, Anti-Friction Bearing Manufacturers' Association)
AGA	American Gas Association
AGC	Associated General Contractors
AGMA	American Gear Manufacturers' Association
AHRI	Air-Conditioning, Heating, and Refrigeration Institute
AI	Asphalt Institute
AIA	American Institute of Architects
AIMA	Acoustical and Insulating Materials Association
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AITC	American Institute of Timber Construction
AMCA	Air Moving and Conditioning Association International, Inc.
AMG	Arizona Masonry Guild
ANSI	American National Standards Institute
APA	American Plywood Association
API	American Petroleum Institute
ASAHC	American Society of Architectural Hardware Consultants
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers

ASME	American Society of Mechanical Engineers
ASTM	ASTM International
AWI	Architectural Woodwork Institute
AWPA	American Wood Protection Association
AWPI	American Wood Preservers Institute
AWS	American Welding Society
AWSC	American Welding Society Code
AWWA	American Water Works Association
BHMA	Builders Hardware Manufacturers Association
BIA	Brick Institute of America
BSI	Building Stone Institute
CFR	United States Code of Federal Regulations
CLFMI	Chain Link Fence Manufacturers Institute
CPSC	U.S. Consumer Product Safety Commission
CRA	California Redwood Association
CRI	Carpet and Rug Institute
CRSI	Concrete Reinforcing Steel Institute
CS	Commercial Standards
CSA	CSA International
CSI	Construction Specifications Institute
CTI	Ceramic Tile Institute
DHI	Door and Hardware Institute
EIFS	Exterior Insulation and Finish System
EJCDC	Engineers Joint Contract Documents Committee
EPA	United States Environment Protection Agency
FDA	Food and Drug Administration
FGMA	Flat Glass Marketing Association
FHWA	Federal Highway Administration
FIA	Factory Insurance Association
FM	FM (Factory Mutual) Global
FS	Federal Specifications
FTI	Facing Tile Institute
GA	Gypsum Association
HI	Hydraulic Institute
HMMA	Hollow Metal Manufacturers Association
IAPMO	International Association of Plumbing and Mechanical Officials
ICBO	International Conference of Building Officials
ICC	International Code Council
ICEA	Insulated Cable Engineer's Association
IEEE	Institute of Electrical and Electronics Engineers
ISA	International Society of Automation
ISO	International Organization for Standardization
JIC	Joint Industrial Council

MIA	Marble Institute of America
ML/SFA	Metal Lath/Steel Framing Association
MS	Military Specifications
NAAMM	National Association of Architectural Metal Manufacturers
NACE	NACE International
NAPA	National Asphalt Pavement Association
NAVFAC	Department of the Navy Facilities Engineering Command
NBHA	National Builders Hardware Association
NCMA	National Concrete Masonry Association
NEBB	National Environmental Balancing Bureau
NEC	National Electrical Code
NECA	National Electrical Contractors Association
NETA	International Electrical Testing Association
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NFPA	National Forest Products Association
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NMWIA	National Mineral Wool Insulation Association
NPCA	National Paint and Coatings Association
NRCA	National Roofing Contractors Association
NSF	NSF International
NTMA	National Terrazzo and Mosaic Association
NWMA	National Woodwork Manufacturer's Association
OSHA	Occupational Safety and Health Administration
PCA	Portland Cement Association
PCI	Prestressed Concrete Institute
PDCA	Paint and Decorating Contractors of America
PDI	Plumbing and Drainage Institute
PEI	Porcelain Enamel Institute
PS	Product Standard
RCSC	Research Council on Structural Connections
RILEM	International Union of Testing and Research Laboratories for Materials and Structures
RTI	Resilient Tile Institute
SAE	SAE International
SCPA	Structural Clay Products Association
SDI	Steel Door Institute
SIGMA	Sealed Insulating Glass Manufacturers Association
SJI	Steel Joist Institute
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
SSPC	Society for Protective Coatings
TABB	Testing, Adjusting, and Balancing Bureau
TCA	Tile Council of America

UL	Underwriters Laboratories, Inc.
UNS	Unified Numbering System
USDA	United States Department of Agriculture
USACE	U.S. Army Corps of Engineers
VA	Vermiculite Association
WCLA	West Coast Lumberman's Association
WCLIB	West Coast Lumber Inspection Bureau
WPA	Western Pine Association
WPOA	Western Plumbing Officials Association
WRC	Welding Research Council
WSCPA	Western States Clay Products Association
WWPA	Western Wood Products Association

B. Abbreviations used in Specifications and Drawings:

a	year or years (metric unit)
A	ampere or amperes
am	ante meridian (before noon)
ac	alternating current
ac-ft	acre-foot or acre-feet
APC	average power consumption
atm	atmosphere
AWG	American Wire Gauge
bbl	barrel or barrels
bd	board
bhp	brake horsepower
BIL	basic impulse insulation level
bil gal	billion gallons
BOD	biochemical oxygen demand
BNR	biological nutrient removal
Btu	British thermal unit or units
Btuh	British thermal units per hour
bu	bushel or bushels
BV	bed volume(s)
C	degrees Celsius
cal	calorie or calories
cap	capita
cd	candela or candelas
cfm	cubic feet per minute
Ci	curie or curies
CIP	clean-in-place
CIPP	Cured-in-Place Pipe
CFD	computational fluid dynamic
cm	centimeter or centimeters
cmu	concrete masonry unit
CO	carbon monoxide
Co.	Company

CO ₂	carbon dioxide
COD	chemical oxygen demand
Corp.	Corporation
counts/min	counts per minute
cu	cubic
cu cm	cubic centimeter or centimeters
cu ft	cubic foot or feet
cu ft/day	cubic feet per day
cu ft/hr	cubic feet per hour
cu ft/min	cubic feet per minute
cu ft/sec	cubic feet per second
cu in	cubic inch or inches
cu m	cubic meter or meters
cu yd	cubic yard or yards
d	day (metric units)
day	day (English units)
db	decibels
D/d	column diameter to particle diameter ratio
DB	dry bulb (temperature)
dc	direct current
diam	diameter
DO	dissolved oxygen
DS	dissolved solids
EBCT	empty bed contact time
EGL	energy grade line
emf	electromotive force
F	degrees Fahrenheit
ft	feet or foot
fc	foot-candle or foot candles
fpm	feet per minute
fps	feet per second
ft/day	feet per day
ft/hr	feet per hour
ft/min	feet per minute
ft/sec	feet per second
g	gram or grams
G	gravitational force
gal	gallon or gallons
gal/day	gallons per day
gal/min	gallons per minutes
gal/sec	gallons per second
gfd	gallons per square foot per day
g/L	grams per liter
gpd	gallons per day
gpd/ac	gallons per day per acre
gpd/cap	gallons per day per capita
gpd/sq ft	gallons per day per square foot
gph	gallons per hour

gpm	gallons per minute
gpm/ft ²	gallons per minute per square foot
gps	gallons per second
g/cm ³	grams per cubic centimeter
h	hour or hours (metric units)
ha	hectare or hectares
HMI	human machine interface
hp	high point
hp	horsepower
hp-hr	horsepower-hour or horsepower-hours
hr	hour or hours (English units)
Hz	hertz
ID	inside diameter
ihp	indicated horsepower
Inc.	Incorporated
inch	inch
inches	inches
inches/sec	inches per second
IPT	initial performance test
J	joule or joules
JTU	Jackson turbidity unit or units
k	kips
K	kelvin
K	thermal conductivity
kA	kiloampere
kcal	kilocalorie or kilocalories
kcmil	thousand circular mils
kg	kilogram or kilograms
kip	kilopound or kilopounds
km	kilometer or kilometers
kN	kilonewton or kilonewtons
kPa	kilopascal or kilopascals
ksi	kips per square inch
kV	kilovolt or kilovolts
kVA	kilovolt-ampere or kilovolt-amperes
kW	kilowatt or kilowatts
kWh	kilowatt hour
L	liter or liters
lb/1000 cu ft	pounds per thousand cubic foot
lb/acre-ft	pounds per acre-foot
lb/ac	pounds per acre
lb/cu ft	pounds per cubic foot
lb/day/cu ft	pounds per day per cubic foot
lb/day/acre	pounds per day per acre
lb/sq ft	pounds per square foot
L/D Ratio	Ratio of filter height to filter media particle diameter
lin	linear, lineal

lin ft	linear foot or feet
lm	lumen or lumens
lmh	liters per square meter per hour
log	logarithm (common)
ln	logarithm (natural)
lx	lux
m	meter or meters
M	molar (concentration)
mA	milliampere or milliamperes
max	maximum
mCi	millicurie or millicuries
meq	milliequivalent
meq/mL	milliequivalents per milliliter
MFBM	thousand feet board measure
mfr	manufacturer
mg	milligram or milligrams
mgd/ac	million gallons per day per acre
mgd	million gallons per day
mg/L	milligrams per liter
mrem	millirem
μF	microfarad or microfarads
Mil	0.001 inch (used for coating thickness)
mile	mile
mil. gal	million gallons
miles	miles
min	minimum
min	minute or minutes
ML	mixed liquor
MLSS	mixed liquor suspended solids
MLVSS	mixed liquor volatile suspended solids
mm	millimeter or millimeters
mol wt	molecular weight
mol	mole
Mpa	megapascal or megapascals
mph	miles per hour
MPN	most probable number
MPT	National Pipe Thread, male fitting
mR	milliroentgen or milliroentgens
Mrad	megarad or megarads
MTP	monitored test period
mV	millivolt or millivolts
MW	megawatt or megawatts
μg/L	micrograms per liter
μm	micrometer or micrometers
μS/cm	microSeimens per centimeter
N	newton or newtons
N	normal (concentration)
ND	not detected
No.	number
Nos	numbers

NPT	National Pipe Thread
NRC	noise reduction coefficient
NTU or ntu	nephelometric turbidity unit
oc	on center
OD	outside diameter
ORP	oxidation-reduction potential
OT	ortho-tolidine
OTA	ortha-tolidine-arsenite
oz	ounce or ounces
oz/sq ft	ounces per square foot
Pa	pascal or pascals
pl	plate or property line
PLC	programmable logic controller
pm	post meridiem (afternoon)
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
pr	pair
psf/hr	pounds per square foot per hour
psf	pounds per square foot
psi	pounds per square inch
psia	pounds per square inch absolute
psig	pounds per square inch gauge
PVC	polyvinyl chloride
qt	quart or quarts
R	radius
R	roentgen or roentgens
rad	radiation absorbed dose
RAS	return activated sludge
RH	relative humidity
rpm	revolutions per minute
rps	revolutions per second
s	second (metric units)
S	Siemens (mho)
SCADA	supervisory control and data acquisition
scfh	standard cubic feet per hour
SDI	sludge density index or silt density index
sec	second (English units)
SI	International System of Units
sp	static pressure
sp gr	specific gravity
sp ht	specific heat
sq	square
cm ² or sq cm	square centimeter or centimeters
sq ft	square feet or foot
sq inch	square inch
sq inches	square inches
km ² or sq km	square kilometer or kilometers

m ² or sq m	square meter or meters
mm ² or sq mm	square millimeter or millimeters
sq yd	square yard or yards
SRT	solids retention time
SS	suspended solids
STC	Sound Transmission Class
SVI	sludge volume index
TDS	total dissolved solids
TEFC	totally enclosed, fan-cooled
TCF	temperature correction factor
TIN	total inorganic nitrogen
TKN	total Kjeldahl nitrogen
TLM	median tolerance limit
TMP	trans-membrane pressure
TOC	total organic carbon
TOD	total oxygen demand
TOW	top of weir
TS	total solids
TSS	total suspended solids
TVS	total volatile solids
U	U Factor/U Value
U	Coefficient of Heat Transfer
U	heat transfer coefficient
UNS	Uniform Numbering System
US	United States
V	volt or volts
VA	volt-ampere or volt-amperes
W	watt or watts
WAS	waste activated sludge
WB	wet bulb
wg	water gauge
WSE	water surface elevation
wk	week or weeks
WRT	water remediation technologies
wt	weight
yd	yard or yards
yr	year or years (English unit)

C. Abbreviations used on Drawings: As listed on Drawings or in Specifications.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01610

PROJECT DESIGN CRITERIA

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Project design criteria such as temperature and site elevation.

1.02 PROJECT DESIGN CRITERIA

- A. All equipment and materials for the project are to be suitable for performance in:
1. 3 to 100 degrees Fahrenheit.
 2. Design groundwater elevation: 5 feet below grade.
 3. Freeze-thaw conditions.
 4. Moisture conditions: Defined in individual equipment sections.
 5. Site elevation: Approximately 15.5 feet above mean sea level.
 6. Marine environment with coastal fog and sea salt spray.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

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SECTION 01612

SEISMIC DESIGN CRITERIA

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Seismic design criteria for the following:
 - 1. Anchorage of mechanical and electrical equipment.
 - 2. Seismic design and design of anchorage for small tanks fabricated off site and shipped to the Project site.
 - 3. Other structures or items as specified or indicated on the Drawings.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01410 - Regulatory Requirements.

1.02 REFERENCES

- A. American Society of Civil Engineers (ASCE):
 - 1. 7-05 - Minimum Design Loads for Buildings and Other Structures,

1.03 SYSTEM DESCRIPTION

- A. Design requirements:
 - 1. Design in accordance with the requirements of the building code as specified in Section 01410:
 - a. **[Design spectral acceleration at short period, S_{DS} : FILL-IN.]**
 - b. **[Design for the larger of the following:**
 - 1) **Design spectral acceleration at short periods, S_{DS} : FILL-IN.**
 - 2) **Design spectral acceleration at short periods, S_{DS} : Equal to the peak acceleration from site specific response spectra attached to this Section.**
 - c. Component amplification factor, a_p : In accordance with ASCE 7-05, Tables 13.5-1 and 13.6-1.
 - d. Component response modification factor, R_p : In accordance with ASCE 7-05, Tables 13.5-1 and 13.6-1.
 - e. Component importance factor, I_p : **[1.00] [1.50].**
 - 2. Do not use friction to resist sliding due to seismic forces.
 - 3. Do not use more than 60 percent of the weight of the mechanical and electrical equipment for designing anchors for resisting overturning due to seismic forces.

4. Do not use more than 60 percent of the weight of the tank for resisting overturning due to seismic forces.
5. Resist seismic forces through direct bearing on anchors and fasteners. Do not design or provide connections that use friction to resist seismic loads.
6. Do not use chemical anchors, concrete anchors, flush shells, powder actuated fasteners, sleeve anchors, or other types of anchors unless indicated on the Drawings or accepted in writing by the Engineer.
7. Seismic forces must be resisted by direct bearing on the fasteners used to resist seismic forces. Do not use connections that use friction to resist seismic forces.

1.04 SUBMITTALS

- A. Shop drawings and calculations: Complete shop drawings and seismic calculations.
- B. Calculations shall be signed and stamped by a civil or structural engineer licensed in the state where the Project is located.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01756

TESTING, TRAINING, AND FACILITY START-UP

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Requirements for equipment and system testing and facility start-up, including the following:
 - 1. Start-up plan.
 - 2. Performance testing.
 - 3. General start-up and testing procedures.
 - 4. Functional testing.
 - 5. Operational testing.
 - 6. Certificate of proper installation.
 - 7. Services of manufacturer's representatives.
 - 8. Training of Owner's personnel.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 11500 – Membrane Equipment System.
 - b. Section 15050 - Common Work Results for Mechanical Equipment.
 - c. Section 15954 - HVAC Systems Testing, Adjusting, and Balancing.
 - d. Section 15958 - Mechanical Equipment Testing.
 - e. Section 16950 - Field Electrical Acceptance Tests.
 - f. Section 17950 - Testing, Calibration, and Commissioning.

1.02 GENERAL TESTING, TRAINING, AND START-UP REQUIREMENTS

- A. Contract requirements: Testing, training, and start-up are requisite to the satisfactory completion of the Contract.
- B. Complete testing, training, and start-up within the Contract Times.
- C. Allow realistic durations in the Progress Schedule for testing, training, and start-up activities.
- D. Contractor to furnish labor, power, chemicals, tools, equipment, instruments, and services required for and incidental to completing functional testing, performance testing, and operational testing.

- E. Provide competent, experienced technical representatives of equipment manufacturers for assembly, installation and testing guidance, and operator training.

1.03 START-UP PLAN

- A. Submit start-up plan for the membrane equipment system.
- B. Provide detailed sub-network of Progress Schedule with the following activities identified:
 - 1. Manufacturer's services.
 - 2. Installation certifications.
 - 3. Operator training.
 - 4. Submission of Operation and Maintenance Manual.
 - 5. Functional testing.
 - 6. Performance testing.
 - 7. Operational testing.
- C. Provide testing plan with test logs for each item of equipment and each system when specified. Include testing of alarms, control circuits, capacities, speeds, flows, pressures, vibrations, sound levels, and other parameters.
- D. Provide summary of shutdown requirements for existing systems that are necessary to complete start-up of new equipment and systems.
- E. Revise and update start-up plan based upon review comments, actual progress, or to accommodate changes in the sequence of activities.

1.04 PERFORMANCE TESTING

- A. Test equipment for proper performance at point of manufacture or assembly when specified.
- B. When source quality control testing is specified:
 - 1. Demonstrate equipment meets specified performance requirements.
 - 2. Provide certified copies of test results.
 - 3. Do not ship equipment until certified copies have received written acceptance from Engineer. Written acceptance does not constitute final acceptance.
 - 4. Perform testing as specified in the equipment sections.

1.05 GENERAL START-UP AND TESTING PROCEDURES

- A. Mechanical systems: As specified in the individual equipment Sections and Sections 15050, 15954, and 15958:
 - 1. Remove rust preventatives and oils applied to protect equipment during construction.
 - 2. Flush lubrication systems and dispose of flushing oils. Recharge lubrication system with lubricant recommended by manufacturer.
 - 3. Flush fuel system and provide fuel for testing and start-up.
 - 4. Install and adjust packing, mechanical seals, O-rings, and other seals. Replace defective seals.
 - 5. Remove temporary supports, bracing, or other foreign objects installed to prevent damage during shipment, storage, and erection.

6. Check rotating machinery for correct direction of rotation and for freedom of moving parts before connecting driver.
 7. Perform cold alignment and hot alignment to manufacturer's tolerances.
 8. Adjust V-belt tension and variable pitch sheaves.
 9. Inspect hand and motorized valves for proper adjustment. Tighten packing glands to insure no leakage, but permit valve stems to rotate without galling. Verify valve seats are positioned for proper flow direction.
 10. Tighten leaking flanges or replace flange gasket. Inspect screwed joints for leakage.
 11. Install gratings, safety chains, handrails, shaft guards, and sidewalks prior to operational testing.
- B. Electrical systems: As specified in Section 16950 and the individual equipment Sections:
1. Perform insulation resistance tests on all conductors except conductors for 120 V lighting and conductors for control signals that are completely internal to electrical panels.
 2. Perform continuity tests on grounding systems.
 3. Test and set switchgear and circuit breaker relays for proper operation.
 4. Perform direct current high potential tests on all cables that will operate at more than 2,000 volts. Obtain services of independent testing lab to perform tests.
 5. Check motors for actual full load amperage draw. Compare to nameplate value.
- C. Instrumentation systems: As specified in Section 17950 and the individual equipment Sections:
1. Bench or field calibrate instruments and make required adjustments and control point settings.
 2. Leak test pneumatic controls and instrument air piping.
 3. Energize transmitting and control signal systems, verify proper operation, ranges, and settings.

1.06 FUNCTIONAL TESTING

- A. Supplier to supervise functional testing by the installation contractor.
1. Functionally test mechanical and electrical equipment, and instrumentation and controls systems for proper operation after general start-up and testing tasks have been completed.
 2. Demonstrate proper rotation, alignment, speed, flow, pressure, vibration, sound level, adjustments, and calibration. Perform initial checks in the presence of and with the assistance of the manufacturer's representative.
 3. Demonstrate proper operation of each instrument loop function including alarms, local and remote controls, instrumentation, and other equipment functions. Generate signals with test equipment to simulate operating conditions in each control mode.
 4. Conduct function test under full load conditions, as specified in Section 11500 Membrane Equipment System. Replace parts that operate improperly.

1.07 OPERATIONAL TESTING

- A. After completion of operator training, Supplier to conduct operational test of the entire facility. Demonstrate satisfactory operation of equipment and systems in actual operation.
- B. Supplier to conduct operational test for continuous period, as specified in Section 11500 Membrane Equipment System. Operational test consist of the Initial Performance Test and the Membrane Equipment System Monitored Test Period, including the Average Power Consumption Test.
- C. Owner will provide operations personnel, power, fuel, and other consumables for duration of test.
- D. Supplier to immediately correct defects in material, workmanship, or equipment that became evident during operational test.
- E. Repeat operational test when malfunctions or deficiencies cause shutdown or partial operation of the facility or results in performance that is less than specified.

1.08 CERTIFICATE OF PROPER INSTALLATION

- A. At completion of Functional Testing, furnish written report prepared and signed by manufacturer's authorized representative, certifying equipment:
 - 1. Has been properly installed, adjusted, aligned, and lubricated.
 - 2. Is free of any stresses imposed by connecting piping or anchor bolts.
 - 3. Is suitable for satisfactory full-time operation under full load conditions.
 - 4. Operates within the allowable limits for vibration.
 - 5. Controls, protective devices, instrumentation, and control panels furnished as part of the equipment package are properly installed, calibrated, and functioning.
 - 6. Control logic for start-up, shutdown, sequencing, interlocks, and emergency shutdown have been tested and are properly functioning.
- B. Furnish written report prepared and signed by the electrical and/or instrumentation subcontractor certifying:
 - 1. Motor control logic that resides in motor control centers, control panels, and circuit boards furnished by the electrical and/or instrumentation subcontractor has been calibrated and tested and is properly operating.
 - 2. Control logic for equipment start-up, shutdown, sequencing, interlocks, and emergency shutdown has been tested and is properly operating.
- C. Co-sign the reports along with the manufacturer's representative and subcontractors.

1.09 TRAINING OF OWNER'S PERSONNEL

- A. Supplier to provide operations and maintenance training for items of mechanical, electrical, and instrumentation equipment. Utilize manufacturer's representatives to conduct training sessions.

- B. Contractor to coordinate training sessions to prevent overlapping sessions. Arrange sessions so that individual operators and maintenance technicians do not attend more than 2 sessions per week.
- C. Supplier to provide Operation and Maintenance Manual for specific pieces of equipment or systems 1 month prior to training session for that piece of equipment or system.
- D. Satisfactorily complete functional testing before beginning operator training.
- E. **[Provide training sessions for each work shift listed below during the time periods shown. Pooling of shifts will not be permitted unless accepted by Owner.]**

Shift		
Day	Tuesday, 7 a.m.-11 a.m.	Thursday, 7 a.m.-11 a.m.
Swing	Wednesday, 3 p.m.-7 p.m.	Thursday, 3 p.m.-7 p.m.
Graveyard	Monday, 11 p.m.-3 a.m.	Wednesday, 11 p.m.-3 a.m.]

- F. Training sessions: Provide training sessions for equipment as specified in the individual equipment Sections.

Section Number	Section title	O&M Manual Required	Minimum Number of Days for Actual Training
11242	Diaphragm-Type Metering Pumps	X	2
11312R	Rotary Lobe Positive Displacement Pumps	X	1
	All other pump Sections	X	1
11376A	Rotary Lobe Positive Displacement Blower System	X	2
11500	Membrane Equipment System	X	5
11500C	Chemical Cleaning System	X	1
11500E	Air Compressors	X	1
13446	Manual Actuators	X	-
13447	Electric Motorized Actuators	X	1
15112	Butterfly Valves	X	-
15114	Check Valves	X	-
15118	Pressure Reducing and Pressure Relief Valves	X	-
15120	Piping Specialties: Pressure Gauges	X	-

Section Number	Section title	O&M Manual Required	Minimum Number of Days for Actual Training
	Thermometers	X	-
16222	Low Voltage Motors Up to 500 Horsepower	X	-
16262	Variable Frequency Drives 0.50-50 Horsepower	X	3
16444	Low Voltage Motor Control Centers	X	1
16445	Panelboards	X	1
16500	Lighting	X	-
17050	Common Work Results for Process Control and Instrumentation Systems	X	1*

- G. The Contractor shall videotape all training sessions and provide a copy for the Owner.
- H. The Contractor shall designate and provide 1 or more persons to be responsible for coordinating and expediting his/her training duties. The person or persons so designated shall be present at all training coordination meetings with the Owner.
- I. The Contractor's coordinator shall coordinate the training periods with Owner personnel and manufacturer's representatives, and shall submit a training schedule for each piece of equipment or system for which training is to be provided. Such training schedule shall be submitted not less than 21 calendar days prior to the time that the associated training is to be provided and shall be based on the current plan of operation.

1.10 RECORD KEEPING

- A. Maintain and submit following records generated during start-up and testing phase of Project:
 1. Daily logs of equipment testing identifying all tests conducted and outcome.
 2. Logs of time spent by manufacturer's representatives performing services on the job site.
 3. Equipment lubrication records.
 4. Electrical phase, voltage, and amperage measurements.
 5. Insulation resistance measurements.
 6. Data sheets of control loop testing including testing and calibration of instrumentation devices and setpoints.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

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SECTION 01782

OPERATION AND MAINTENANCE DATA

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Preparation and submittal of Operation and Maintenance Manuals.
- B. Related section:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 11500 – Membrane Equipment System.
 - b. Section 15958 - Mechanical Equipment Testing.

1.02 SUBMITTALS

- A. Submit Operation and Maintenance Manuals before field quality control testing and before training of each piece of equipment or system.
- B. Submit **[4]** hardcopy manuals for each piece of equipment or system.
- C. Submit **FILL-IN** electronic copy manuals for each piece of equipment or system.
- D. Make manuals available at project site for use by construction personnel and Engineer.
- E. Make additions and revisions to the manuals in accordance with Engineer's review comments.

1.03 OPERATION AND MAINTENANCE MANUALS

- A. Preparation:
 - 1. Provide hardcopy Operations and Maintenance Manuals in 3-ring binders with rigid covers. Utilize numbered tab sheets to organize information.
 - 2. Provide electronic copy Operations and Maintenance Manuals in PDF Format.
 - 3. Provide original and clear text on reproducible non-colored paper.
 - 4. Provide all dimensions in English units.

B. Contents of Operation and Maintenance Manuals:

1. Cover page:
 - a. Equipment name, equipment tag number, project name, Owner's name, appropriate date.
2. Table of Contents:
 - a. General description of information provided within each tab section.
3. Equipment Summary Form:
 - a. Completed form in the format shown in Appendix A.
 - b. The manufacturer's standard form will not be acceptable.
4. Lubrication information:
 - a. Required lubricants and lubrication schedules.
5. Control diagrams:
 - a. Internal and connection wiring, including logic diagrams, wiring diagrams for control panels, ladder logic for computer based systems, and connections between existing systems and new additions, and adjustments such as calibrations and set points for relays, and control or alarm contact settings.
 - b. Complete set of 11-inch by 17-inch drawings of the control system.
 - c. Complete set of control schematics.
6. Programming:
 - a. Copies of all Contractor furnished programming.
7. Start-up procedures:
 - a. Recommendations for installation, adjustment, calibration, and troubleshooting.
8. Operating procedures:
 - a. Step-by-step procedures for starting, operating, and stopping equipment under specified modes of operation.
 - b. Include safety precautions and emergency operating shutdown instructions.
9. Preventative maintenance procedures:
 - a. Recommended steps and schedules for maintaining equipment.
10. Overhaul instructions:
 - a. Directions for disassembly, inspection, repair and reassembly of the equipment; safety precautions; and recommended tolerances, critical bolt torques, and special tools that are required.
11. Parts list:
 - a. Complete parts list for all equipment being provided.
 - b. Catalog data for all products or equipment furnished including generic title and identification number of each component part of equipment.
 - 1) Include bearing manufacturer, model and ball or roller pass frequencies for every bearing.
12. Spare parts list:
 - a. Recommended number of parts to be stored at the site and special storage precautions.
13. Drawings:
 - a. Exploded view or plan and section views with detailed callouts.
 - b. Complete set of 11-inch by 17-inch drawings of equipment.
 - c. Provide electrical and instrumentation schematic record drawings.
14. Source (factory) quality control test results:
 - a. Provide copies of factory test reports as specified in Sections 15958 or the equipment section.

15. Field quality control test results:
 - a. After field-testing is completed, insert field test reports as specified in Sections 15958 or the equipment section.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

APPENDIX A
EQUIPMENT SUMMARY FORM

1. EQUIPMENT ITEM _____
2. MANUFACTURER _____
3. EQUIPMENT IDENTIFICATION NUMBER(S) _____
(maps equipment number)
4. LOCATION OF EQUIPMENT _____
5. WEIGHT OF INDIVIDUAL COMPONENTS (OVER 100 POUNDS) _____

NAMEPLATE DATA -

Horsepower _____
Amperage _____
Voltage _____
Service Factor (S.F.) _____
Speed _____
ENC Type _____
Capacity _____
Other _____

7. MANUFACTURER'S LOCAL REPRESENTATIVE

Name _____
Address _____
Telephone Number _____

8. MAINTENANCE REQUIREMENTS _____

9. LUBRICANT LIST _____

10. SPARE PARTS (recommendations) _____

11. COMMENTS _____

SECTION 05120

STRUCTURAL STEEL

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Structural steel shapes and plate.
 - 2. Fasteners and structural hardware:
 - a. All thread rods.
 - b. Anchor bolts.
 - c. Assembly bolts.
 - d. Eyebolts.
 - e. High-strength bolts.
 - f. Welded studs.
 - 3. Isolation sleeves and washers.
 - 4. Thread coating.
 - 5. Welding.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents:
 - a. **[Section 03055 - Epoxy Bonding Reinforcing Bars and All Thread Rods In Concrete.]**
 - b. **[Section 04055 – Epoxy Bonding Reinforcing Bars and All Thread Rods in Masonry.]**
 - c. Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
 - d. Section 09910 - Painting.
 - e. Section 09960 - High-Performance Coatings.

1.02 REFERENCES

- A. American Institute of Steel Construction (AISC):
 - 1. 303 - Code of Standard Practice for Steel Buildings and Bridges.
 - 2. 360 - Specification for Structural Steel Buildings.
- B. American Iron and Steel Institute (AISI):
 - 1. Steel and stainless steel alloys ("types") as indicated.

- C. American Welding Society (AWS):
1. A5.1 - Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding.
 2. A5.17 - Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding.
 3. A5.20 - Specification for Carbon Steel Electrodes for Flux Cored Arc Welding.
 4. D1.1 - Structural Welding Code - Steel.
 5. D1.6 - Structural Welding Code - Stainless Steel.
 6. D10.4 – Recommended Practices for Welding Austenitic Chromium-Nickel Stainless Steel Piping and Tubing.
- D. ASTM International (ASTM):
1. A 6 - Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.
 2. A 36 - Standard Specification for Carbon Structural Steel.
 3. A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
 4. A 108 – Standard Specification for Steel Bars, Carbon, Cold Finished Standard Quality.
 5. A 123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 6. A 153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 7. A 193 - Standard Specification for Alloy Steel and Stainless Steel Bolting Materials for High-Temperature or High Pressure Service and Other Special Purpose Applications.
 8. A 194 - Standard Specification for Steel Bars Subject to Restricted End-Quench Hardenability Requirements.
 9. A 240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 10. A 276 - Standard Specification for Stainless Steel Bars and Shapes.
 11. A 307 – Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
 12. A 325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
 13. A 380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
 14. A 489 - Standard Specification for Carbon Steel Lifting Eyes.
 15. A 490 - Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength.
 16. A 496 – Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement.
 17. A 500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
 18. A 501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
 19. A 563 - Standard Specification for Carbon and Alloy Steel Nuts.
 20. A 992 - Standard Specification for Structural Steel Shapes.
 21. F 436 - Standard Specification for Hardened Steel Washers.
 22. F 593 – Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

23. F 959 - Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners.
 24. F 2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.
- E. Research Council on Structural Connections (RCSC):
1. Specification for Structural Joints Using High-Strength Bolts (RCSC Specification).

1.03 DEFINITIONS

- A. Snug-tight: At bolted joints, the tightness attained with a few impacts of an impact wrench, or by the full effort of an ironworker using a spud wrench to bring the connected plies into firm contact.
- B. Stainless steel related terms:
1. Descaling: Removal of heavy, tightly adherent oxide films resulting from hot-forming, heat-treatment, welding, and other high-temperature operations.
 2. Pickling: Chemical descaling of stainless steel using aqueous solutions of nitric and hydrofluoric acid, or various proprietary formulations as specified.
 3. Passivation: Chemical treatment of stainless steel with a mild oxidant for the purpose of enhancing the spontaneous formation of the steel's protective passive film.

1.04 SUBMITTALS

- A. Quality control submittals:
1. Submit shop drawings of members to be fabricated before starting fabrication.
 2. Welder's certificates.
- B. Test reports:
1. Certified copies of mill tests and analyses made in accordance with applicable ASTM standards, or reports from a recognized commercial laboratory, including chemical and tensile properties of each shipment of structural steel or part thereof having common properties.

1.05 QUALITY ASSURANCE

- A. Qualifications:
1. Perform welding of structural metals with welders who have current AWS certificate for the type of welding to be performed.
 2. Notify Engineer 24 hours minimum before starting shop or field welding.
 3. Engineer may check materials, equipment, and qualifications of welders.
 4. Engineer may use gamma ray, magnetic particle, dye penetrant, trepanning, or other aids to visual inspection to examine any part of welds or all welds.
 5. Supplier shall bear costs of retests on defective welds.
 6. Supplier shall also bear costs in connection with qualifying welders.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Packing and shipping: Deliver structural steel free from mill scale, rust, and pitting.

- B. Storage and protection: Until erection and painting, protect from weather items not galvanized or protected by a shop coat of paint.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Unless otherwise specified or indicated on the Drawings, materials shall conform to the following:

Item	ASTM Standard	Class, Grade, Type, or Alloy Number
Steel		
Plate, bars, rolled shapes (except W and WT shapes), and miscellaneous items	A 36	--
Rolled W and WT shapes	A 992	Grade 50
Hollow structural sections (HSS): Round, square, or rectangular	A 500	Grade B
Tubing, hot-formed	A 501	--
Round HSS	A 500	Grade B
Steel pipe	A 53	Grade B
Stainless steel		
Plate, sheet, and strip	A 240	Type 304* or 316**
Bars and shapes	A 276	Type 304* or 316**
* Use Type 304L if material will be welded.		
** Use Type 316L if material will be welded.		

- B. Where stainless steel is welded, use low-carbon stainless steel.

2.02 FASTENERS AND STRUCTURAL HARDWARE

- A. General: Furnish threaded fasteners, except high strength bolts, with flat washers, and self-locking nuts, or lock washers and nuts:
- Bolt heads and nuts: Hex type.
 - Bolts, nuts, and washers: Of domestic manufacture.
 - Where fasteners and hardware are specified to be galvanized, galvanize in accordance with ASTM A 153 or ASTM F 2329.
- B. All thread rods:
- Uncoated
 - In accordance with ASTM A 36 unless otherwise indicated on the Drawings.
 - Nuts: ASTM A 194.
 - Washers: ASTM F 436.

2. Galvanized:
 - a. In accordance with ASTM A 36 unless otherwise indicated on the Drawings, and hot dip galvanized in accordance with ASTM A 123.
 - b. Nuts : ASTM A 194, hot-dip galvanized in accordance with ASTM A 153.
 - c. Washers: ASTM F 436, hot-dip galvanized in accordance with ASTM A 153.
3. Stainless steel:
 - a. Units descaled, pickled, and passivated as specified in "Fabrication" in this Section.
 - b. Threaded rods and nuts to be the products of a single manufacturer/fabricator to ensure proper fit without galling. Ship threaded rods with properly fitting nuts attached.
 - c. Type 316 stainless steel in accordance with ASTM F 593 for use in wet and moist locations, including:
 - 1) Below and at water level.
 - 2) Above water level:
 - a) Below top of walls of water-containing structures.
 - b) Under the roof, slab, beam, or walkway of enclosed water-containing structures.
 - c) Dry side of walls of water-containing structures.
 - 3) Pump bases.
 - d. **[Alloy: Type 316/316L:**
 - a) **Bolts: ASTM A 193, Grade B8M, Class 1, heavy hex.**
 - b) **Nuts: ASTM A 194, Grade 8M, heavy hex.**
 - c) **Washers: Type 316 stainless steel.]**
 - e. **[Alloy as indicated on the Drawings.**
 - 1) **Alloy 304/304L:**
 - a) **Bolts: ASTM A 193, Grade B8, Class 1, heavy hex.**
 - b) **Nuts: ASTM A 194, Grade 8, heavy hex.**
 - c) **Washers: Type 304 stainless steel.**
 - 2) **Alloy 316/316L:**
 - a) **Bolts: ASTM A 193, Grade B8M, Class 1, heavy hex.**
 - b) **Nuts: ASTM A 194, Grade 8M, heavy hex.**
 - c) **Washers: Type 316 stainless steel.]**

C. Anchor bolts, anchor rods, and post-installed steel anchors: As indicated on the Drawings and as specified in Section 05190.

D. Anchor Bolts:

1. Anchor Bolts, Nuts, and Washers: Type 316 stainless steel in accordance with ASTM F 593 for use in wet and moist locations, including:
 - a. Water-Containing Structures:
 - 1) Below and at water level.
 - 2) Above Water Level:
 - a) Below top of walls of water-containing structures.
 - b) Under the roof, slab, beam, or walkway of enclosed water-containing structures.
 - 3) Dry side of walls of water-containing structures.
 - b. Pump bases.
2. Anchor Bolts, Nuts, and Washers: Type 304 or Type 316 stainless steel for fastening aluminum to concrete or steel.

3. Anchor Bolts, Nuts, and Washers: Hot-dip galvanized ASTM A 307 steel bolt or hot-dip galvanized ASTM A 36 steel, for applications other than those specified.
- E. Assembly Bolts:
1. Bolts, nuts, and washers for wood baffles, collectors, and other field-assembled construction: Type 316 stainless steel in accordance with ASTM F 593 for use in wet and moist locations, including:
 - a. Water-Containing Structures:
 - 1) Below and at water level.
 - 2) Above water level:
 - a) Below top of walls of water-containing structures.
 - b) Under the roof, slab, beam, or walkway of enclosed water-containing structures.
 - c) Dry side of walls of water-containing structures.
 - 3) Pump bases.
 - b. Type 304 or Type 316 stainless steel in accordance with ASTM F 593 for aluminum assemblies.
 - c. Hot-dip galvanized ASTM A 307 steel for galvanized assemblies and for applications other than those specified.
- F. Eyebolts:
1. Welded or forged, when manufactured of materials other than carbon steel.
 2. Having geometric and strength characteristics of eyebolts specified in ASTM A 489, Type 1. The strength characteristics include proof load requirements, breaking strength requirements, tensile strength requirements, bend test, and impact strength.
- G. Welded Studs:
1. ASTM A 108 with 50,000-pounds per square inch (psi) minimum yield strength, and 60,000-psi minimum tensile strength.
 2. Headed Studs: Manufacturers: One of the following of equal:
 - a. Nelson Stud Welding Company, S3L Shear Connectors or H4L Concrete Anchors.
 - b. Stud Welding Products, Headed Concrete Anchors and Shear Connectors or Concrete Anchors.
- H. High-strength bolts:
1. Provide high-strength bolt assembly, with nuts, hardened flat washers, and compressible-washer-type direct tension indicators. Provide uncoated components unless galvanized coating is indicated on the Drawings.
 2. Uncoated:
 - a. Bolts: Plain heavy hex structural bolts in accordance with ASTM A 325 Type 1.
 - b. Nuts: Heavy hex nuts in accordance with ASTM A 563, Grade C.
 - c. Washers: Flat:
 - 1) Adjacent to normal, oversized, and short-slotted holes: Circular and square or rectangular beveled washers in accordance with ASTM F 436.
 - 2) Adjacent to long slotted holes: 5/16-inch thick plate washer fabricated from steel in accordance with ASTM A 36.
 - d. Washers: Tension indicating: In accordance with ASTM F 959.

3. Galvanized:
 - a. Bolt and nut assemblies fabricated, galvanized, tested for rotational capacity, and shipped accordance with the provisions ASTM A 325 and the RCSC Specification.
 - b. Bolts, nuts, and washers: Hot-dip galvanized and in accordance with ASTM A 153, Class C or ASTM F 2329.
 - c. Bolts: Plain heavy hex structural bolts in accordance with ASTM A 325 Type 1 and galvanized as specified.
 - d. Nuts: Heavy hex nuts in accordance with ASTM A 563, Grade DH, galvanized as specified, and lubricated in accordance with ASTM A 563, Supplementary Requirement S1 to minimize galling.
 - e. Washers:
 - 1) Adjacent to normal, oversized, and short-slotted holes: Circular and square or rectangular beveled washers in accordance with ASTM F 436 and galvanized as specified.
 - 2) Adjacent to long slotted holes: 5/16-inch thick plate washer fabricated from steel in accordance with ASTM A 36, and galvanized in accordance with ASTM A 123.
 4. Direct-tension indicators.
 - a. For each high-strength bolt at slip-critical connections, provide compressible washer type direct tension indicator in accordance with ASTM F 959.
- I. Stainless steel bolts (for use in stainless steel structures):
1. General:
 - a. Alloy: Type 304/304L or Type 316/316L, to match alloy of structural members being connected.
 - b. Units descaled, pickled and passivated as specified in "Fabrication of this Section"
 - c. Bolts and nuts shall be the products of a single manufacturer/fabricator to ensure proper fit without galling. Ship bolts with properly fitting nuts attached.
 2. Alloy 304/304L:
 - a. Bolts: ASTM A 193, Grade B8, Class 1, heavy hex.
 - b. Nuts: ASTM A 194, Grade 8, heavy hex.
 - c. Washers: Type 304 stainless steel.
 3. Alloy 316/316L:
 - a. Bolts: ASTM A 193, Grade B8M, Class 1, heavy hex.
 - b. Nuts: ASTM A 194, Grade 8M, heavy hex.
 - c. Washers: Type 316 stainless steel.
 4. Welded studs: As indicated on the Drawings and as specified in Section 05190.

2.03 ISOLATING SLEEVES AND WASHERS

- A. As indicated on the Drawings and as specified in Section 05190.
- B. Manufacturers: One of the following or equal:
 1. Central Plastics Company, Shawnee, Oklahoma.
 2. Corrosion Control Products, PSI Inc., Gardena, California.

- C. Sleeves: Mylar, 1/32-inch thick, 4,000 volts per mil dielectric strength, of proper size to fit bolts and extending half way into both steel washers:
 - 1. One sleeve required for each bolt.
- D. Washers: The inside diameter of all washer shall fit over the isolating sleeve and both the steel and isolating washers shall have the same inside diameter and outside diameter:
 - 1. Proper size to fit bolts. Two insulating washers are required for each bolt.
 - 2. Two 1/8-inch thick steel washers for each bolt.
 - 3. G3 Phenolic:
 - a. Thickness: 1/8 inch.
 - b. Base Material: Glass.
 - c. Resin: Phenolic.
 - d. Water Absorption: 2 percent.
 - e. Hardness (Rockwell): 100.
 - f. Dielectric Strength: 450 volts per mil.
 - g. Compression Strength: 50,000 psi
 - h. Tensile Strength: 20,000 psi.
 - i. Maximum Operating Temperature: 350 degrees Fahrenheit.

2.04 GALVANIZED SURFACE REPAIR

- A. Manufacturers: One of the following or approved equal:
 - 1. Galvinox.
 - 2. Galvo-Weld.

2.05 THREAD COATING

- A. Manufacturers: One of the following or approved equal:
 - 1. Never Seez Compound Corporation, Never-Seez.
 - 2. Oil Research, Inc., WLR No. 111.

2.06 SUPPLEMENTARY PARTS

- A. Furnish as required for complete structural steel erection, whether or not such parts and Work are specified or indicated on the Drawings.

2.07 FABRICATION

- A. Shop assembly:
 - 1. Fabricate structural steel in accordance with AISC 360 and AISC 303 unless otherwise specified or modified by applicable regulatory requirements.
 - 2. Where anchors, connections, or other details of structural steel are not specifically indicated on the Drawings or specified, their material, size and form shall be equivalent in quality and workmanship to items specified.
 - 3. Round off sharp and hazardous projections and grind smooth.
 - 4. Take measurements necessary to properly fit work in the field. Take responsibility for and be governed by the measurements and proper working out of all the details.
 - 5. Take responsibility for correct fitting of all metalwork.

- B. Stainless steel shapes and assemblies:
1. For structural members such as W shapes, S shapes, channels, angles, and similar rolled shapes not available in quantity, size, and type of stainless steel specified or indicated on the Drawings:
 - a. Fabricate shapes using laser-fused, full penetration welds between pieces of plate to attain same or higher section modulus and moment of inertia as that of members indicated on the Drawings.
 - b. Fabricate shapes from dual grade stainless steel.
 - c. Fabricate beams and channels to ASTM A 6 tolerances.
 - d. Manufacturers: The following, or equal:
 - 1) Stainless Structurals, LLC, Jacksonville, FL.
 2. Cleaning and passivation:
 - a. Following shop fabrication of stainless steel members and bolts, clean and passivate fabrications at point of manufacture.
 - b. Finish requirements: Remove free iron, heat tint oxides, weld scale and other impurities, and obtain a bright passive finished surface with no etching, pitting, frosting, or discoloration.
 - c. Provide quality control testing to verify effectiveness of cleaning agents and procedures and to confirm that finished surfaces are clean and passivated:
 - 1) Conduct sample runs using test specimens with proposed cleaning agents and procedures as required to avoid adverse effects on surface finishes and base materials.
 - d. Pre-clean, chemically de-scale ("pickle"), passivate, and final-clean fabrications in accordance with the requirements of ASTM A 380:
 - 1) If degreasing is required before cleaning (pickling) to remove scale or iron oxide, cleaning with citric acid treatments is permissible; however, such treatments shall be followed inorganic cleaners.
 - 2) Pickle and passivate stainless steel using a nitric acid solution in accordance with ASTM A 380, Annex A2, Table A2.1, Part II.
 - 3) Pickling by citric acid treatment or sulfuric acid treatment is not considered to satisfy the requirements of this Section.
 - e. Inspect after cleaning using methods specified for "gross inspection" in ASTM A 380.
 - f. Improperly or poorly cleaned and passivated materials shall not be shipped and will not be accepted at the site.
- C. Galvanized steel:
1. Where galvanizing is required, hot-dip structural steel after fabrication in accordance with ASTM A 123:
 2. Do not electro-galvanize or mechanically-galvanize unless specified or accepted by Engineer.
 3. Re-straighten galvanized items that bend or twist during galvanizing.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of conditions: Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

3.02 ERECTION

A. General:

1. Fabricate structural and foundry items to true dimensions without warp or twist.
2. Form welded closures neatly, and grind off smooth where weld material interferes with fit or is unsightly.
3. Install structural items accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.
4. Do not cock out of alignment, re-drill, re-shape, or force fit fabricated items.
5. Place anchor bolts or other anchoring devices accurately and make surfaces that bear against structural items smooth and level.
6. Rigidly support and brace structural items needing special alignment to preserve straight, level, even, and smooth lines. Keep structural items braced until concrete, grout, or dry pack mortar has hardened for 48 hours minimum.
7. Erect structural steel in accordance with AISC 360 unless otherwise specified or modified by applicable regulatory requirements.
8. Where anchors, connections, and other details of structural steel erection are not specifically indicated on the Drawings or specified, form, locate, and attach with equivalent in quality and workmanship to items specified.
9. Round off sharp or hazardous projections and grind smooth.
10. Paint or coat steel items as specified in Sections 09910 and 09960.

B. Stainless steel. Take all necessary precautions to avoid iron contamination of stainless steel during delivery, storage, and handling:

1. Segregate stainless steel from iron.
2. Tools and handling devices:
 - a. Do not use iron tools clamps, chokes, working surfaces, or brushes when fabricating, handling, and erecting stainless steel.
 - b. Do not use tools that have been contaminated by contact with iron.
 - c. Use stainless steel, polymer coated, or wood tools and handling equipment. Do not use tools that have been contaminated by contact with iron or steel.

C. Welding: General:

1. Make welds full penetration type, unless otherwise indicated on the Drawings.
2. Remove backing bars and weld tabs after completion of weld. Repair defective welds observed after removal of backing bars and weld tabs.

D. Welding stainless steel:

1. General: In accordance with AWS D1.6.
 - a. Perform with electrodes and techniques in accordance with AWS D10.4.

E. Welding carbon steel:

1. General: In accordance with AWS D1.1:
 - a. Weld ASTM A 36 and A 992 structural steel, ASTM A 500 and A 501 structural tubing, and ASTM A 53 pipe with electrodes conforming to AWS A5.1, using E70XX electrodes; AWS A5.17, using F7X-EXXX electrodes; or AWS A5.20, using E7XT-X electrodes:
 - b. Field repair cut or otherwise damaged galvanized surfaces to equivalent original condition using a galvanized surface repair.

- F. Interface with other products:
1. Where steel members and fasteners come in contact with dissimilar metals (aluminum, stainless steel, etc), separate or isolate the dissimilar metals with isolating sleeves and washers as specified in Section 05190.
 - a. Prior to installing nuts, coat threads of stainless steel fasteners with thread coating to prevent galling of threads.
- G. Fasteners: General:
1. Install bolts to project 2 threads minimum, but 1/2 inch maximum beyond nut.
 2. Anchor bolts and anchor rods: Install as specified in Section 05190.
 - a. Unless otherwise specified, tighten nuts on anchor bolts and anchor rods specified in Section 05190 to the "snug-tight" condition.
 3. **[All thread rods in drilled holes and bonded to concrete with epoxy: Install as specified in Section 03055.]**
 4. **[All thread rods in drilled holes and bonded to masonry with epoxy: Install as specified in Section 04055.]**
- H. Fasteners: Anchor bolts:
1. Cast-in-place when concrete is placed.
 2. Accurately locate anchor bolts embedded in concrete with bolts perpendicular to surface from which they project.
 3. Do not allow anchor bolts to touch reinforcing steel.
 4. Where anchor bolts are within 1/4 inch of reinforcing steel, isolate with a minimum of 4 wraps of 10-mil polyvinyl chloride tape in area adjacent to reinforcing steel.
 5. In anchoring machinery bases subject to heavy vibration, use 2 nuts, with 1 serving as a locknut.
 6. Where bolts are indicated on the Drawings for future use, first coat thoroughly with nonoxidizing wax, then turn nuts down full depth of thread and neatly wrap exposed thread with waterproof polyvinyl tape.
 7. Furnish anchor bolts with standard hex bolt head or an equivalent head acceptable to Engineer. "L" or "J" anchor bolts are not equivalent to an anchor bolt with a hex bolt head.
 8. Minimum anchor bolt embedment: 10-bolt diameters, unless longer embedment is indicated on the Drawings.
 9. Where indicated on the Drawings, set anchor bolts in metal sleeves having inside diameter approximately 2 inches greater than bolt diameter and minimum 10-bolt diameters long. Seal top of sleeve to prevent grout from filling sleeve.
 10. Anchor bolts may be cast in concrete in lieu of using concrete anchors.
- I. Fasteners: Deformed bar anchors:
1. Butt weld with automatic stud welding gun as recommended by manufacturer.
 2. Ensure butt weld develops full strength of the anchor.
- J. Fasteners: High-strength bolts:
1. Connections with high-strength bolts shall conform to AISC Specification for Structural Joints Using ASTM A 325 or A 490 Bolts.
 2. Provide slip-critical joints at bolted connections unless otherwise indicated on the Drawings.
 3. Furnish hardened flat washer:
 - a. Under element, nut, or bolt head, turned in tightening.

- b. On outer plies for short slotted holes.
- 4. Joints: Slip-critical.
 - a. Confirm that faying surfaces at connections are free of dirt and other foreign material, have been blast cleaned, and are free of coatings and inadvertent overspray in accordance with RCSC Specification.
 - b. Furnish hardened flat washers in accordance with ASTM F 436:
 - 1) On outer plies with slotted holes.
 - 2) When 1 or more plies of the connected material has a yield strength less than 40 ksi.
 - 3) Under element, nut, or bolt head, turned in tightening.
 - c. Install tension indicator washers, placed in accordance with ASTM F 959 Figure X1, to confirm adequate tightening of bolts.
 - d. Tighten bolts to full pretension.
- A. Fasteners: Stainless steel bolts:
 - 1. Connections shall be snug-tight joints unless otherwise indicated on the Drawings.
 - 2. Prior to installing nuts, coat threads of stainless steel fasteners with thread coating to prevent galling of threads.
 - 3. Rotate nuts using a slow, smooth action without interruptions. Avoid over-tightening.
- B. Fasteners: Welded studs:
 - 1. Butt weld with automatic stud welding gun as recommended by the manufacturer.
 - 2. Ensure butt weld develops full strength of the stud.

END OF SECTION

SECTION 05140
STRUCTURAL ALUMINUM

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Structural aluminum products, including sheet, pipe, extrusions, and associated accessories.
- B. Related Sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents:
 - a. Section 05120 – Structural Steel.
 - b. Section 09960 - High-Performance Coatings.
 - c. Section 11500 – Membrane Equipment Systems.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. B 209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
 - 2. B 221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
 - 3. B 308 - Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
- B. American Welding Society (AWS):
 - 1. A5.10 - Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods.
 - 2. D1.2 - Structural Welding Code - Aluminum.

1.03 SUBMITTALS

- A. Quality control submittals:
 - 1. Test Reports: Certified copies of mill tests or reports from a recognized commercial laboratory including chemical and tensile properties of each shipment of structural metal or part thereof having common properties. Tests and analyses shall be made in accordance with applicable ASTM Standards.
 - 2. Welder's certificates.

1.04 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Perform welding of structural metals with welders who have current AWS certificate for the type of welding to be performed.
 - 2. Notify Engineer 24 hours minimum before starting shop or field welding.
 - 3. Engineer may check materials, equipment, and qualifications of welders.
 - 4. Remove welders performing unsatisfactory work, or require to requalify.
 - 5. Engineer may use gamma ray, magnetic particle dye penetrant, or other aids to visual inspection to examine any part of welds or all welds.
 - 6. Supplier shall bear costs of retests on defective welds.
 - 7. Supplier shall bear costs in connection with qualifying welders.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Structural sheet aluminum: ASTM B 209, Alloy 6061-T6.
- B. Structural aluminum: ASTM B 308, Alloy 6061-T6.
- C. Extruded aluminum: ASTM B 221, Alloy 6063-T42.
- D. Miscellaneous materials:
 - 1. Furnish supplementary parts necessary to complete each item even where such work is neither definitely indicated on the Drawings nor specified.
 - 2. Size, form, attachment, and location shall conform to the best of current practice.
 - 3. Conform to applicable ASTM Standards for materials not otherwise specified.

2.02 FABRICATION

- A. Aluminum layout:
 - 1. Center punch hole centers, and punch or scribe cutoff lines, except where marks would remain on fabricated material.
 - 2. Apply temperature correction where necessary in layout of critical dimensions. Use a coefficient of expansion of 0.000013 per degree of Fahrenheit.
- B. Cutting aluminum:
 - 1. Material 1/2-inch thick or less: Shear, saw, or cut with a router.
 - 2. Material more than 1/2-inch thick: Saw or rout.
 - 3. Make cut edges true and smooth, free from excessive burrs or ragged breaks.
 - 4. Avoid reentrant cuts wherever possible. Where used, fillet by drilling prior to cutting.
 - 5. Do not flame cut aluminum alloys.
 - 6. Punch or drill rivet or bolt holes to finished size before assembly:
 - a. Make finished diameter of holes for bolts 1/16-inch maximum larger than nominal bolt diameter.
 - b. Make holes cylindrical and perpendicular to principal surface.
 - c. Do not permit holes to drift in a manner to distort metal.

- C. Aluminum forming and assembly:
 - 1. Do not heat structural aluminum, except as follows:
 - a. Heat aluminum to 400 degrees Fahrenheit for 30 minutes maximum, to facilitate bending or welding.
 - b. Heat only when proper temperature controls and supervision can ensure that limitations on temperature and time are observed.
- D. Before assembly, remove chips lodged between contacting surfaces.
- E. Welding aluminum:
 - 1. Perform welding of aluminum in accordance with AWS D1.2.
 - 2. Weld aluminum in accordance with the following:
 - a. Preparation:
 - 1) Remove dirt, grease, forming or machining lubricants, and organic materials from areas to be welded by cleaning with a suitable solvent or by vapor degreasing.
 - 2) Additionally, etch or scratch brush to remove oxide coating just prior to welding when inert gas tungsten arc welding method is used.
 - 3) Oxide coating may not need to be removed if welding is performed by automatic or semi-automatic inert gas shielded metal arc.
 - 4) Suitably prepare edges to assure 100 percent penetration in butt welds by sawing, chipping, machining, or shearing. Do not cut with oxygen.
 - b. Filler metal: Aluminum alloys conforming to the requirements of AWS A5.10 and AWS classification ER 4043, ER 5654, ER 5554, ER 5183, ER 5356, or ER 5556.
 - c. Perform welding of structures, which are to be anodized using filler alloys which will not discolor when anodized, AWS ER 5654, ER 5554, ER 5183, ER 5356, or ER 5556.
 - d. Perform welding by using a non-consumable tungsten electrode with filler metal in an inert gas atmosphere (TIG) or using a consumable filler metal electrode in an inert gas atmosphere (MIG).
 - e. Do not use welding process that requires use of a welding flux.
 - f. Neatly make welded closures.
 - g. Where weld material interferes with fit or is unsightly in appearance, grind it smooth.
 - h. Make welds full penetration welds unless otherwise indicated on the Drawings.

2.03 FINISHES

- A. Coating for dissimilar metals:
 - 1. Alkali resistant bitumastic: Manufacturers: One of the following or equal:
 - a. Caroline, Bitumastic Super Service Black.
 - b. Tnemec, 46-465.
 - c. Wasser, MC-Tar.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of conditions: Examine Work in place to verify that it is satisfactory to receive the Work of this Section. If unsatisfactory conditions exist, do not begin this Work until such conditions have been corrected.

3.02 INSTALLATION

- A. Install structural aluminum products as indicated on the Drawings and specified.
- B. Install structural aluminum products accurately and securely, true to level, plumb, in correct alignment and grade, with all parts bearing or fitting structure or equipment for which intended.
- C. Do not cock out of alignment, redrill, reshape, or force fit fabricated items.
- D. Place anchor bolts or other anchoring devices accurately and make surfaces which bear against structural items smooth and true to level.
- E. Rigidly support and brace structural products needing special alignment to preserve straight, level, even, smooth lines, and keep braced until concrete, grout, or dry pack mortar has hardened for a minimum 48-hour period.
- F. Interface with other products:
 - 1. Where aluminum comes in contact with dissimilar metals, bolt it with stainless steel bolts and separate or isolate it from dissimilar metals as specified in Section 05120.
 - 2. Coat those parts of aluminum which will be cast into concrete or which will be in contact with concrete, grout, masonry, wood, or other materials that will cause the aluminum to corrode, as specified in Section 09960.

END OF SECTION

SECTION 05500

METAL FABRICATIONS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Aluminum grating stair tread.
 - 2. Handrails and guardrails.
 - 3. Metal tread plate.
 - 4. Miscellaneous metals.
 - 5. Associated accessories to the above items.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents:
 - a. Section 09960 - High Performance Coatings.
 - b. Section 11500 – Membrane Equipment Systems.
 - c. Section 15061 - Pipe Supports.
 - d. Section 15062 - Preformed Channel Pipe Support System.

1.02 REFERENCES

- A. Aluminum Association (AA):
 - 1. DAF-45: Designations from Start to Finish.
 - a. M12-C22-A41 – Aluminum Finishes.
- B. American Association of State Highway and Transportation Officials (AASHTO):
 - 1. Standard Specifications for Highway Bridges.
- C. ASTM International (ASTM):
 - 1. A 36 - Standard Specification for Carbon Structural Steel.
 - 2. A 48 - Standard Specification for Gray Iron Castings.
 - 3. A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
 - 4. A 123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 5. A 240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels for General Applications.
 - 6. A 269 – Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
 - 7. A 276 - Standard Specification for Stainless Steel Bars and Shapes.

8. A 307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
 9. A 325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
 10. A 380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
 11. A 489 - Standard Specification for Carbon Steel Lifting Eyes.
 12. A 490 - Standard Specification for Structural Bolts, Alloy Steel, Heat-Treated , 150 ksi Minimum Tensile Strength.
 13. A 500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
 14. A 501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
 15. A 569 – Standard Specification for Steel, Carbon (0.15 Maximum, Percent) Hot-Rolled Sheet and Strip Commercial Quality.
 16. A 635 - Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Alloy, Carbon, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, General Requirements for.
 17. A 653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
 18. A 992 - Standard Specification for Structural Steel Shapes.
 19. B 209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
 20. B 221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
 21. B 308 - Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
 22. B 429 - Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
 23. F 593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.
- D. American Welding Society (AWS):
1. A2.4 - Standard Symbols for Welding, Brazing, and Nondestructive Examination.
- E. National Association of Architectural Metal Manufacturers (NAAMM):
1. Metal Finishes Manual.
- F. Occupational Safety and Health Administration (OSHA):
1. Code of Federal Regulations (CFR), Title 29, Labor, Pt. 1900-1990.

1.03 DEFINITIONS

- A. Passivation: Removal of exogenous iron or iron compounds from the surface of a stainless steel by means of chemical dissolution resulting from treatment with an acid solution that removes the surface contamination but does not significantly affect the stainless steel itself.

1.04 SUBMITTALS

- A. Product Data:
1. Aluminum grating stair tread.

2. Handrail and guardrail.
 3. Metal grating.
- B. Shop drawings:
1. Handrails and guardrails:
 - a. Including details on connection attachments, gates, kick plates, ladders, and angles.
 - b. Indicate profiles, sizes, connection attachments, reinforcing, anchorage, size and type of fasteners, and accessories.
 - c. Include erection drawings, elevations, and details where applicable.
 - d. Indicate welded connections using standard AWS A2.4 welding symbols. Indicate net weld lengths.
 2. Metal grating.
 3. Metal tread plate.
 4. Miscellaneous metals.
- C. Samples:
1. Guardrails with specified finishes.
- D. Quality control submittals:
1. Design data.
 2. Test reports:
 - a. Guardrails: 3 copies of certified tests performed by an independent testing laboratory certifying that guardrails meet current State and OSHA strength requirements.
 - b. Gratings:
 - 1) Grating manufacturers' calculations showing that gratings will meet specified design load, stress, and deflection requirements for each size grating for each span.
 - 2) Reports of tests performed.

PART 2 PRODUCTS

2.01 MATERIALS

- A. General: Unless otherwise specified or indicated on the Drawings, structural and miscellaneous metals in accordance with the standards of the ASTM, including the following:

Item	ASTM Standard No.	Class, Grade Type or Alloy No.
Cast Iron		
Cast Iron	A 48	Class 40B
Steel		
Galvanized sheet iron or steel	A 653	Coating G90
Coil (plate)	A 635	--

Item	ASTM Standard No.	Class, Grade Type or Alloy No.
Structural plate, bars, rolled shapes, and miscellaneous items (except W shapes).	A 36	--
Rolled W shapes	A 992	Grade 50
Standard bolts, nuts, and washers	A 307	--
High strength bolts, nuts, and hardened flat washers	A 325 A 490	--
Eyebolts	A 489	Type 1
Tubing, cold-formed	A 500	--
Tubing, hot-formed	A 501	--
Steel pipe	A 53	Grade B
Stainless Steel		
Plate, sheet, and strip	A 240	Type 304* or 316**
Bars and shapes	A 276	Type 304* or 316**
Bolts (Type 304)	F593	Group 1 Condition CW
Bolts (Type 316)	F593	Group 2 Condition CW
Aluminum		
Flashing sheet aluminum	B 209	Alloy 5005-H14, 0.032 inches minimum thickness
Structural sheet aluminum	B 209	Alloy 6061-T6
Structural aluminum	B 209 B 308	Alloy 6061-T6
Extruded aluminum	B 221	Alloy 6063-T42
* Use Type 304L if material will be welded. ** Use Type 316L if material will be welded.		

1. Stainless steels are designated by type or series defined by ASTM.

2. Where stainless steel is welded, use low-carbon stainless steel.

2.02 MANUFACTURED UNITS

- A. Aluminum grating stair tread:
 1. Manufacturers: One of the following or equal:
 - a. IKG Borden Industries, Aluminum Grating Stair Tread with Mebac nosing.
 - b. McNichols Co., Type A-Standard with Corrugated Angle Nosing.
 2. Material: Welded aluminum grating tread with non-slip nosing and integral end plates for bolt on attachment to stair stringers
 3. Size:
 - a. Tread width: To equal tread spacing plus 1 inch minimum.
 - b. Tread length: Length to suit stringer-to-stringer dimension indicated on the Drawings.
 - c. Depth: 1-3/4 inches.
 4. Bolts: Type 316 stainless steel.
- B. Handrails and guardrails:
 1. General:
 - a. Design and fabricate assemblies to conform to current local, State, and OSHA standards and requirements.
 - b. Coordinate layout of assemblies and post spacings to avoid conflicts with equipment and equipment operators.
 - 1) Indicate on the shop drawings locations of such equipment.
 - 2) Highlight locations where railings cannot be made continuous, and obtain Engineer's directions on how to proceed before fabricating or installing railings.
 2. Aluminum handrails and guardrails (nonwelded pipe):
 - a. Rails, posts, and fitting-assembly spacers:
 - 1) In accordance with ASTM B 429, 6005, 6063 or 6105, minimum Schedule 40, extruded aluminum pipe of minimum 1.89-inch outside diameter and 0.14-inch wall thickness.
 - b. Kick plates: 6061 or 6105 aluminum alloy.
 - c. Fastenings and fasteners: As recommended or furnished by the manufacturer.
 - d. Other parts: 6063 extruded aluminum, or F214 or F514.0 aluminum castings:
 - 1) Fabrications: In accordance with ASTM B 209 or ASTM B 221 extruded bars:
 - a) Bases: 6061 or 6063 extruded aluminum alloy.
 - 2) Plug screws or blind rivets: Type 305 stainless steel.
 - a) Other parts: Type 300 series stainless steel.
 - e. Finish of aluminum components:
 - 1) Anodized finish, 0.7 mil thick, applied to exposed surfaces after cutting. Aluminum Association Specification M12-C22-A41, mechanical finish non specular as fabricated, chemical finish-medium matte, anodic coating-clear Class I Architectural.
 - 2) Pretreat aluminum for cleaning and removing markings before anodizing.
 - f. Fabrication and assembly:
 - 1) Fabricate posts in single, unspliced pipe length.
 - 2) Perform without welding.

- 3) Do not epoxy bond the parts.
 - 4) Maximum clear opening between assembled railing components as indicated on the Drawings.
 - g. Manufacturers: One of the following or equal:
 - 1) Moultrie Manufacturing Company, Wesrail.
 - 2) Golden Railings, Golden, CO, Riveted System.
 - 3) Craneveyor Corporation Enerco Metals, C-V Rail.
 - 3. Fastenings and fasteners: As recommended or furnished by guardrail manufacturer for use with this system.
- C. Metal tread plate:
- 1. Plate having a raised figured pattern on 1 surface to provide improved traction.
- D. Preformed channel pipe supports:
- 1. Preformed channel pipe supports for pipe supports and other applications are specified in Section 15062.
- E. Miscellaneous aluminum:
- 1. Fabricate aluminum products, not covered separately in this Section, in accordance with the best practices of the trade and field assemble by riveting or bolting.
 - 2. Do not weld or flame cut.
- F. Miscellaneous cast iron:
- 1. General:
 - a. Tough, gray iron, free from cracks, holes, swells, and cold shuts.
 - b. Quality such that hammer blow will produce indentation on rectangular edge of casting without flaking metal.
 - c. Before leaving the foundry, clean castings and apply 16-mil dry film thickness coating of coal-tar epoxy, unless otherwise specified or indicated on the Drawings.
- G. Miscellaneous stainless steel:
- 1. Provide miscellaneous stainless steel items not specified in this Section as indicated on the Drawings or specified elsewhere.
 - a. Fabricate and install in accordance with the best practices of the trade.
 - 2. Cleaning and passivation.
 - a. Following shop fabrication of stainless steel members, clean and passivate fabrications.
 - b. Finish requirements: Remove free iron, heat tint oxides, weld scale and other impurities, and obtain a passive finished surface.
 - c. Provide quality control testing to verify effectiveness of cleaning agents and procedures and to confirm that finished surfaces are clean and passivated.
 - 1) Conduct sample runs using test specimens with proposed cleaning agents and procedures as required to avoid adverse effects on surface finishes and base materials.

- d. Pre-clean, chemically descale (pickle), and final clean fabrications in accordance with the requirements of ASTM A 380 to remove deposited contaminants before shipping.
 - 1) Passivation by citric acid treatment is not allowed.
 - a) If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible; however, these treatments shall be followed by inorganic cleaners such as nitric-hydrofluoric acid.
 - 2) Provide acid descaling (pickling) in accordance with Table A1.1 of Annex A1 of ASTM A 380.
 - 3) After pickling, final cleaning of stainless steel shall conform to Part II of Table A2.1 of Annex A2 of ASTM A 380.
 - e. After cleaning, inspect using methods specified for "gross inspection" in ASTM A 380.
 - f. Improperly or poorly cleaned and passivated materials shall not be shipped and will not be accepted at the job site.
- H. Miscellaneous structural steel:
- 1. Provide miscellaneous steel items not specified in this Section as indicated on the Drawings or specified elsewhere.
 - a. Fabricate and install in accordance with the best practices of the trade.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of conditions:
 - 1. Examine work in place to verify that it is satisfactory to receive the work of this Section.
 - 2. If unsatisfactory conditions exist, do not begin this work until such conditions have been corrected.

3.02 INSTALLATION

- A. General: Install products as indicated on the Drawings, and in accordance with shop drawings and manufacturer's printed instructions, as applicable except where specified otherwise.
- B. Handrails and guardrails:
 - 1. General:
 - a. Fasten pipe rails to fittings with Series 300 stainless steel pop rivets or flush set screws.
 - b. Make pipe cuts clean and straight, free of burrs and nicks, and square and accurate for minimum joint-gap.
 - c. Drill and countersink holes to proper size, as required for a tight flush fit of screws and other component parts.
 - d. Space attachment brackets as indicated in the manufacturer's instructions.
 - 2. Aluminum pipe handrails and guardrails:
 - a. During construction, keep exterior surfaces of handrails and guardrails covered with 0.4 millimeters, minimum, heat shrink polyethylene film.

- b. Do not remove protective film before handrails and guardrails have been accepted by Engineer nor before other work in proximity of handrails and guardrails has been completed.
- c. Discontinue handrails and guardrails at lighting fixtures.
- d. Provide 1/8-inch diameter weep hole at base of each post.
- e. Where protection is applied for prevention of dissimilar materials electrolysis, make application such that none of the protective material is visible in the completed assembly.
- f. Space posts as indicated on the Drawings.
- g. Anchor posts into concrete by grouting posts into formed holes in concrete, into stainless steel sleeves cast in concrete; or bracket mount to face of concrete surfaces as specified and indicated on the Drawings.
- h. Space rails as indicated on the Drawings.
- i. Make adequate provision for expansion and contraction of kick plates and rails.
 - 1) Make provisions for removable sections where indicated on the Drawings.
- j. Make lower rails a single, unspliced length between posts, or continuous.
- k. Make top rails continuous whenever possible, and attach single, unspliced lengths to 3 posts minimum.
- l. Draw up fasteners tight with hand wrench or screw driver.
- m. Space attachment brackets as indicated on shop drawings or in manufacturer's installation instructions.
- n. Completed installation shall have handrails and railings rigid and free of play at joints and attachments.
- o. Protect handrail and guardrail finish from scratches, gouges, dents, stains, and other damage.
- p. Replace damaged or disfigured handrails and guardrails with new.
- q. Shortly before final acceptance of the work, and after removal of protective polyethylene film, clean handrails and guardrails with mild detergent or with soap and water.
 - 1) After cleaning, thoroughly rinse handrails and guardrails and wipe with soft cloth.
- r. Erect guardrail straight, level, plumb, and true to the positions as indicated on the Drawings. Correct deviations from true line of grade, which are visible to the eye.

END OF SECTION

SECTION 09960

HIGH-PERFORMANCE COATINGS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Shop and Field applied coatings.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 11500 – Membrane Equipment Systems.
 - c. Section 16075 - Electrical Identification.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. D 16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications.
 - 2. D 4262-83 – Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces.
 - 3. D 4263-83 – Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
 - 4. D4285-83 – Test Method for Indicating Oil or Water in Compressed Air.
 - 5. D 4541-93 - Standard Test Method for Pull-off Strength of Coatings Using Portable Adhesion Testers.
- B. NACE International (NACE):
 - 1. SP0178 - Design, Fabrication, and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service.
 - 2. SP0188-06 - Discontinuity (Holiday) Testing of Protective Coatings.
- C. National Association of Pipe Fabricators (NAPF):
 - 1. NAPF 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings Receiving Special External Coatings and/or Special Internal Linings.
- D. NSF International (NSF):
 - 1. NSF 61 - Drinking Water System Components - Health Effects.

- E. Society for Protective Coatings (SSPC):
 - 1. SP COM - Surface Preparation Commentary for Steel and Concrete Substrates.
 - 2. SP-1 - Solvent Cleaning.
 - 3. SP-2 - Hand Tool Cleaning.
 - 4. SP-3 - Power Tool Cleaning.
 - 5. SP-5 - White Metal Blast Cleaning.
 - 6. SP-6 - Commercial Blast Cleaning.
 - 7. SP-7 – Brush-Off Blast Cleaning.
 - 8. SP-10 – Near-White Blast Cleaning.
 - 9. SP-11 – Power Tool Cleaning to Bare Metal.
 - 10. SP-12 – High- and Ultrahigh-Pressure Water Jetting.
- F. U.S. Environment Protection Agency (EPA):
 - 1. Method 24 - Surface Coatings.

1.03 DEFINITIONS

- A. Submerged metal: Steel or iron surfaces below tops of channel or structure walls which will contain water even when above expected water level.
- B. Submerged concrete and masonry surfaces: Surfaces which are or will be:
 - 1. Underwater.
 - 2. In structures which normally contain water.
 - 3. Below tops of walls of water containing structures.
- C. Exposed surface: Any metal or concrete surface, indoors or outdoors that is exposed to view.
- D. Dry film thickness (DFT): Thickness of fully cured coating, measured in mils.
- E. Volatile organic compound (VOC): Content of air polluting hydrocarbons in uncured coating product measured in units of grams per liter or pounds per gallon, as determined by EPA Method 24.
- F. Ferrous: Cast iron, ductile iron, wrought iron, and all steel alloys except stainless steel.
- G. Where SSPC surface preparation standards are specified or implied for ductile iron pipe or fittings, the equivalent NAPF surface preparation standard shall be substituted for the SSPC standard.

1.04 PERFORMANCE REQUIREMENTS

- A. Coating materials shall be especially adapted for use in wastewater treatment plants.
- B. Coating for final coats shall be fume resistant, compounded with pigment suitable for exposure to sewage gases, especially to hydrogen sulfide and to carbon dioxide.
- C. Pigments shall be materials that do not darken, discolor, or fade due to action of sewage gases.

- D. Coating materials used in conjunction with potable water supply systems shall be certified to NSF 61.

1.05 SUBMITTALS

- A. General: Submit as specified in Section 01330.
- B. Shop drawings:
 - 1. Schedule of proposed coating materials.
 - 2. Schedule of surfaces to be coated with each coating material.
- C. Product Data: Include description of physical properties of coatings including solids content and ingredient analysis, VOC content, temperature resistance, typical exposures and limitations, and manufacturer's standard color chips:
 - 1. Regulatory requirements: Submit data concerning the following:
 - a. Volatile organic compound limitations.
 - b. Coatings containing lead compounds and PCBs.
 - c. Abrasives and abrasive blast cleaning techniques, and disposal.
 - d. NSF certification of coatings for use in potable water supply systems.
- D. Samples: Include 8-inch square drawdowns or brush-outs of topcoat finish when requested. Identify each sample as to finish, formula, color name and number and sheen name and gloss units.
- E. Certificates: Submit in accordance with requirements for Product Data.
- F. Manufacturer's Instructions: Include the following:
 - 1. Special requirements for transportation and storage.
 - 2. Mixing instructions.
 - 3. Shelf life.
 - 4. Pot life of material.
 - 5. Precautions for applications free of defects.
 - 6. Surface preparation.
 - 7. Method of application.
 - 8. Recommended number of coats.
 - 9. Recommended dry film thickness (DFT) of each coat.
 - 10. Recommended total dry film thickness (DFT).
 - 11. Drying time of each coat, including prime coat.
 - 12. Required prime coat.
 - 13. Compatible and non-compatible prime coats.
 - 14. Recommended thinners, when recommended.
 - 15. Limits of ambient conditions during and after application.
 - 16. Time allowed between coats (minimum and maximum).
 - 17. Required protection from sun, wind, and other conditions.
 - 18. Touch-up requirements and limitations.
 - 19. Minimum adhesion of each system submitted in accordance with ASTM D 4541.
- G. Manufacturer's Representative's Field Reports.
- H. Operations and Maintenance Data: Submit as specified in Section 01782.
 - 1. Reports on visits to project site to view and approve surface preparation of structures to be coated.

2. Reports on visits to project site to observe and approve coating application procedures.
 3. Reports on visits to coating plants to observe and approve surface preparation and coating application on items that are "shop coated."
- I. Quality Assurance Submittals:
1. Quality Assurance plan.
 2. Qualifications of coating applicator including List of Similar Projects.
- J. Certifications:
1. Submit notarized certificate that:
 - a. All paints and coatings to be used on this project comply with current federal, state, and local VOC regulations.

1.06 QUALITY ASSURANCE

- A. Quality Assurance Plan:
1. The structures to be coated in accordance with the above requirements are listed herein.
 2. All coatings for metal surfaces shall be especially adapted for use around wastewater treatment plants and shall be applied in conformance with the manufacturer's published specifications.
 3. All coating for final coats shall be fume resistant, compounded with pigments suitable for exposure to sewage gases, especially to hydrogen sulfide and to carbon dioxide.
 4. Pigments shall be materials that do not tend to darken, discolor, or fade due to the action of sewage gases. If a coating manufacturer proposes use of a coating that is not designated "fume resistant" in its literature, it shall furnish full information concerning the pigments used in this paint.
 5. Coatings used in conjunction with potable water supply systems shall have US Environmental Protection Agency (EPA) and Food and Drug Administration (FDA) approval for use with potable water and shall not impart a taste or odor to the water. Complete data on each type and kind of paint and primer shall be submitted to the Engineer for review and acceptance.
 6. Acceptance shall be received from the Engineer before the coating is delivered to the jobsite. This procedure must be followed whether or not the coating that the Supplier proposes to use is named in the Contract Documents.
 7. Submittal data shall show where and for what uses each coating product is proposed to be used with cross reference made to paragraphs of the Contract Documents or Coating Schedule.
 8. Data submitted on each proposed type and kind of paint shall include data to show that the paint meets the detailed requirements herein.
- B. Manufacturers' Instructions:
1. The manufacturers' published instructions for use as a guide in specifying and applying the manufacturers' proposed coating shall be submitted to the Engineer. Coatings shall not be delivered to the job before acceptance of the manufacturers' instructions is given by the Engineer. A manufacturer's coating will not be considered for use unless that manufacturer's published instructions meet the following requirements:
 - a. The instructions must have been written and published by the manufacturer for the purpose and with the intent of giving complete

instruction for the use and application of the proposed coating in the locality and for the conditions for which the coating is specified or shown to be applied under this Contract.

- b. All limitations, precautions, and requirements that may adversely affect the coating; that may cause unsatisfactory results after the painting application; or that may cause the coating not to serve the purpose for which it was intended, that is, to protect the covered material from corrosion, shall be clearly and completely stated in the instructions.
 - c. These limitations and requirements shall, if they exist, include, but not be limited to the following list:
 - 2. Methods of application:
 - a. Number of coats.
 - b. Thickness of each coat.
 - c. Total thickness.
 - d. Drying time of each coat, including primer.
 - e. Primer required to be used.
 - f. Primers not permitted.
 - g. Use of a primer.
 - h. Thinner and use of thinner.
 - i. Temperature and relative humidity limitations during application and after application.
 - j. Time allowed between coats.
 - k. Protection from sun.
 - l. Physical properties of coating including solids content and ingredient analysis.
 - m. Surface preparation.
 - n. Touch up requirements and limitations.
- C. Applicator qualifications:
- 1. Minimum of 5 years experience applying specified type or types of coatings under conditions similar to those of the Work:
 - a. Provide qualifications of applicator and references listing 5 similar projects completed in the past 2 years.
 - 2. Manufacturer approved applicator when manufacturer has approved applicator program.
 - 3. Approved and licensed by polymorphic polyester resin manufacturer to apply polymorphic polyester resin coating system.
 - 4. Approved and licensed by elastomeric polyurethane (100 percent solids) manufacturer to apply 100 percent solids elastomeric polyurethane system.
 - 5. Applicator of off-site application of coal tar epoxy shall have successfully applied coal tar epoxy on similar surfaces in material, size, and complexity as on the Project.
- D. Regulatory requirements: Comply with governing agencies' regulations by using coatings that do not exceed permissible volatile organic compound limits and do not contain lead:
- 1. Do not use coal tar epoxy in contact with drinking water or exposed to ultraviolet radiation.
- E. Certification: Certify that applicable pigments are resistant to discoloration or deterioration when exposed to hydrogen sulfide and other sewage gases and product data designates coating as suitable for wastewater service.

- F. Field samples:
 - 1. Prepare and coat a minimum 100 square foot area between corners or limits such as control or construction joints of each system.
 - 2. Approved field sample may be part of Work.
 - 3. Obtain approval before painting other surfaces.
- G. Pre-installation conference: Conduct as specified in Section 01312.
- H. Compatibility of coatings: Use products by same manufacturer for prime coats, intermediate coats, and finish coats on same surface, unless specified otherwise.
- I. Services of coating manufacturer's representative: Arrange for coating manufacturer's representative to attend pre-installation conferences. Make periodic visits to the project site to provide consultation and inspection services during surface preparation and application of coatings, and to make visits to coating plants to observe and approve surface preparation procedures and coating application of items to be "shop primed and coated".

1.07 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle products as specified in Section 01600.
- B. Remove unspecified and unapproved paints from Project site immediately.
- C. Deliver new unopened containers with labels identifying the manufacturer's name, brand name, product type, batch number, date of manufacturer, expiration date or shelf life, color, and mixing and reducing instructions.
 - 1. Do not deliver materials aged more than 12 months from manufacturing date.
- D. Store coatings in well-ventilated facility that provides protection from the sun weather, and fire hazards. Maintain ambient storage temperature between 45 and 90 degrees Fahrenheit, unless otherwise recommended by the manufacturer.
- E. Take precautions to prevent fire and spontaneous combustion.

1.08 PROJECT CONDITIONS

- A. Surface moisture contents: Do not coat surfaces that exceed manufacturer specified moisture contents, or when not specified by the manufacturer, the following moisture contents:
 - 1. Plaster and gypsum wallboard: 12 percent.
 - 2. Masonry, concrete, and concrete block: 12 percent.
 - 3. Interior located wood: 15 percent.
 - 4. Concrete floors: 7 percent.
- B. Do not apply coatings:
 - 1. Under dusty conditions or adverse environmental conditions, unless tenting, covers, or other such protection is provided for structures to be coated.
 - 2. When light on surfaces measures less than 15 foot-candles.
 - 3. When ambient or surface temperature is less than 55 degrees Fahrenheit unless manufacturer allows a lower temperature.
 - 4. When relative humidity is higher than 85 percent.
 - 5. When surface temperature is less than 5 degrees Fahrenheit above dew point.

6. When surface temperature exceeds the manufacturer's recommendation.
 7. When ambient temperature exceeds 90 degrees Fahrenheit, unless manufacturer allows a higher temperature.
 8. Apply clear finishes at minimum 65 degrees Fahrenheit.
- C. Provide fans, heating devices, dehumidifiers, or other means recommended by coating manufacturer to prevent formation of condensate or dew on surface of substrate, coating between coats and within curing time following application of last coat.
- D. Provide adequate continuous ventilation and sufficient heating facilities to maintain minimum 55 degrees Fahrenheit for 24 hours before, during and 48 hours after application of finishes.

1.09 MAINTENANCE

- A. Extra materials: Deliver as specified in Section 01782. Include minimum 1 gallon of each type and color of coating applied:
1. When manufacturer packages material in gallon cans, deliver unopened labeled cans as comes from factory.
 2. When manufacturer does not package material in gallon cans, deliver material in new gallon containers, properly sealed and identified with typed labels indicating brand, type, and color.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Special coatings: One of the following or equal:
1. Carboline: Carboline, St. Louis, MO.
 2. Ceilcote: International Protective Coatings, Berea, OH.
 3. Dampney: The Dampney Company, Everett, MA.
 4. Devoe: International Protective Coatings, Louisville, KY.
 5. Dudick: Dudick, Inc., Streetsboro, OH.
 6. GET: Global Eco Technologies, Pittsburg, CA.
 7. Henkel: Henkel North America, Madison Heights MI.
 8. IET: Integrated Environmental Technologies, Santa Barbara, CA.
 9. PPC: Polymorphic Polymers Corp., N. Miami, FL.
 10. PPG Amercoat: PPG Protective & Marine Coatings, Brea, CA.
 11. Rustoluem : Rustoleum Corp., Sommerset, NJ.
 12. Sanchem: Sanchem, Chicago, IL.
 13. Superior: Superior Environmental Products, Inc., Addison, TX.
 14. S-W: Sherwin-Williams Co., Cleveland, OH.
 15. Tnemec: Tnemec Co., Kansas City, MO.
 16. Wasser: Wasser High Tech Coatings, Kent, WA.
 17. ZRC: ZRC Worldwide Innovative Zinc Technologies, Marshfield, MA.

2.02 PREPARATION AND PRETREATMENT MATERIALS

- A. Metal pretreatment: As manufactured by one of the following or equal:
1. Ameron: Galvaprep.
 2. Henkel: Galvaprep 5.

3. International: AWLGrip Alumiprep 33.
 4. S-W: P60G2, Wash Primer.
 5. Tnemec: Series N69 Hi-Build Epoxoline II.
- B. Surface cleaner and degreaser: As manufactured by one of the following or equal:
1. Carboline Surface Cleaner No.3.
 2. Devoe: Devprep 88.
 3. S-W: Clean and Etch.

2.03 COATING MATERIALS

- A. High solids epoxy (self priming) not less than 72 percent solids by volume: As manufactured by one of the following or equal:
1. Carboline: Carboguard 891.
 2. Devoe: Bar Rust 233H.
 3. PPG Amercoat: Amerlock 2.
 4. S-W: Macropoxy 646.
 5. Tnemec: HS Epoxy Series 104.
- B. Aliphatic or aliphatic-acrylic polyurethane: As manufactured by one of the following or equal:
1. Carboline: Carbothane 134 VOC.
 2. Devoe: Devthane 379.
 3. PPG Amercoat: Amershield VOC.
 4. Non-submerged: S-W High Solids Polyurethane.
 5. Tnemec: Endura-Shield II Series 1075 (U).

2.04 MIXES

- A. Mix in accordance with manufacturer's instructions.

PART 3 EXECUTION

3.01 GENERAL PROTECTION

- A. Protect adjacent surfaces from coatings and damage. Repair damage resulting from inadequate or unsuitable protection:
- B. Protect adjacent surfaces not to be coated from spatter and droppings with drop cloths and other coverings:
1. Mask off surfaces of items not to be coated or remove items from area.
- C. Furnish sufficient drop cloths, shields, and protective equipment to prevent spray or droppings from fouling surfaces not being coated and in particular, surfaces within storage and preparation area.
- D. Place cotton waste, cloths, and material which may constitute fire hazard in closed metal containers and remove daily from site.
- E. Remove electrical plates, surface hardware, fittings, and fastenings, prior to application of coating operations. Carefully store, clean, and replace on completion

of coating in each area. Do not use solvent or degreasers to clean hardware that may remove permanent lacquer finish.

3.02 GENERAL PREPARATION

- A. Prepare surfaces in accordance with coating manufacturer's instructions, unless more stringent requirements are specified in this Section.
- B. Protect following surfaces from abrasive blasting by masking, or other means:
 - 1. Threaded portions of valve and gate stems, grease fittings, and identification plates.
 - 2. Machined surfaces for sliding contact.
 - 3. Surfaces to be assembled against gaskets.
 - 4. Surfaces of shafting on which sprockets are to fit.
 - 5. Surfaces of shafting on which bearings are to fit.
 - 6. Machined surfaces of bronze trim, including those slide gates.
 - 7. Cadmium-plated items except cadmium-plated, zinc-plated, or sherardized fasteners used in assembly of equipment requiring abrasive blasting.
 - 8. Galvanized items, unless scheduled to be coated.
- C. Protect installed equipment, mechanical drives, and adjacent coated equipment from abrasive blasting to prevent damage caused by entering sand or dust.
- D. Concrete:
 - 1. Allow new concrete to cure for minimum of 28 days before coating.
 - 2. Clean concrete surfaces of dust, mortar, fins, loose concrete particles, form release materials, oil, and grease. Fill voids so that surface is smooth. Etch or brush off-blast clean in accordance with SSPC SP-7 to provide surface profile equal to 40 to 60-grit sandpaper, or as recommended by coating manufacturer. All concrete surfaces shall be vacuumed clean prior to coating application.
- E. Ferrous metal surfaces:
 - 1. Remove grease and oil in accordance with SSPC SP-1.
 - 2. Remove rust, scale, and welding slag and spatter, and prepare surfaces in accordance with appropriate SSPC standard as specified.
 - 3. Abrasive blast surfaces prior to coating.
 - a. When abrasive blasted surfaces rust or discolor before coating, abrasive blast surfaces again to remove rust and discoloration.
 - b. When metal surfaces are exposed because of coating damage, abrasive blast surfaces and feather in to a smooth transition before touching-up.
 - c. Ferrous metal surfaces not to be submerged: Abrasive blast in accordance with SSPC SP-10, unless blasting may damage adjacent surfaces, prohibited or specified otherwise. Where not possible to abrasive blast, power tool clean surfaces in accordance with SSPC SP-3.
 - d. Ferrous metal surfaces to be submerged: Unless specified otherwise, abrasive blast in accordance with SSPC SP-5 to clean and provide roughened surface profile of not less than 2 mils and not more than 4 mils in depth when measured with Elcometer 123, or as recommended by the coating manufacturer.
 - 4. All abrasive blast cleaned surfaces shall be blown down with clean dry air and or vacuumed.

- F. Ductile iron pipe and fittings to be lined or coated: Abrasive blast clean in accordance with NAPF 500-03.
- G. Sherardized, aluminum, copper, and bronze surfaces: Prepare in accordance with coating manufacturer's instructions.
- H. Galvanized surface:
 - 1. Degrease or solvent clean (SSPC SP-1) to remove oily residue.
 - 2. Power tool or hand tool clean or whip abrasive blast.
 - 3. Test surface for contaminants using copper sulfate solution.
 - 4. Apply metal pretreatment within 24 hours before coating galvanized surfaces that cannot be thoroughly abraded physically, such as bolts, nuts, or preformed channels.
- I. Shop primed metal:
 - 1. Certify that primers applied to metal surfaces in the shop are compatible with coatings to be applied over such primers in the field.
 - 2. Remove shop primer from metal to be submerged by abrasive blasting in accordance with SSPC SP-10, unless greater degree of surface preparation is required by coating manufacturer's representative.
 - 3. Correct abraded, scratched, or otherwise damaged areas of prime coat by sanding or abrasive blasting to bare metal in accordance with SSPC SP-2, SP-3, or SP-6, as directed by the Engineer.
 - 4. When entire shop priming fails or has weathered excessively (more than 25 percent of the item), or when recommended by coating manufacturer's representative, abrasive blast shop prime coat to remove entire coat and prepare surface in accordance with SSPC SP-10.
 - 5. When incorrect prime coat is applied, remove incorrect prime coat by abrasive blasting in accordance with SSPC SP-10.
 - 6. When prime coat not authorized by Engineer is applied, remove unauthorized prime coat by abrasive blasting in accordance with SSPC SP-10.
 - 7. Shop applied bituminous paint or asphalt varnish: Abrasive blast clean shop applied bituminous paint or asphalt varnish from surfaces scheduled to receive non-bituminous coatings.
- J. Cadmium-plated, zinc-plated, or sherardized fasteners:
 - 1. Abrasive blast in same manner as unprotected metal when used in assembly of equipment designated for abrasive blasting.
- K. Abrasive blast components to be attached to surfaces which cannot be abrasive blasted before components are attached.
- L. Grind sharp edges to approximately 1/16-inch radius before abrasive blast cleaning.
- M. Remove and grind smooth all excessive weld material and weld spatter before blast cleaning in accordance with NACE SP0178.
- N. PVC and FRP Surfaces:
 - 1. Prepare surfaces to be coated by light sanding (de-gloss) and wipe-down with clean cloths, or by solvent cleaning in strict accordance with coating manufacturer's instructions.

3.03 MECHANICAL AND ELECTRICAL EQUIPMENT PREPARATION

- A. Identify equipment, ducting, piping, and conduit as specified in Section 16075.
- B. Remove grilles, covers, and access panels for mechanical and electrical system from location and coat separately.
- C. Prepare and finish coat-primed equipment with color selected by the Engineer.
- D. Prepare and prime and coat insulated and bare pipes, conduits, boxes, insulated and bare ducts, hangers, brackets, collars, and supports, except where items are covered with prefinished coating.
- E. Replace identification markings on mechanical or electrical equipment when coated over or spattered.
- F. Prepare and coat interior surfaces of air ducts, convactor and baseboard heating cabinets that are visible through grilles and louvers with 1 coat of flat black paint, to limit of sight line.
- G. Prepare and coat dampers exposed immediately behind louvers, grilles, convactor and baseboard cabinets to match face panels.
- H. Prepare and coat exposed conduit and electrical equipment occurring in finished areas with color and texture to match adjacent surfaces.
- I. Prepare and coat both sides and edges of plywood backboards for electrical equipment before installing backboards and mounting equipment on them.
- J. Color code equipment, piping, conduit, and exposed ductwork and apply color banding and identification, such as flow arrows, naming and numbering, in accordance with Contract Documents.

3.04 GENERAL APPLICATION REQUIREMENTS

- A. Apply coatings in accordance with manufacturer's instructions.
- B. Coat metal unless specified otherwise:
 - 1. Aboveground piping to be coated shall be empty of contents during application of coatings.
- C. Verify metal surface preparation immediately before applying coating in accordance with SSPC SP COM.
- D. Allow surfaces to dry, except where coating manufacturer requires surface wetting before coating.
- E. Wash coat and prime sherardized, aluminum, copper, and bronze surfaces, or prime with manufacturer's recommended special primer.
- F. Prime shop primed metal surfaces. Spot prime exposed metal of shop primed surfaces before applying primer over entire surface.

- G. Multiple coats:
1. Apply minimum number of specified coats.
 2. Apply additional coats when necessary to achieve specified thicknesses.
 3. Apply coats to thicknesses specified, especially at edges and corners.
 4. When multiple coats of same material are specified, tint prime coat and intermediate coats with suitable pigment to distinguish each coat.
 5. Lightly sand and dust surfaces to receive high gloss finishes, unless instructed otherwise by coating manufacturer.
 6. Dust coatings between coats.
- H. Coat surfaces without drops, overspray, dry spray, runs, ridges, waves, holidays, laps, or brush marks.
- I. Remove spatter and droppings after completion of coating.
- J. Apply coating by brush, roller, trowel, or spray, unless particular method of application is required by coating manufacturer's instructions or these Specifications.
- K. Plural component application: Drums shall be premixed each day. All gauges shall be working order prior to the start of application. Ratio checks shall be completed prior to each application. A spray sample shall be sprayed on plastic sheeting to insure set time is complete prior to each application. Hardness testing shall be preformed after each application.
- L. Spray application:
1. Stripe coat edges, welds, nuts, bolts, difficult to reach areas by brush before beginning spray application, as necessary, to ensure specified coating thickness along edges.
 2. When using spray application, apply coating to thickness not greater than that recommended in coating manufacturer's instructions for spray application.
 3. Use airless spray method, unless air spray method is required by coating manufacturer's instruction or these Specifications.
 4. Conduct spray coating under controlled conditions. Protect adjacent construction and property from coating mist, fumes, or overspray.
- M. Drying and recoating:
1. Provide fans, heating devices, or other means recommended by coating manufacturer to prevent formation of condensate or dew on surface of substrate, coating between coats and within curing time following application of last coat.
 2. Limit drying time to that required by these Specifications or coating manufacturer's instructions.
 3. Do not allow excessive drying time or exposure which may impair bond between coats.
 4. Recoat epoxies within time limits recommended by coating manufacturer.
 5. When time limits are exceeded, abrasive blast clean and de-gloss clean prior to applying another coat.
 6. When limitation on time between abrasive blasting and coating cannot be met before attachment of components to surfaces which cannot be abrasive blasted, coat components before attachment.

7. Ensure primer and intermediate coats of coating are unscarred and completely integral at time of application of each succeeding coat.
8. Touch up suction spots between coats and apply additional coats where required to produce finished surface of solid, even color, free of defects.
9. Leave no holidays.
10. Sand and feather in to a smooth transition and recoat and recoat scratched, contaminated, or otherwise damaged coating surfaces so damages are invisible to naked eye.

N. Concrete:

1. Apply first coat (primer) only when surface temperature of concrete is decreasing in order to eliminate effects of off-gassing on coating.

3.05 HIGH SOLIDS EPOXY SYSTEM

A. Preparation:

1. Prepare surfaces in accordance with general preparation requirements and as follows:
 - a. Abrasive blast ferrous metal surfaces to be submerged at jobsite in accordance with SSPC SP-5 prior to coating. When cleaned surfaces rust or discolor, abrasive blast surfaces in accordance with SSPC SP-10.
 - b. Abrasive blast non-submerged ferrous metal surfaces at jobsite in accordance with SSPC SP-10, prior to coating. When cleaned surfaces rust or discolor, abrasive blast surfaces in accordance with SSPC SP-6.
 - c. Abrasive blast clean ductile iron surfaces at jobsite in accordance with SSPC SP-7.

B. Application:

1. Apply coatings in accordance with general application requirements and as follows:
 - a. Apply minimum 2-coat system with minimum total dry film thickness (DFT) of 12 mils.
 - b. Recoat or apply succeeding epoxy coats within time limits recommended by manufacturer. Prepare surfaces for recoating in accordance with manufacturer's instructions.
 - c. Coat metal to be submerged before installation when necessary, to obtain acceptable finish, and to prevent damage to other surfaces.
 - d. Coat entire surface of support brackets, stem guides, pipe clips, fasteners, and other metal devices bolted to concrete.
 - e. Coat surface of items to be exposed and adjacent 1 inch to be concealed when embedded in concrete or masonry.

3.06 HIGH SOLIDS EPOXY AND POLYURETHANE COATING SYSTEM

A. Preparation:

1. Prepare surfaces in accordance with general preparation requirements and as follows:
 - a. Prepare concrete surfaces in accordance with general preparation requirements.
 - b. Touch up shop primed steel and miscellaneous iron.
 - c. Abrasive blast ferrous metal surfaces at jobsite prior to coating. Abrasive blast clean rust and discoloration from surfaces.

- d. Degrease or solvent clean, whip abrasive blast, power tool, or hand tool clean galvanized metal surfaces.
 - e. Lightly sand (de-gloss) fiberglass and poly vinyl chloride (PVC) pipe to be coated and wipe clean with dry cloths, or solvent clean in accordance with coating manufacturer's instructions.
 - f. Abrasive blast clean ductile iron surfaces.
- B. Application:
- 1. Apply coatings in accordance with general application requirements and as follows:
 - a. Apply 3 coat system consisting of:
 - 1) Primer: 4 to 5 mils dry film thickness high solids epoxy.
 - 2) Intermediate coat: 4 to 5 mils dry film thickness high solids epoxy.
 - 3) Topcoat: 2.5 to 3.5 mils dry film thickness aliphatic or aliphatic-acrylic polyurethane topcoat.
 - 2. Recoat or apply succeeding epoxy coats within 30 days or within time limits recommended by manufacturer, whichever is shorter. Prepare surfaces for recoating in accordance with manufacturer's instructions.
 - 3. For fiberglass and PVC pipe, apply 1 coat high solids epoxy (4 to 5 mils DFT) and 2 coats aliphatic or aliphatic-acrylic polyurethane.

3.07 FIELD QUALITY CONTROL

- A. Each coat will be inspected. Strip and remove defective coats, prepare surfaces and recoat. When approved, apply next coat.
- B. Control and check dry film thicknesses and integrity of coatings.
- C. Measure dry film thickness with calibrated thickness gauge.
- D. Dry film thicknesses on ferrous-based substrates may be checked with Elcometer Type 1 Magnetic Pull-Off Gage or Positector 6000.
- E. Verify coat integrity with low-voltage sponge or high-voltage spark holiday detector, in accordance with SP0188 06. Allow Engineer to use detector for additional checking.
- F. Check wet film thickness before coal tar epoxy coating cures on concrete or non-ferrous metal substrates.
- G. Arrange for services of coating manufacturer's field representative to provide periodic field consultation and inspection services to ensure proper surface preparation of facilities and items to be coated, and to ensure proper application and curing:
 - 1. Notify Engineer 24 hours in advance of each visit by coating manufacturer's representative.
 - 2. Provide Engineer with a written report by coating manufacturer's representative within 48 hours following each visit.

3.08 SCHEDULE OF ITEMS NOT REQUIRING COATING

- A. General: Unless specified otherwise, the following items do not require coating:
1. Items that have received final coat at factory and not listed to receive coating in field.
 2. Aluminum, brass, bronze, copper, plastic (except PVC pipe), rubber, stainless steel, chrome, Everdur, or lead.
 3. Buried or encased piping or conduit.
 4. Exterior concrete.
 5. Galvanized steel wall framing, galvanized electrical conduits, galvanized pipe trays, galvanized cable trays, and other galvanized items:
 - a. Areas on galvanized items or parts where galvanizing has been damaged during handling or construction shall be repaired as follows:
 - 1) Clean damaged areas by SSPC SP-1, SP-2, SP-3, or SP-7 as required.
 - 2) Apply 2 coats of a Galvanizing Zinc Compound in strict accordance with manufacturer's instructions.
 6. Grease fittings.
 7. Fiberglass ducting or tanks in concealed locations.
 8. Steel to be encased in concrete or masonry.

END OF SECTION

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SECTION 11312R

ROTARY LOBE POSITIVE DISPLACEMENT PUMPS

PART 1 GENERAL

1.01 SUMMARY

- A. The Supplier as specified under Section 11500 - Membrane Equipment System, shall size, select, and provide the equipment specified under this Section.
- B. Supplier shall provide bi-directional rotary lobe pumping equipment for use as permeate pumps, complete with base plate, motor, coupling, controls, and drive appurtenances, as required by the membrane Supplier.
- C. Coordination: To ensure that all equipment is properly coordinated and will function properly, the Supplier shall size the pumps for the process and obtain all the pump and motor equipment specified from a single pump supplier.
- D. Section includes rotary lobe type positive displacement pump with driver, and features as specified and scheduled in this Section. Refer to related Specifications for additional requirements.
- E. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01756 - Testing, Training, and Facility Start-Up.
 - b. Section 01782 – Operation and Maintenance Data
 - c. Section 09960 - High-Performance Coatings.
 - d. Section 11500 – Membrane Equipment System.
 - e. Section 15050 - Common Work Results for Mechanical Equipment.
 - f. Section 15958 - Mechanical Equipment Testing.
 - g. Section 16222 - Low Voltage Motors up to 500 Horsepower.

1.02 REFERENCES

- A. American Gear Manufacturers Association (AGMA).
- B. American National Standards Institute (ANSI).
- C. ASTM International (ASTM):
 - 1. A 48 - Standard Specification for Gray Iron Castings.
 - 2. A 276 - Standard Specification for Stainless Steel Bars and Shapes.

3. A 278 - Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650°F (350°C).
 4. A 283 - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
 5. A 470 - Standard Specification for Vacuum-Treated Carbon and Alloy Steel Forgings for Turbine Rotors and Shafts.
 6. A 516 - Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate and Lower Temperature Service.
 7. D 2240 - Standard Test Method for Rubber Property-Durometer Hardness.
- D. Hydraulic Institute (HI):
1. 3.1-3.5 - Rotary Pumps for Nomenclature, Definitions, Application and Operation.
 2. 3.6 - Rotary Pump Tests.
 3. 9.1-9.5 - Pumps - General Guidelines for Types, Definitions, Application, Sound Measurement and Decontamination.
- E. National Electrical Manufacturers Association (NEMA).

1.03 DEFINITIONS

- A. Pump head (total dynamic head, TDH), flow capacity, pump efficiency, net positive suction head available (NPSHa), and net positive suction head required (NPSHr) are as defined in HI 3.1-3.5, 3.6, and 9.1-9.5 and as modified in the Specifications.
- B. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric. Average when using multiple suction pressure taps, regardless of variation in individual taps.

1.04 SYSTEM DESCRIPTION

- A. Pump Type and Components: Rotary lobe, positive displacement pumps with components. System includes pump, motor or other driver, variable frequency drives, drive arrangements, seals or packing, couplings, base plates, guards, supports, anchor bolts, necessary valves, gauges, taps, lifting eyes, stands, and other items as required for a complete and operational system.
- B. Design requirements:
1. Pump performance characteristics:
 - a. As specified in the Pump Schedule.
 - b. Performance tolerances shall be the same as the test tolerances specified in Section 15958.
 - c. Pumps shall be suitable for installation as specified in this Section and as indicated on the Drawings.
 2. Motor characteristics: As specified in the Pump Schedule.
- C. Permeate (Membrane Permeate/Filtrate) Pumps:
1. Pumps shall be rotary lobe positive displacement pumps in accordance with these specifications.
 2. Pumps shall be self-priming pumps.
 3. Number: As required by the Supplier's design requirements (minimum 1 duty per membrane train).

4. Each pump shall have sufficient capacity to operate one membrane train and meet the design flow rates. This requirement shall be met at the maximum transmembrane pressure and allow for all other system losses.
5. Each pump shall be able to maintain a constant permeate flow regardless of transmembrane pressure up to the maximum transmembrane pressure.
6. Permeate pumps shall also provide membrane backpulsing, if required, and maintenance and chemical cleaning backpulsing.
7. Pumps shall be designed to provide the required backpulse flowrate to each membrane train at the highest allowable transmembrane pressure.
8. In addition to the Membrane System requirements, the permeate pump shall deliver sufficient total dynamic head to drive downstream processes. See Schedule at end of this Section for discharge head requirements.

1.05 SUBMITTALS

- A. Submit as specified in Section 15050.
- B. Torsional analysis: When scheduled, submit as specified in Section 15050.
- C. Submit motor information as specified in Section 16222.
- D. Shop drawings: Submit the following for approval:
 1. Performance Data pump curves.
 2. Manufacturer's data and drawing describing the equipment in sufficient detail, including materials of construction.
 3. Detail drawings showing dimensions and weight of the pumping unit and the motor.
 4. Provide proof of compatibility for all materials with the intended use.

1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: the manufacturer of the rotary lobe pumping equipment shall have experience in producing similar type equipment, and show evidence of five installations in satisfactory operation for at least five years.
- B. As specified in Section 15050.
- C. Provide pumps specified in this Section from same manufacturer.
- D. Require pump manufacturer to furnish pump, motor, and pump components as specified and scheduled and to provide written installation and checkout requirements.

1.07 DELIVERY STORAGE AND HANDLING

- A. As specified in Section 15050.

1.08 PROJECT CONDITIONS

- A. Environmental requirements: As specified in Section 15050.

1.09 SEQUENCING AND SCHEDULING

- A. Coordinate work with restrictions as specified in Section 01140.

1.10 WARRANTY

- A. Pumps specified in this Section, in addition to all other requirements specified in Section 15050, shall be warranted free from defects in workmanship, design, and materials for a period of 2 years from the date of acceptance of the equipment or first beneficial use of the equipment. If any part of the equipment should prove to be defective during the warranty period, the pump manufacturer shall, at no expense to the Owner, replace the part.

1.11 MAINTENANCE

- A. Special tools: For each type or size of pump specified, provide 1 set of all special tools required for complete assembly or disassembly of the pump system components.
- B. Spare parts: Deliver the following for each type or size of pump.
 - 1. 1 spare rotor set or set of replaceable rotor tips.
 - 2. 1 set of mechanical seals.
 - 3. 1 set of O-rings.
 - 4. 1 set of wear plates (front, back, and radial).

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Pumps: One of the following, or equal.
 - 1. Boerger, LLC.
 - 2. Vogelsang USA, LTD.

2.02 PROCESS SYSTEM DESIGN AND PERFORMANCE

- A. Pumps shall be sized using the Supplier design criteria.
- B. Pump sizing and calculations shall be finalized with the submittal drawings for the membrane system.

2.03 EQUIPMENT AND COMPONENTS

- A. General:
 - 1. The Rotary Lobe Pumps shall be designed to be abrasion resistant for applications in wastewater treatment plants.
 - 2. The ratio of the axial length of the lobe as compared to the lobe diameter (length/diameter) shall not exceed 1.0.

2.04 SYSTEM AND FLUID CONDITIONS

- A. Fluid (name): Permeate Wastewater.

- B. Specific Gravity: 1.0.
- C. pH value: 6-9.
- D. Capacity (gpm): As required by Supplier.
- E. Differential Pressure: Per Supplier.
- F. Temperature: 12.5 to 22 degrees Celsius.
- G. Duty (hrs/day): 24 (continuous).

2.05 MATERIALS

- A. General: Materials in the Pump Schedule shall be the type and grade as specified in this Section.
- B. Cast iron: ASTM A 48, Class 30 minimum.
- C. Gray iron casting: ASTM A 278, Class 30.
- D. Buna-N: Synthetic rubber with a minimum Durometer hardness of 70 in accordance with ASTM D 2240 test methods.
- E. Steel: ASTM A 283, Grade D or ASTM A516 Grade 70
- F. Stainless steel: ASTM A 276, Type 316 stainless steel; nickel - chrome- boron coating as scheduled.
- G. Carbon steel: ASTM A 470.
- H. All elastomers shall be Buna-N.

2.06 GENERAL PUMP CONSTRUCTION

- A. Characteristics:
 - 1. Drive Type: Geared motor.
 - 2. Drive Arrangement: In line.
 - 3. Motor Power (HP): TBD by manufacturer.
 - 4. Pump speed (60 Hz): TBD by manufacturer.
 - 5. Suction Flange: ANSI 150 lbs.
 - 6. Discharge Flange: ANSI 150 lbs.
- B. Type: Industrial, heavy duty, positive displacement, rotary lobe type pumps meeting performance requirements and features as scheduled and as specified.
- C. Service: Pumping units shall be designed to convey membrane permeate. Other service requirements shall be as scheduled.
- D. All equipment shall be designed and built for 24-hour continuous service at the rated design condition without overheating, without cavitation, and without excessive vibration or strain.

- E. All working parts of the pumps and motors, such as bearings, wearing rings, shaft, sleeves, etc., shall be standard dimensions built to limit gauges or formed templates, such that parts will be interchangeable between like units and such that the Owner may obtain replacement and repair parts for those furnished in the original machines at any time in the future.
- F. All lubrication fittings shall be brought to the outside of all equipment so that they are readily accessible from the outside without the necessity of removing covers, plates housings, or guards.
- G. All fluid-wetted parts including the mechanical seal shall be replaceable through the quick release front cover without disassembly of coupling, drive unit or the pipe system.
- H. Pump shall be capable of temporarily running dry without damage and operate in either direction. Oil-quench for protection of the mechanical seal is mandatory. Seal water flush systems are not acceptable.
- I. The pumps shall be fitted with maintenance-free, quenched mechanical seals with silicon carbide seal faces. The seals shall be operating in a common oil-filled intermediate chamber (Quench for lubrication and cooling). Purge systems for the seals are not acceptable. The rotating holding bush shall be locked in a fixed radial position by a keyway that also holds the rotor in place. Seal designs that open during rotor replacement are not acceptable. No sleeves shall be necessary for the mechanical seal set up. Design of the pump shall allow removal and replacement of the seal via the front cover.
- J. Bearings and timing gear shall be located in a common oil-filled cast iron gearbox, fitted with a built in sight glass to monitor oil level. The timing gear shall maintain non-contact between the rotors. Bearing life to be designed for L-10 bearing life rating of 100,000 hours at design conditions.
- K. Pump and drive fitted on common base.
- L. Vibration: Pumps and motors shall operate at any point within their operating range without undue noise and vibration. Vibration at any point in the operating range shall not exceed the limits allowed by the Hydraulic Institute.

2.07 MOTORS

- A. General:
 - 1. Shall meet the requirements of Section 16222.
 - 2. Shall meet the requirements of these documents and rated for VFD operation.
 - 3. Each unit shall consist of a pump/geared motor configuration and shall be supplied with an in-line reducer complete with electric motor, 1,800 RPM, 3 phase, 60 Hz, 460 Volt, TEFC, Class H Insulation, 50 degrees Celsius rating.
 - 4. Motor needs to be inverter duty rated for a minimum of 4:1 constant torque ratio.
 - 5. All motors shall be built in accordance with latest NEMA, IEEE, ANSI and AFBMA standards where applicable.
 - 6. Suitable for operation with variable frequency drives.
 - 7. Variable Frequency Drives (VFD): Provide as specified in Section 16262.

2.08 PUMP CASING

- A. Materials:
 - 1. Pump casing: As scheduled.
 - 2. Pump top and bottom housing: As scheduled: minimum 750 Brinell hardness.
 - 3. Front and end covers: Same as pump casing.
 - 4. Wear plates: As specified.
- B. Construction: Material as scheduled of sufficient strength, weight, and thickness to provide accurate alignment, and prevent excessive deflection.
- C. Design Working Pressure: Not less than the maximum of 1.25 the Rated Design Point head or 1.1 times the maximum discharge pressure at the maximum revolutions per minute in vendor published information for the specified model.
- D. Hydrostatic Test: 5 minute hydrostatic test minimum 1.5 times Design Working Pressure.
- E. Suction and Discharge Piping Connections: Flanged meeting ANSI/ASME B 16.1, Class 125, or ANSI/ASME B 16.5, Class 150; provide higher pressure class as required to meeting Design Working Pressure.
- F. The pump casing shall be manufactured in a single block construction from cast iron Class 30. Multiple Piece Design Pump Casings held together by screw connections are not acceptable.
- G. Top and bottom pump housing: Top and bottom segments of the pump shall be adjustable based on wear up to 6 millimeters. The adjustment shall be accomplished by simply moving stainless steel shims from one hole to the next in the pump housing, allowing for the closing of tolerance around the rotors. This adjustment must be available a minimum of 2 times from factory tolerance.
 - 1. In lieu of providing adjustable top and bottom segments, manufacturer may provide radial wear plates on the casing walls that utilize the same philosophy as the front and rear wear plates.
 - 2. The radial wear plates shall be designed to allow the OWNER to replace the worn component and bring the radial casing back to factory tolerance.
- H. Housing Cover Plates: for access to rotor and shaft ends without otherwise dismantling the pump.
- I. Front cover:
 - 1. The removable front cover shall be mounted to the pump with 4 individual bolts.
 - 2. The front cover shall permit removal of the rotors without disturbing piping, bearings, and mechanical seals.
 - 3. The front cover shall be machined to accept a reversible wear plate.
 - 4. The rear of the pump casing and the front cover shall be protected with replaceable wear plates of stainless steel.
- J. End cover:
 - 1. The removable end cover shall be flush with no recesses or dead pockets where solids can accumulate.

- 2. The end cover shall be sealed with Buna-N O-ring and provide complete access to the pump chamber without disconnecting pipe work glands or bearings.
- K. Wear plates: Wear plates shall be constructed of Hardox 500 material, or equal, with a minimum Brinell hardness of 550 and a finished, hardened, reversible surface of 700 Brinell.
- L. Port connections: Provide ANSI Class 150 raised face flanges. Connections shall be suitable for field coating as specified in Section 09960.
- M. Vent and Taps: Provide casings with both 3/4 inch National Pipe Thread high point vent and low point drain taps.

2.09 PUMP ROTORS

- A. Materials:
 - 1. Rotor core: As scheduled.
 - 2. Rotor (and/or rotor tip) coating: As scheduled.
- B. Construction:
 - 1. The pump shall utilize 2 **[quad lobe rotors] [tri-lobe rotors]**, which are driven through positive timing gears running in oil.
 - 2. Rotors shall be multiple lobe screw rotor design with individually replaceable tips or lobes and the tips or lobes shall be vulcanized with FPM. The length of the rotor shall not exceed its diameter.
 - 3. Rotor cores shall be covered with a rotor coating as scheduled.
 - 4. The geometry of the rotor core shall be the same as that of the finished rotor.
 - 5. Rotor vane geometry shall be convoluted to provide pressure-pulse free operation.
 - 6. Designs with rotor vanes parallel to the shaft centerline will not be accepted.
 - 7. Rotors shall be positioned on the shaft by replaceable hardened key ways and secured to the shaft by internal/external expansion clamp sleeves and flush discs requiring no recesses in the end cover.
 - 8. The rotor/shaft connection shall be oil-lubricated fed by an intermediate chamber and shall not come into contact with the pumped fluid.
- C. In lieu of providing solid rotors, rotors may be provided with replaceable tips. Rotor, rotor tip, and rotor coating material shall be as specified.
- D. Stacking of lobes is not acceptable.

2.10 SHAFTS

- A. Materials:
 - 1. Shaft: As scheduled.
 - 2. Shaft sleeve: As scheduled: ceramic coated.
- B. Construction: Pump shafts shall be designed to withstand 1.5 times maximum operating torque and other loads, and of sufficient stiffness to operate without distortion, damaging vibration, or excessive wear throughout the range of operation specified.

- C. The shafts shall be non-fluid-wetted, the rotor/shaft connection shall be lubricated with quench fluid of the intermediate chamber. They shall be timed in their rotation by straight cut timing gears running in a separate oil chamber, which also contains the ball and roller bearings for each shaft.
- D. Fluid-wetted rotor/shaft connections are not acceptable.
- E. The shafts shall be constructed from carbon steel AISI 4140.
- F. Resonant Frequency: As specified in Section 15050.
- G. Shaft Connecting Rod: Design to limit operating angle to within 1 degree angular deflection.

2.11 BEARINGS AND BEARING FRAME

- A. Bearing Life: Minimum L_{10} life of 100,000 hours at rated design point but not less than 24,000 hours in accordance with ABMA 9 or 11 at bearing design load imposed by pump shutoff with maximum sized impeller at rated speed.

2.12 STUFFING BOXES

- A. Construction:
 - 1. A blocking chamber located behind the mechanical seal and in front of the bearing housing lip seal shall be molded into the casting of the pump.
 - a. This chamber shall be suitable for oil fill through the top and bottom of the pump.
 - b. This chamber will have an external pressurized oil bottle mounted above the pump from the fill nipples to view the status of the mechanical seals.
 - 2. The external oil bottle will be located in view of the operator. Oil-quench shall provide lubrication and cooling of the mechanical seal, allow detection of seal failures, and provide a buffer zone to the sealed timing gear. Seal water flush systems are not acceptable.
 - a. In lieu of providing an external pressurized oil bottle mounted above the pump, manufacturer may provide a plastic stopper on the chamber that is vented to the atmosphere, which will allow fluid to escape as an indication of seal failure.
- B. Shaft seal type: Double Mechanical Seals.
- C. Drain Size: Minimum 3/4 inch, with drain line routed to nearest equipment floor drain.
- D. Design of the pump shall allow removal and replacement of the seal via the front cover.
 - 1. Seal designs that open during rotor replacement are not acceptable.
- E. Oil drain gearbox and intermediate chamber shall be easily accessible with side mounted drain screw.
 - 1. Oil drain under the pump is not acceptable.

2.13 GEAR REDUCERS

- A. Gear reducers and couplings shall meet the requirements as specified in Section 15050.
- B. Provide NEMA C face connection between motor and gearbox.
- C. Provide helical reduction gears, rated for AGMA Class II service with a 1.5 service factor.
- D. Provide oil bath lubrication.

2.14 COUPLINGS

- A. Types: When driver or gear coupled to pump, provide flexible coupling as specified in Section 15050.
- B. Flexible Coupling Life: Infinite at up to 0.30-degree misalignment angle total or per disk for disk type at maximum operating loads.
- C. Design coupling to withstand a minimum of 1.5 times the maximum operating torque and other imposed loads.

2.15 SUPPORTS, PEDESTALS, AND BASEPLATES

- A. Type: Single piece baseplate with drive arrangement as scheduled and as specified in Section 15050.
- B. Materials: Same as pump casing or ASTM A 283 steel, hot-dip galvanized after fabrication and coated as specified in Section 09960.
- C. Pump, driver, and intermediate bearing support strength: Able to withstand minimum 1.5 times maximum imposed operating loads or imposed seismic loads, whichever is greater.
- D. Configuration:
 - 1. Support pump, gear reducers, and motor on a common structural steel baseplate.
 - 2. Pumping unit shall be furnished in a piggyback arrangement, belt driven with motor overtop of pump.
 - 3. Allow easy access to stuffing boxes, bearing frames, suction housing and couplings; suction flange at least 2 inches above pump foundation; factory mount pump and driver to baseplate.
 - 4. Belt drive shall be as specified in Section 15050.
- E. Motor Arrangement:
 - 1. For Piggyback Arrangement: Provide motor base with slide rails to allow for adequate belt and alignment adjustment of pump and motor.
 - 2. When In-Line Motor Arrangement Scheduled:
 - a. Motor centerline to coincide with pump centerline.
 - b. Provide gearbox as needed to provide specified pump speed.
 - 3. When Piggyback or Overhead Motor Arrangement Scheduled:
 - a. Support motor directly above pump centerline.

- b. Mount motor minimum of 6 inches above top of pump on structural frame.

- F. Anchor bolts: Designed by the pump manufacturer.
 - 1. 3/4-inch minimum diameter.
 - 2. As specified in Section 05190.

2.16 SPEED REDUCERS

- A. V-Belt Drives:
 - 1. Design to transfer torque of installed driver.
 - 2. Limit speed reduction ratio to 5 to 1.
 - 3. As specified in Section 15050.

2.17 EQUIPMENT GUARDS

- A. Provide safety guards as specified in Section 15050.

2.18 DRIVERS

- A. Horsepower:
 - 1. As scheduled.
 - 2. Listed driver horsepower is the minimum to be supplied.
 - a. Increase driver horsepower if required to prevent driver overload while operating at any point of the supplied pump operating head-flow curve including runout.
 - b. When scheduled driver is a motor, increase motor horsepower if required to prevent operation in the service factor.
 - c. Make all structural, mechanical, and electrical changes required to accommodate increased horsepower.
- B. Motors: Provide motors as specified in Section 16222 and as specified in this Section.
 - 1. Revolutions per minute: As scheduled.
 - 2. Enclosure: As scheduled.
 - 3. Electrical characteristics: As scheduled.
 - 4. Efficiency, service factor, insulation, and other motor characteristics: As specified in Section 16222.
 - 5. Motor accessories: As specified in Section 16222 and in this Section.
 - 6. Coordinate motors with the variable frequency drive manufacturer to ensure compatibility between the motor and variable frequency drive.
- C. Other drivers: As scheduled and as specified in sections listed in the Schedule.
- D. Non-reverse ratchets: When scheduled, provide driver with non-reverse ratchets or pin mechanism to prevent reverse rotation of the pump and driver in the event of discharge valve failure.

2.19 FINISHES

- A. Prepare surfaces and apply protective finishes as specified in Section 09960.

2.20 SOURCE QUALITY CONTROL

- A. Witnessing: Source or factory testing shall be witnessed by the Engineer or Owner when scheduled. Provide advanced notice of source testing as specified in Section 15958.
- B. Equipment performance test: Test level as scheduled; test as specified in Section 15958.
- C. Vibration test: Test level as scheduled; test as specified in Section 15958.
- D. Noise test: Test level as scheduled; test as specified in Section 15958.
- E. Motor factory tests: Test as specified in Section 16222.
- F. Hydrostatic pressure tests: As specified for components in this Section.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

- A. Witnessing: All field-testing shall be witnessed by the Engineer; provide advanced notice of field-testing as specified in Section 15958.
- B. Inspection and checkout: As specified in Sections 15050 and 15958.
- C. Equipment performance test: Test level as scheduled; test as specified in Section 15958.
- D. Vibration test: Test level as scheduled; test as specified in Section 15958.
- E. Noise test: Test level as scheduled; test as specified in Section 15958.
- F. Driver and motor tests: Test as specified in scheduled section.
- G. Operational testing: As specified in Section 01756.

3.02 MANUFACTURER'S FIELD SERVICES

- A. Require manufacturer to inspect system before initial start-up and certify that system has been correctly installed and prepared for start-up as specified in this Section and Section 15050.
- B. Training: As specified in Section 01756.

3.03 PUMP SCHEDULE

Tag Numbers	PMP2511, PMP2521, PMP2531, PMP2541
<u>General Characteristics:</u>	
Service	Permeate Pumps
Quantity	1 per membrane train
First Named Manufacturer's Model Number	Per Membrane Supplier
Maximum Noise, dBA at 3 feet	85
Minimum Pump Displacement (gal/100 rev)	Per Supplier
Torsional Analysis	Not Required
Minimum Pumped Fluid degrees Fahrenheit	54.5
Normal Pumped Fluid degrees Fahrenheit	63
Maximum Pumped Fluid degrees Fahrenheit	71.6
<u>Pump Characteristics:</u>	
Impeller Type	Positive Displacement, Rotary Lobe
Shaft Seal Type	Double Mechanical
Coupling Type	Spacer
Speed Control	Variable Frequency Drive
Maximum Pump rpm	Per Supplier
Minimum Pump rpm	Per Supplier
Suction Flange Diameter, Inches	Per Supplier
Discharge Flange Diameter, Inches	Per Supplier
<u>Rated Design Point (at Maximum Revolutions per Minute):</u>	
Flow, Gallons per Minute	Per Supplier
Head, Feet	71
<u>Maximum Rated Head Condition (at Maximum Revolutions per Minute):</u>	
Flow, Gallons per Minute	Per Supplier
Head Range, Feet	Per Supplier
<u>Normal Operating Range:</u>	
Flow, Gallons per Minute	Per Supplier
Head Range, Feet	Per Supplier
<u>Other Conditions:</u>	
Minimum NPSHa at Every Specified Flow, Feet	Per Supplier

Tag Numbers	PMP2511, PMP2521, PMP2531, PMP2541
<u>Pump Materials:</u>	
Casing	Gray Cast Iron
Top and Bottom Pump Housing	Gray Cast Iron
Rotor Core	Gray Cast Iron
Rotor Coating (including rotor tip coating)	Buna-N
Shaft	Carbon Steel
Shaft Sleeve	316 Stainless Steel, Ceramic Coated
Nuts and Bolts	316 Stainless Steel
<u>Driver Characteristics:</u>	
Driver Type	Motor
Drive Arrangement	Belt Drive
Minimum Driver Horsepower	Per Supplier
Maximum Driver rpm	Per Supplier
<u>Motor Characteristics (when motor is driver type):</u>	
Inverter Duty Rated	Yes
Motor Voltage/Phases/Hertz	460/3/60
Enclosure Type	TEFC
<u>Source Quality Control Testing:</u>	
Test Witnessing	Not Witnessed
Performance Test Level	A. 1
Vibration Test Level	1
Noise Test Level	1
<u>Field Quality Control Testing:</u>	
Performance Test Level	B. 2
Vibration Test Level	2
Noise Test Level	2

END OF SECTION

SECTION 11376A

ROTARY-LOBE BLOWERS

PART 1 GENERAL

1.01 SUMMARY

- A. The supplier as specified under Section 11500 – Membrane Equipment System, shall provide the equipment specified under this Section.
- B. Supplier shall provide rotary lobe blower equipment for use as MBR tank agitation aeration blower, complete with enclosure, motor, VFDs, surge control system, controls, and drive appurtenances, as required by membrane supplier.
- C. Section includes: Rotary lobe blower system including blower panel, and appurtenances.
- D. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01600 - Product Requirements.
 - b. Section 01612 - Seismic Design Criteria.
 - c. Section 01756 - Testing, Training and Facility Start-Up.
 - d. Section 01782 - Operation and Maintenance Data.
 - e. Section 09960 - High-Performance Coatings.
 - f. Section 13446 - Manual Actuators.
 - g. Section 13447 - Electric Motorized Actuators.
 - h. Section 15082 - Piping Insulation.
 - i. Section 15117 - Specialty Valves.
 - j. Section 16222 - Low Voltage Motors up to 500 Horsepower.
 - k. Section 17100 - Control Strategies.
 - l. Section 17101 - Specific Control Strategies.
 - m. Section 17710 - Control Systems - Panels, Enclosures, and Panel Components.

1.02 REFERENCES

- A. American Bearing Manufacturers Association (ABMA):
 - 1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
 - 2. 11 - Load Ratings and Fatigue Life for Roller Bearings.
- B. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

1. 52.1 - Testing for HVAC Air Filtration.
- C. American Society of Mechanical Engineers (ASME):
1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
- D. National Electrical Manufacturers Association (NEMA):
1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

1.03 DEFINITIONS

- A. NEMA Type 4X enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION

- A. General: Aeration blowers and appurtenances shall include the following items and supplied by blower manufacturer:
1. Rotary positive displacement blower and motor.
 2. Air intake filters.
 3. Silencers, inlet, discharge, and vent.
 4. Butterfly valves in blowoff circuit.
 5. Check valves.
 6. Relief valves.
 7. Flexible pipe connectors.
 8. Pressure gauges.
 9. Acoustic enclosure.
 10. Appurtenances as required.

- B. Design requirements:

Type of Blower	Rotary lobe, positive displacement
Number of blowers	One per membrane train
Rated speed (max)	1,700 revolutions per minute, maximum
Rated inlet air flow at rated speed	Per supplier
Inlet filter pressure loss	0.20 pounds per square inch
Rated discharge pressure	23.0 pounds per square inch absolute
Rated inlet pressure	13.7 pounds per square inch absolute
Inlet temperature	120 Fahrenheit maximum/ 20 Fahrenheit minimum/rated for 100 Fahrenheit

1. Motor: As specified in Section 16222, except as otherwise specified or supplemented below:

Power supply	480-volt, 3-phase, 60-hertz
Horsepower	Per supplier
Speed, maximum	1,800
Enclosure	TEFC

Service factor	1.15
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2. Drive: Belt.
 3. Noise control:
 - a. Sound pressure levels radiated from equipment furnished shall not exceed 78 dBA (mean, A-weighted) at 3 feet ($RE\ 2 \times 10^{-5}\ N/m^2$) for free field condition when unit is in operation at 1,030 actual cubic feet per minute.
 - b. Sound pressure level measurements: Take measurements at 6 points, 3 feet from acoustic enclosure, with piping and silencers installed, at the following locations:
 - 1) 1 point at each end of unit.
 - 2) 2 points on either side of unit at approximate midpoints of motor and blower casings.
 - c. Run certified acoustic tests on each blower at place of manufacture, and submit 4 certified copies of test results for each blower to Engineer before shipment.
 - d. Ship blowers after Engineer has approved noise certification.
 4. Provide control panel, instrumentation, and alarms as indicated on the P&ID Drawings and as specified in Sections 17100 and 17101.
- C. System operation: System operation shall be as specified in Sections 17100 and 17101.

1.05 SUBMITTALS

- A. Product data and shop drawings: Include:
1. Blower panel device layout and material list.
 2. Literature and drawings describing equipment performance and construction in sufficient detail, including parts list, dimensions, materials, and details of construction and installation.
 3. Schematic electrical wiring diagrams and other data as required for complete system.
 4. Certified dimensional data for components, including foundation and anchor bolts and details.
 5. Equipment data:
 - a. Blower information:
 - 1) Manufacturer.
 - 2) Model.
 - 3) Blower speed in revolutions per minute.
 - 4) Blower site capacity, actual cubic feet per minute.
 - 5) Discharge pressure, pounds per square inch absolute.
 - 6) Horsepower required including loss in V-belt drive.
 - 7) Weight of blower.
 - 8) Weight of motor.
 - 9) Free-field noise level at 3 feet from blower acoustic enclosure.
 - b. Motor performance and construction data.
 - c. Construction details of acoustic enclosure.
 - d. Descriptive brochures and applicable performance and construction data for each item of auxiliary equipment along with their weights.

1.06 QUALITY ASSURANCE

- A. Manufacturer qualifications:
1. Minimum 5 years experience in manufacturing similar equipment utilized in water and wastewater treatment plants.
 2. Supplies accessories including motor.
 3. Assumes responsibility for compatibility of components furnished.
 4. Furnishes services of factory representatives with complete knowledge of proper installation, operation, and maintenance of equipment to inspect and approve final installation and supervise test runs of equipment.

1.07 ENVIRONMENTAL CONDITIONS

- A. Blower shall be suitable for continuous service and outdoor installation.
- B. Site conditions are as follows:
1. Elevation 15.5 feet.
 2. Ambient temperature:
 - a. Maximum: 100 degrees Fahrenheit.
 - b. Minimum: 3 degrees Fahrenheit.

1.08 SPARE PARTS

- A. Furnish 1 set of special tools with equipment when required for normal operation and maintenance.
- B. Spare parts: Include:
1. 1 complete set of bearings.
 2. 4 complete sets of ventilation and air intake filters.
 3. 4 lubrication oil filter cartridges.
 4. 2 complete sets of gaskets and O-rings.
 5. 2 sets of drive belts.
- C. Label spare parts as specified in Section 01600 and box for storage.

1.09 POWER GUARANTEE

- A. The blower manufacturer shall submit guaranteed wire-to-air ("wire") KW values. The wire KW shall include all losses associated with the blower system at all specified operating points. The manufacturer shall provide wire KW values by completing Table 1 of Article 1.12 below. The completed table will be considered the basis of the Power Guarantee and all related requirements as specified herein.
- B. The blower manufacturer shall reaffirm stated guaranteed wire KW values for the blower unit in the Final Submittal and associated Shop Drawings. The guaranteed wire KW values must match what is presented in the Preliminary Submittal. Failure to meet this requirement will result in immediate rejection.

<u>Table 1</u>							
<u>Operating Point</u>	<u>Capacity %</u>	<u>Flow scfm</u>	<u>Pressure (psia)</u>		<u>Inlet Temp °F</u>	<u>RH %</u>	<u>Guaranteed Wire KW</u>
			<u>Barometric</u>	<u>Outlet</u>			

Table 1							
<u>Operating Point</u>	<u>Capacity %</u>	<u>Flow scfm</u>	<u>Pressure (psia)</u>		<u>Inlet Temp °F</u>	<u>RH %</u>	<u>Guaranteed Wire KW</u>
			<u>Barometric</u>	<u>Outlet</u>			
<u>1</u>	<u>100</u>	<u>*</u>	<u>*</u>	<u>*</u>	<u>110⁽¹⁾</u>	<u>25</u>	<u>**</u>
<u>2</u>	<u>45</u>	<u>*</u>	<u>*</u>	<u>*</u>	<u>110⁽¹⁾</u>	<u>25</u>	<u>**</u>
<u>3</u>	<u>100</u>	<u>*</u>	<u>*</u>	<u>*</u>	<u>32⁽¹⁾</u>	<u>99</u>	<u>**</u>
<u>4</u>	<u>45</u>	<u>*</u>	<u>*</u>	<u>*</u>	<u>32⁽¹⁾</u>	<u>99</u>	<u>**</u>
Notes: 1. If cooling air is exhausted to the blower inlet, add 10 degrees Fahrenheit to account for heat associated with cooling of motor, VFD and other electrical appurtenances within the enclosure. * Values to be selected by SUPPLIER **Wire KW consists of blower, motor, intake filter/silencer, VFD or inverter, and cooling system (if used).							

PART 2 PRODUCTS

2.01 BLOWERS

A. Manufacturers: One of the following or equal:

1. Roots.
2. Aerzen.

2.02 MATERIALS

A. General:

1. Blower assembly: Complete with blower, drive, inlet and discharge silencers, valves, and appurtenances.
2. Blower rating: As specified above.
3. Rotation direction of blower shall match requirements of piping.

B. Blower and drive:

1. General:
 - a. Blower shall deliver oil-free air.
 - b. Blower and motor mounting: On common base.
 - c. Lifting provisions: Lifting eyes on blowers, motors, and base so each major component or entire unit can be lifted.
 - d. Piping connections: 125 pound class flanges in accordance with ASME B16.1.
2. Type: Positive displacement rotary blowers using 2 impellers to pressurize a trapped volume of air at a controlled rate prior to exposing it to a discharge pressure.
3. Casing and head plates:
 - a. Blower casing: 1 piece with separate head plates and end covers.
 - b. Casing and head plates: Made of close-grained, machined cast iron.

- c. End covers and head plates: Reinforced with bosses at penetrations with cast, machined support feet.
- 4. Impellers:
 - a. Material: Ductile iron or cast iron.
 - b. Design: Straight, 2-lobe, involute type.
 - c. Balance: Statically and dynamically, by removing metal from impeller body.
 - d. Operation: Free of rubbing without need for liquid seals or lubrication.
 - e. Timing: positively by a pair of accurately machined, heat-treated, alloy steel timing gears.
 - f. Shafts: Alloy steel forgings, pressed into each end of each impeller and pinned.
 - g. Impeller assembly support: Anti-friction type bearings, sized for a minimum ABMA 9 and 11 L10 life for bearings of 100,000 hours.
- 5. Lubrication:
 - a. Positive oil seal: Provided at each bearing.
 - b. Seal design: Capable of preventing lubricant from leaking into air stream.
 - c. Vent provisions: Capable of venting impeller side of oil seal to atmosphere while eliminating possible carryover of lubricant into air stream.
 - d. Drive-end bearings: Grease lubricated.
 - e. Timing gears and gear-end bearings: Splash oil lubricated.
 - f. Blowers shipment: With openings sealed after injection of rust inhibitor.

2.03 APPURTENANCES

- A. Inlet filter: 2-stage pleated media type, minimum 24 inch by 24 inch by 2 inch each, using replaceable pleated lofted fiber elements with final media efficiency of not less than 45 percent in accordance with ASHRAE Standard 52.1, with resettable tell-tale "replace filter" indicator for each filter, housed in a weather-protected welded galvanized steel housing.
- B. Silencers:
 - 1. Manufacturers: One of the following or equal:
 - a. Burgess-Manning, Model BMSI, BMSS, or equal.
 - 2. Construction: Welded steel.
 - 3. Discharge silencer: Furnished with polyester acoustical absorption material.
 - 4. Silencers sizing: For design conditions and specifically designed for use with positive displacement blowers, size as indicated on the Drawings unless a larger size is recommended by the manufacturer.
 - 5. Mounting of silencers: As indicated on the Drawings.
 - 6. Noise attenuation of silencers shall as a minimum, meet the following:

Octave Band Center Frequency, hertz	Attenuation, dbA
63	12
125	20
250	27
500	30
1,000	31
2,000	29

Octave Band Center Frequency, hertz	Attenuation, dbA
4,000	25
8,000	21

- C. Acoustic enclosure:
1. Galvanized sheet-metal sandwich construction.
 2. With noise attenuating walls and with ventilation openings ported, ducted, shielded, and lined with acoustic absorptive material as required to achieve specified noise levels.
 3. Design criteria:
 - a. Seismic: As specified in Section 01612.
 - b. Wind: As specified in Section 01614.
 4. Raintight and dusttight, suitable for outdoor unprotected installation.
 5. With ventilation system designed for not more than 10 degrees Fahrenheit air temperature rise with aeration blower operating at maximum load.
 6. With fan interlocked with blower motor to start when blower starts and to stop with an adjustable time delay after the blower motor stops.
 7. With a weather-protected ventilation air intake filter:
 - a. Of disposable, dry type, pleated lofted cotton and polyester fiber media construction, securely bonded to a welded galvanized wire backing, with a frame of heavy-duty paperboard.
 - b. Sized for not more than 400 feet per minute face velocity.
 - c. With ASHRAE Standard 52.1 cleaning efficiency of not less than 25 percent.
 - d. With thickness not less than 2 inches.
 - e. With an easily visible and resettable "replace filter" indicator with retained indication independent of blower on/off status.
 8. With removable access panels located for maintenance and inspection access to the housed equipment, each weighing not more than 40 pounds, or hinged if weight exceeds 40 pounds.
- D. Relief valve: High-capacity, full-nozzle type; 3 inch minimum valve inlet, sized to relieve full blower capacity with 10 percent accumulation; 10 pounds per square inch gauge set pressure with flow switch for remote indication of actuation.
1. Manufacturers: One of the following or equal:
 - a. Kunkle Valve Co.
- E. Butterfly valves:
1. Constructed as specified in Sections 13446, 13447, and 15117.
 2. Lined with 10 mils of epoxy suitable for temperatures to 300 degrees Fahrenheit.
 3. Sealed with seals suitable for temperatures of 300 degrees Fahrenheit.
- F. Check valves: No. 8808-GAX-SSF; dual disc, wafer style with torsion spring induced closure:
1. Manufacturers: The following or equal:
 - a. Val-Matic.
 2. Consisting of following components:
 - a. Valve body: ASTM A 126 cast iron.
 - b. Disc: ASTM B 148-9A, aluminum bronze.
 - c. Spring: ASTM A 276, Type 316 stainless steel.

- d. Pins and thrust bearings: ASTM A 276 Type 316, stainless steel.
 - e. Seals, rated for minimum 300 degrees Fahrenheit.
- G. Pressure gauges: Liquid filled case with minimum 4 inch dial face:
- 1. Type on suction side of blower: Vacuum gauge calibrated in inches of water.
 - 2. Type on discharge side of blower: Pressure gauge calibrated in pounds per square inch gauge.
 - 3. A suitable tee handled corporation stop or ball valve and snubber shall be installed between each gauge and connection to air piping.
- H. Switches:
- 1. High oil temperature switch:
 - a. Integral with unit.
 - b. Adjustable over range of 80 to 300 degrees Fahrenheit or as recommended by blower manufacturer: Initial setting as recommended by blower manufacturer.
 - c. Activation shuts down unit and activates an alarm condition.
 - 2. High vibration switch:
 - a. With 30-second start delay and 3-second monitoring delay.
 - b. In NEMA Type 4X enclosure.
 - c. Operating power: 120 volt, 1 phase, 60 hertz.
 - d. Manufacturers: One of the following or equal:
 - 1) Robertshaw, Model 376.
 - 3. High enclosure air temperature switch:
 - a. As recommended by blower manufacturer.
 - b. Activation illuminates an alarm and shuts down the blower.
 - 4. Flow switch:
 - a. As recommended by the blower manufacturer to detect actuation of the pressure relief valve.
 - b. Activation illuminates an alarm and shuts down the blower.
 - 5. High discharge air temperature switch:
 - a. With thermowell, suitable for mounting in discharge piping.
 - b. Adjustable over range of 80 to 300 degrees Fahrenheit or as recommended by blower manufacturer. Initial setting as recommended by blower manufacturer.
 - c. With local indication of temperature.
 - d. Activation shuts down unit and activates an alarm condition.
- I. Other safety devices and controls: As recommended by blower manufacturer.
- J. Rubber expansion joints:
- 1. Provided at inlet and discharge flanges of blowers.
 - 2. Suitable for pressures up to 15 pounds per square inch gauge and temperature up to 300 degrees Fahrenheit.
 - 3. At discharge joints, provided with control rods to restrict axial pipe movement.
 - 4. Manufacturers: One of the following or equal:
 - a. General Rubber, or equal.
- K. Discharge piping and silencer insulation: As specified in Section 15082, and as indicated on the Drawings. Insulation inside acoustic enclosure by blower manufacturer.

- L. Supports and bracing: As required to support blower, associated equipment and piping, and to prevent excessive or harmful vibration or movement of equipment or piping.

2.04 CONTROLS

- A. Enclosure: NEMA Type 4X blower local control panel for blower as specified in Section 17710 for factory-wired controllers and monitoring for blowers.
- B. Components: Include provisions for start/stop push buttons, selector switches, indicating lights, annunciators, and other devices for alarm and shutdown systems.
- C. Mounting position of vibration and temperature switches: As recommended by manufacturer of sensing equipment to provide maximum protection.

2.05 SURFACE PREPARATION AND PAINTING

- A. Prepare and shop paint surfaces as specified in Section 09960.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install adequate supports and bracing to support blower, associated equipment and piping, and to prevent excessive or harmful vibration or movement of equipment or piping resulting from operation of the system.
- B. Mount blower on base plate. Properly align and grout base plate for blower and base for electric motor with sliding rails.
- C. Secure silencers with hold-down bolts.

3.02 FIELD INSPECTION

- A. Require factory representative to inspect and approve final installation, supervise test run of equipment, and instruct Owner in proper operation and maintenance of equipment.

3.03 FIELD TESTING

- A. After installation of equipment, approval of installation by manufacturer's representative, and operation equipment for sufficient period to make corrections and adjustments, test aeration blower system in the presence of Engineer.
- B. During test period, take and record readings of essential data at 30-minute intervals, including but not limited to noise, vibration, oil and air temperature, and operating pressures.

3.04 CORRECTIVE MEASURES

- A. When units or system performance or operation fails to meet specifications, take corrective measures, or remove and replace units with acceptable units.

- B. Operate equipment for 7-day operating period as specified in Section 01756.

END OF SECTION

SECTION 11500

MEMBRANE EQUIPMENT SYSTEM

PART 1 GENERAL

1.01 SUMMARY

- A. This Section covers Work necessary to provide a complete membrane equipment system for the treatment of secondary wastewater for Phase I of the Oak Harbor Wastewater Treatment Plant Design Project for the City of Oak Harbor, Washington, as described herein.
- B. The Work to be provided by the Supplier of the membrane equipment system includes, but is not limited to, the following:
 - 1. Submission of shop drawings and other descriptive information.
 - 2. Design and coordination/assistance.
 - 3. Review of preliminary construction Drawings.
 - 4. Design and fabrication of the membrane equipment system.
 - 5. Factory testing.
 - 6. Programmable logic controllers (PLCs)/computer control system hardware, software, and programming.
 - 7. Delivery of equipment to the facility site or a designated storage location as directed by the General Contractor (Contractor) or Construction Manager.
 - 8. Installation assistance, quality control, quality assurance, and inspection.
 - 9. Onsite testing, equipment startup, training of CITY's staff, and follow up testing services.
 - 10. Disposal of glycerin or other compounds used to preserve membranes during shipment by CONTRACTOR.
- C. Related Sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the SUPPLIER's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of SUPPLIER's Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the SUPPLIER to see that the completed Work complies accurately with the Contract Documents.
 - a. Division 0 Specifications.
 - b. Section 01330 – Submittal Procedures.
 - c. Section 01782 – Operation and Maintenance Data.
 - d. Section 09960 – Coatings
 - e. Section 11312O – ANSI Horizontal End Suction Pumps.
 - f. Section 11312R – Rotary Lobe Positive Displacement Pumps.
 - g. Section 11376 – Rotary Lobe Blowers.
 - Section 11500C – Clean-In-Place Chemical Feed Systems.
 - i. Section 13445A – Hydraulic and Pneumatic Cylinder Operators
 - j. Section 13448 – Intelligent Actuators

- k. Section 15100 – Valves.
- l. Division 16 Specifications.
- m. Division 17 Specifications.

1.02 EQUIPMENT

- A. Equipment and instrument tags and loop numbers shall be as indicated on the Preliminary Drawings included as part of these Contract Documents, and shall be used for all documentation and all programming software.
- B. Equipment supplied by the SUPPLIER shall comply with all the requirements of these Contract Documents.

1.03 DEFINITIONS

- A. Backwash or Backpulse Clean: Any routine instance a membrane basin is taken offline for application of water, and/or chemical solution for the purpose of maintaining permeate production rate of membrane.
- B. Cassette/rack: A group of membrane modules or multiple elements sharing a common air and permeate connection. A module is the smallest assembled unit of a delivered system that is designed to be removed and replaced as a complete unit.
- C. Clean-In-Place (CIP): The periodic application of a concentrated chemical solution at high concentration (i.e., more than 10 mg/L of free chlorine or the addition of an acid which results in a pH of less than 4) to a membrane for the intended purpose of reducing membrane fouling. Any chemical cleaning is generally considered a CIP if it requires more than 40 minutes downtime per procedure (including rinsing), requires water and/or chemical solution, and requires operator initiation or direct operator labor. CIP is synonymous with chemical cleaning, chemical clean, and recovery clean.
- D. Days are defined as calendar days.
- E. Design flow is equivalent to “production capacity.” Refer to “daily production capacity” for definition.
- F. Daily Production Capacity: Equals the net production rate of treated effluent (permeate), in million gallons per day (mgd), over a 24-hour period of continuous operation and accounting for periods of relaxation and cleaning.
- G. Flux or Flux rate (gpd/sf or gfd): Equals the permeate flow rate, in gallons per day (gpd), produced during the service cycle divided by the total membrane outside surface areas (sf). Service cycle is defined as the period of continuous permeation between the membrane relaxation, backwash or backpulse, where the Supplier's equipment uses backwash/backpulse as a permeability maintenance method. Units of “Flux Rate” are gallons per square foot per day (gfd).

- H. Membrane: An engineered porous media of polymeric materials of hollow fiber construction that is used to filter water and may be backwashed.
- I. Membrane Basin or Tank: A hydraulic structure in which the membrane cassettes/racks are immersed or submerged in mixed liquor.
- J. Maintenance Clean: Any routine instance a membrane basin is taken offline for application of a chemical solution that is not considered part of the normal backwash cycle or recovery clean.
- K. Membrane Module or Module: Basic unit of membrane production. The module may be a single assemblage of fibers in a common potting (element) attached to a support structure.
- L. Membrane Train or Train: A grouping of membrane cassettes, located in a concrete or steel structure (membrane basin), which share a common permeate header and pump, a common air supply header, and that are removed from operation as an entity for back pulsing, relaxing, maintenance cleaning, or recovery cleaning.
- M. Net Flux (gpd/sq.ft. or gfd): Net permeate (filtrate) production (gpd) divided by the associated membrane area (sq.ft.).
- N. Net Flux Rate: Equals the total amount of permeate produced by the membrane system over a representative period that is available for downstream discharge (excluding backwash water) divided by the total membrane outside surface area in square feet. Units of "Flux Rate" are gallons per square foot per day (gfd). Representative time period includes relaxation, backpulsing, chemical cleaning, etc., as appropriate for flow duration being considered.
- O. Net Permeate (or Filtrate) Production (gpd): The production rate of permeate (filtrate) from a given membrane train that is equivalent to the permeate volume (gal) produced over a 30-day period minus backpulse (or backwash) flow volume (gal) during the same 30-day period divided by the equivalent days of operation excluding time for standby, relaxation, backpulsing (backwashing), maintenance cleaning during the same 30-day period.
- P. Normal Operating Mode: Normal operation is defined as operating modes routinely used by the Membrane System including forward flush, backpulse or backwash, membrane integrity testing, or any other operation required on a routine basis by the SUPPLIER to meet specified performance requirements herein. Normal operating mode does not include CIP. Normal operating mode includes periods when operating at instantaneous flux rates.
- Q. NSF refers to National Sanitation Foundation.
- R. Permeability: Equals the flux rate divided by the transmembrane pressure. The units of permeability are gfd/psi.
- S. Permeate: That portion of the feed water that passes through the membrane from the feed side to the filtered side.

- T. Recovery Clean: Any non-routine procedure, manual, automated or semi-automated, that uses one or more cleaning chemicals to reverse the effects of membrane fouling. This may involve removing a membrane tank from service and draining the tank, and then fill with cleaning solution. The membranes may soak for a period of time after which the chemical solution is drained from the tank.
- U. Relaxation: Any routine instance a membrane basin is taken offline by temporarily stopping the permeate pump to maintain net flux rate of membrane system.
- V. Supplier: As specified in Section 00800, Article 1. Synonymous with membrane system SUPPLIER: Refers to the SUPPLIER of the membrane equipment system as specified herein.
- W. Temperature Corrected Permeability: Equals permeability multiplied by SUPPLIER's temperature correction factor (TCF) expressed in the following form:

$$P_{20} = P_t \times \text{TCF} (20-t)$$
 Where:
 P_{20} = permeability at 20 degrees C (Celsius)
 P_t = permeability at measured temperature in degrees C
 t = permeate temperature in degrees C
- X. Trans-Membrane Pressure (TMP) (psi): The pressure differential across the membrane, measured from the water surface in the membrane basin to the pressure of the permeate header at the location where the permeate header leaves the membrane basin footprint, while operating at a given flow. TMP shall be adjusted for losses from membrane discharge to pressure gauge.

1.04 PROJECT MANAGEMENT AND QUALITY ASSURANCE:

- A. The SUPPLIER shall assign both a qualified and experienced contract manager and a project manager for the duration of the project from design through start-up. These managers shall remain the same throughout the duration of the project. Any changes in project management will require approval from CITY and ENGINEER to review the qualifications of the proposed candidates.
 - 1. The contract manager shall act as the main point of communication between CITY, ENGINEER, CONTRACTOR, and SUPPLIER regarding the administration of the procurement contract, payment requests, interpretations of contract terms and conditions, warranty, and handle the assignment to the CONTRACTOR.
 - 2. The project manager shall act as the main point of communication between CITY, ENGINEER, CONTRACTOR, and SUPPLIER regarding the technical aspects of the Membrane Equipment System, including design criteria, materials selection, equipment, control systems, and coordination between SUPPLIER and other parties during the design, bidding, handle shop drawings, RFIs, and schedule deliveries, field inspections, start-up, and performance testing during construction.

1.05 PERFORMANCE REQUIREMENTS:

A. Production Capacity:

1. The membrane equipment system is designed for an initial production capacity (Phase 1) and future expansions in design production capacity (Phase 2 and Buildout). The membrane system shall be designed such that additional modules/cassettes may be installed in each membrane train in addition to equipping additional membrane basins to increase production capacity.
2. Required net design Daily Production Capacity and Net Permeate Production Capacity of 2.4 mgd at a constant flow rate (see Performance Warranty in Section 1.08). Flow to be treated by this membrane equipment system will be accepted from the aeration basins.
3. Maximum allowable peak flow from permeate pump shall not exceed 14.0 mgd (this is the maximum capacity of the UV Disinfection System located downstream.)
4. Required Design Production Capacities and Maximum Allowable Flux Rates:

Variable	Phase 1	Phase 2	Buildout
Average daily flow (ADF)	2.4 mgd	2.7 mgd	4.3 mgd
ADF with one train out of service	2.4 mgd	2.7 mgd	4.3 mgd
Peak Hourly Flow (Phases 1 and 2) Peak Day flow (Buildout)	5.0 mgd	5.1 mgd	12.4 mgd
Max average flux at ADF w/ one train out of service at 12.7 degrees C	Per Supplier	Per Supplier	Per Supplier
Net average membrane flux with all basins in service at 12.7 degrees C	Per Supplier	Per Supplier	Per Supplier

5. Provide sufficient membranes and equipment to treat 2.4 mgd average day flow production capacity, with sufficient redundancy to treat 2.4 mgd average day flow with one treatment train out of service without exceeding the demonstrated maximum allowable flux rate (as provided in Proposal).
6. Provide space for an additional 10 percent membrane area to be installed within each tank based on the maximum month flow at a demonstrated flux (as provided in Proposal). Spares shall be equally distributed between the tanks, compartments and/or cassettes.
7. Permeate pumps, backpulse, and related mechanical equipment shall be capable of handling the constant flow through the treatment plant.
8. Design production capacities shall be met while also meeting all other requirements specified herein including cleaning frequency and membrane permeate quality.
9. Design production capacity shall be based on permeate production, verified by the SUPPLIER and the CITY, during the Initial Performance Test, and subsequent Monitored Test Period. The SUPPLIER, at no cost to the CITY, is responsible for modifying the system to achieve design production capacity if performance testing of membrane system fails to meet the design production capacity.
10. Pressure: The system will be capable of delivering the net production capacity regardless of trans-membrane pressure.
11. Membrane Permeate Quality: Membrane permeate shall be capable of meeting the following requirements upon sampling, which may occur at any time:

- a. Less than or equal to 0.2 NTU on 19 of 20 consecutive samples, and
 - b. No sample shall exceed 0.5 NTU at any time.
12. Cleaning Systems:
- a. Agitation Air System:
 - 1) Provided by agitation air blower system manifolded to provide aeration to the membrane tanks using Rotary Lobe Blowers. SUPPLIER to furnish blowers, control panels, isolation valves, check valves, pressure gauges, discharge pressure safety valves, flow transmitters, low flow switches, and high-pressure switches, as required to meet SUPPLIER's Performance Requirements. Blowers will be supplied by SUPPLIER, installed by CONTRACTOR and integrated into the SUPPLIER's agitation air system with coordination by the SUPPLIER.
 - 2) Air Agitation Blowers will provide airflow to scour the membranes for control of fouling, and to assist in keeping the mixed liquor in a membrane basin in suspension.
 - 3) SUPPLIER to provide the air distribution header(s) for each membrane basin, including connections for additional future cassettes/racks specified above in 1.05, A.5.
 - b. Backwash or Backpulse System:
 - 1) Provide pumps, isolation valves, check valves, chemical injection connection and mixing systems, meters and controls, and other components necessary for an automated backwash system.
 - c. Maintenance Clean and Recovery Clean Systems:
 - 1) Membrane modules shall be cleaned in place using chemical solutions to meet production capacity and other performance requirements herein.
 - 2) Maintenance Cleans shall be performed not more frequently than once every 4 days.
 - 3) Recovery Cleans shall not be performed more frequently than once every 90 days.
 - 4) The SUPPLIER shall provide drain pumps and all the control valves and control elements for the membrane tanks required to perform Maintenance Clean or Recovery Clean cycles including switching from normal operation to cleaning operation, and from cleaning operation to normal operation.
 - 5) The SUPPLIER shall determine the concentration of the chemical solutions to be delivered to the membranes during cleaning cycles.
13. The following chemicals will be provided by the CITY for the chemical cleaning operation:
- a. Sodium hypochlorite as 12.5 percent by weight concentration.
 - b. Citric acid as 50 percent by weight concentration.
 - c. Additional chemicals, both generic and proprietary, required for membrane cleaning, dechlorination and/or neutralization of spent CIP solution, will be identified by SUPPLIER in Manufacturer's Equipment List as required by Document 00440, and as specified herein.
14. Chemical storage tanks and secondary containment shall be provided by the CONTRACTOR.
15. Equipment for chemical metering shall be provided by the SUPPLIER.

- B. Membrane system shall be capable of operating with mixed liquor feed supplied under gravity flow conditions. The water surface elevation (WSE) in the MLSS Feed channel upstream of the membrane system is approximately 11.55 feet.
- C. Minimum Discharge Header Energy Grade Line (EGL): Membrane System permeate pumps shall be designed to pump from the MBR Tank and Membrane Trains to the UV Disinfection inlet pipe. The permeate pumps shall be capable of providing a discharge pressure corresponding to ± 25 psi. SUPPLIER shall coordinate with Permeate Pump specified in Section 11312R. The estimated pressure required is based on the maximum inlet pressure to the UV Disinfection Reactor plus the estimated headloss between the Membrane Equipment System discharge header pipe and the UV Reactor Inlet at 2.7 mgd plant flow. Permeate water from each membrane skid shall be designed to discharge into a 20-inch filtered water header pipe.
- D. Design of backpulse system shall not rely on backpressure from UV Reactor but instead shall make use of a SUPPLIER designed and sized (CONTRACTOR furnished) Backpulse storage tank.
- E. Design Membrane Equipment System for a minimum system backpressure corresponding to the difference in elevation between EGL above and elevation of the outlet of the membrane skid.
- F. Membrane Support Structure Slab Elevation:
 - 1. Membrane Equipment System shall be designed to be installed in a structure with floor slab at elevation as shown on Drawings.
- G. Hydraulic Capacity:
 - 1. System shall be designed to meet hydraulic capacity requirements through common header and outlet piping / strainer systems based on flow rates required for 2.5 mgd net production capacity. Design flow rates through individual trains shall be based on the following:
 - a. Design flow rate at net capacity of 2.4 mgd at 12.7 degrees C assuming one unit is out of service for backpulsing.
 - b. Flow rate through trains if spare membrane area is filled by CITY, and at net capacity of 4.5 mgd peak day flow with all units on line (at net flux rate). SUPPLIER shall design the permeate and air piping headers, and associated equipment, including the permeate pump, to provide the required capacity.
 - 2. Pipe velocities shall not exceed 8 feet per second as specified under worst case conditions specified above.
 - 3. The racks or cells shall be required to maintain a sound level below 80 decibels at distances of 3 feet during any operating scenario. Failure to maintain sound level below 80 decibels shall require the membrane manufacturer to make necessary changes to meet these requirements.
 - 4. Maximum headloss under all operating conditions including when operating at increased flux rates to produce net 2.4 mgd capacity when one unit is out of service for backpulsing: Membrane Systems: Maximum headloss not more than 2 feet as measured through inlet valving to inlet of permeate pump.

1.06 SUBMITTALS

- A. Procedures: Section 01330.

- B. Submit the Following Items for ENGINEER's Review:
 - 1. Detailed shop drawings, with mechanical, electrical, and instrumentation connection types and sizes shown and dimensioned.
 - 2. Provide shop drawing information for each component including manufacturer, level of redundancy, materials of construction, and spare parts provided.
 - 3. Provide clear delineation between SUPPLIER-supplied piping and equipment, and CONTRACTOR supplied items:
 - a. General arrangement drawings and detail drawings including plans, sections, and details in electronic form, using the latest version of AutoCAD or Microstation.
 - b. Equipment access platforms, walkways, stairs, handrails, etc.
 - 4. Provide assembly drawings for the membrane cassettes/racks.
 - 5. Provide interconnection drawings to assist CONTRACTOR during field assembly of ALL components furnished by SUPPLIER.
- C. Provide Pressure Requirements for the Following:
 - 1. Provide detailed mixed liquor feed requirements into the Membrane Tanks including any special connections and required pressure if distribution headers are used.
 - 2. Provide minimum pressure required at connection to agitation air header taking into account submergence, header, and diffuser losses.
- D. For pumps, valves, and all mechanical devices (including but not limited to, air separators, liquid reservoirs):
 - 1. Make, model, weight, and horsepower of each equipment assembly.
 - 2. Complete catalog information, descriptive literature, Specifications, and identification of materials of construction. Seal, coupling, and bearing literature shall be included with the pump information.
 - 3. Detailed mechanical drawings showing the equipment dimensions, size, and locations of connections and weights of associated equipment.
 - 4. Submit calculations and design data to substantiate selection of pumps, blowers, and pipe sizing.
 - 5. Power and control wiring diagrams, including terminals and wire numbers.
 - 6. Complete motor nameplate data, as defined by NEMA, motor manufacturer, and including any motor modifications and as required by Section 16222.
 - 7. Installation information, including mounting requirements, access, approximate weight of each major piece of equipment, and required conduit size and entry.
- E. Provide instrument air demands (total flow and pressure) and air quality.
- F. Provide agitation air flow and filtration requirements as required by air diffuser system.
- G. SUPPLIER shall indicate the required lifting capacity of a hoist (for wet equipment) within the proposal package. CITY to provide hoist.
- H. Field coatings system and painting requirements for each equipment item.
- I. Instrumentation and Control System: Per Division 17.
 - 1. Furnish complete P&ID Loop Drawings and Instrumentation Drawings in the form, tagging and format as described by the CITY and ENGINEER.

- J. Electrical Shop Drawings and Information (SUPPLIER shall supply all interconnecting wiring diagrams, including conductor size, type and number between all electrical and control components):
 - 1. One-line diagram(s) including all transformers, drives, panel boards, meters, and protective devices as required for a complete operating membrane system.
 - 2. Panel elementary diagrams of pre-wired panels including control devices and auxiliary devices.
 - 3. Wiring and control diagrams of membrane systems and equipment.
 - 4. List of special motor features being furnished (i.e., space heaters, altitude corrections, and thermal protectors).
 - 5. Complete motor rating for all motors 15 horsepower and larger, including motor no-load, starting, and full-load current at rated voltage; full-load speed and full-load current at 100 percent voltage; motor efficiency and power factor at 1/2, 3/4, and full load at rated voltage. See Section 16222 for additional requirements.
 - a. Furnish completed motor data sheets as included in Section 16222.
 - 6. List any components that will run off power supply other than 480 V, three-phase and shall meet the requirements of Division 16 (included in this document).
- K. SUPPLIER's required membrane system handling procedures, including, but not limited to, protection of equipment prior to and during installation, removal of membrane preservatives, and extended out-of-service storage and handling.
- L. The SUPPLIER shall provide the following items prior to final payment:
 - 1. Executed warranties.
 - 2. Initial and Final Operation and Maintenance (O&M) Manual for all equipment that is provided per Section 01782. Provide per milestones listed in Agreement (Section 00522).
 - 3. Data summary from testing and startup period.
 - 4. Instrumentation and Control System items.

1.07 DESIGN SUPPORT SERVICES

- A. The SUPPLIER shall provide design support services to the CITY and ENGINEER in order to fully integrate the selected membrane equipment system with the final contract installation drawings for use by the CONTRACTOR.
- B. Scope of the services shall include but not limited to the following tasks:
 - 1. Supplier team shall attend three separate one-week coordination meetings to be conducted in the ENGINEER's office in Seattle, Washington. SUPPLIER shall include the project manager, process specialist, electrical engineers and controls engineers, as well as start-up and O&M specialist.
 - 2. Submit Technical Submittals as required to adequately define Membrane system.
 - 3. Respond to ENGINEER 's questions throughout the final design and installation bid phases.
 - 4. Review and provide comments to construction bid documents prepared by ENGINEER at 50, 90 and 100 percent completion levels.
 - 5. Attend required meetings with ENGINEER and/or CITY related to the construction contract documents.

6. During these meetings, the following topics will be discussed:
 - a. Review and validate hydraulics, flow distribution between and across MBR tanks and trains, as well as the RAS System.
 - b. Review and validate the scum and foam control measures and provide advice and recommendations.
 - c. Review and validate P&IDs, and electrical design.
 - d. Review and validate fine screen manufacturer selection, design criteria, and layout and provide approval.
 - e. Review and validate the whole BNR/MBR tank process layout, design criteria, and provide approval.
 - f. Review and validate the membrane maintenance, removal, accessibility, and crane layout during the design.
 - g. Review and validate the membrane support equipment and piping layout, including permeate pumps, back-pulse, drain pumps, CIP chemical system, blowers, air compressor system, as well as process control equipment and ancillaries.
 - h. Review and validate the installation design of the air scour blowers for use as agitation air system, manufacturer selection, design criteria, and layout and control descriptions, provide approval.
 - i. Review and validate and coordinate the operations and controls of the MBR system.
 - j. Review and validate RAS screen manufacturer selection, design criteria, and layout and provide approval.
 - k. Review and validate specifications for installation contract for use by CONTRACTOR.
7. The SUPPLIER shall prepare a three dimensional computational fluid dynamic (CFD) model of an MBR train for this project. Model shall demonstrate the velocity and solids gradient in one the proposed MBR train with all cassettes or modules in place at peak design flow. Model shall be used as a design tool to assist SUPPLIER and ENGINEER with the design layout and geometry of the MBR train to improve hydraulic efficiency, minimize dead zones, and simulate the effectiveness of the air scour and agitation system in the MBR train.

1.08 SUPPLIER'S WARRANTY

- A. General:
 1. SUPPLIER shall provide a guaranteed membrane replacement or additional purchase price, as a cost per module and as a cost for the total system as part of the Bid Form document.
 2. SUPPLIER shall provide all warranties and guarantees in accordance with the terms of the General Conditions, Document 0701 and Special Conditions, Document 0800, and in accordance with the Agreement, Document 00522.
 3. All warranties and guarantees shall be transferable to the CITY.
 4. SUPPLIER shall guarantee that for components manufactured by the SUPPLIER, replacement parts shall continue to be available to the CITY for a minimum of 20 years from date of successful completion of Operational Test. SUPPLIER shall guarantee that, if SUPPLIER or SUPPLIER's product line is sold, SUPPLIER shall make provisions such that all guarantees, warranties, and bonds will remain in effect and that replacement parts and operational support continue to be available to the CITY for the time period specified above.
 5. No warranties shall be pro-rated.

6. All warranties and support shall be provided directly by the SUPPLIER and not the local manufacturer's representative.
- B. General Equipment Warranty:
 1. SUPPLIER shall provide warranty of Membrane Equipment System in accordance with the terms of the General Conditions, Document 0701 and Special Conditions, Document 0800, and in accordance with the Agreement, Document 00522.
- C. Extended Warranty for Air Actuated Valves and Accessories:
 1. The SUPPLIER shall also provide an extended warranty to cover all air actuated valves, air actuators, and accessories that are started or actuated more than once every five minutes, for 3 years from the date of substantial completion.
- D. Membrane Equipment System Performance Warranty:
 1. SUPPLIER agrees and warrants in accordance with the terms of the General Conditions, Document 0701 and Special Conditions, Document 0800, and in accordance with the Agreement, Document 00522, that the Membrane Equipment System, when operated within the conditions specified in the Contract Documents, will meet or exceed the performance requirements specified herein:
 - a. If, during the Membrane Equipment System performance warranty period, the MBR System is unable to meet the specified performance requirements, the SUPPLIER shall make changes to the system, or shall supply additional membranes or other equipment necessary to bring the system performance into compliance with the specified performance requirements. Any such changes or addition shall be made at no additional cost to the CITY. Any changes to the system shall be approved by both the CITY and the ENGINEER, and shall not result in increased operations and maintenance costs.
 - b. The CITY shall make available the MBR System electronic data records of historical performance for SUPPLIER's review.
 - c. If SUPPLIER is unable to modify the system through addition of membranes or other elements, and cannot satisfy requirements of the Initial Performance Test, or the Membrane Equipment System Monitored Test Period, or system fails to meet specified performance criteria during the warranty period following the date of successful completion of the Initial Performance Test, then SUPPLIER shall be responsible for complete removal of nonconforming system and subsequent installation of membrane products that are capable of meeting specified performance conditions. Payments for replacement or corrections not paid by SUPPLIER in accordance with the Procurement Contract shall be paid from the SUPPLIER's Performance Bond.
 2. The Membrane Equipment System Performance Warranty will end upon final acceptance of the System by the City. Final acceptance will be based on Successful Completion of Membrane Equipment System Monitoring Test Period specified herein.
- E. Membrane Warranty:
 1. SUPPLIER shall provide warranty duration for membranes against defects and workmanship, manufacture, and materials for a minimum of 5 years or as

indicated in the Bid Forms. The warranty shall not be pro-rated. All warrantee and support shall be provided directly by the SUPPLIER and not the local representative.

2. SUPPLIER shall warrant membrane, modules, and cassettes under the following terms:
 - a. SUPPLIER shall repair, replace, or add at no cost to the CITY ("Delivered Duty paid -DDP-Oak Harbor, WA"), with freight and insurance paid by SUPPLIER, to the location of the Project site at Oak Harbor, WA, any membrane, modules, and or cassettes that fail before the end of the warranty period, which shall commence after successful completion of the Initial Performance Test (Substantial Completion).
 - b. Failure is defined as any defect in the membrane manufacturing that causes any of the following:
 - 1) Inability of membrane to pass integrity test as specified within this Section.
 - 2) Inability to meet membrane permeate quality requirements as specified.
3. The CITY will be responsible for the cost of removing the failed membrane modules, and for the cost of installing the replacement membrane, modules, and or cassettes.

1.09 EXTRA MATERIALS

- A. Procedures: Per Section 01782.
- B. Provide a "standard" spare parts list, including prices for all replaceable parts, associated with the Membrane Equipment system as part of the equipment price listed in the Proposal, including the following at a minimum:
 1. One spare set of expendable material such as gaskets, seals, and packing.
 2. One set of new and unused special tools required for installation, operation, and maintenance.
 3. One repair kit for sealing off damaged membrane fibers within the membrane module.
 4. All jigs, fixtures, clamps, lifting beams, hooks, and other instruments required facilitating the removal, disassembly, re-assembly, and installation of each item of equipment within the system.
 5. Reagents/chemicals, calibration sets, and spare parts as specified for individual equipment items or instruments.
 6. Spare parts for instruments, PLC hardware and control devices as specified in Divisions 16 and 17.
- C. Provide recommendations for spare parts and materials for the first 12 months of facility specific system operation listed in the manufacturer's Operation and Maintenance manual as recommended spare parts. Cross-reference with the spare parts list and provide a total cost for all recommended spare parts.
- D. Guarantee availability of "appropriate" spare parts as listed above for a period no less than 20 years.

1.10 DELIVERY AND SCHEDULE

- A. Based on the CONTRACTOR's schedule, the SUPPLIER shall provide equipment in multiple separate freight shipments. Refer to Milestone and Contract Times specified in the Agreement, Document 00522.
- B. Provide notification in writing to the CITY and CONTRACTOR of approximate delivery date(s) 12 weeks before delivery. Notify same of actual delivery date at least 7 days before delivery. Provide description and approximate weight of shipping container and required equipment for unloading. SUPPLIER shall coordinate delivery, unloading, and storage with CONTRACTOR.
- C. SUPPLIER shall coordinate the delivery of equipment with CONTRACTOR. SUPPLIER shall revise schedule for delivering equipment packages if requested by CONTRACTOR without additional cost to CONTRACTOR.

1.11 WORK BY OTHERS

- A. The following items are provided by CONTRACTOR but will be coordinated by the SUPPLIER during the Design Assistance provided by SUPPLIER to ENGINEER. These items will include:
 - 1. Structural:
 - a. Concrete tanks for the membrane cassettes.
 - b. Foundation/housekeeping pads and additional housing for supplied membrane equipment including permeate pumps, back-pulse pumps, drain pumps, chemical clean, etc.
 - c. Protective coatings for concrete shall be supplied by CONTRACTOR.
 - d. Anchor bolts will be designed, provided and installed by CONTRACTOR; anchor bolt design by SUPPLIER.
 - 2. Mechanical:
 - a. Pipe supports and hangers beyond the limits of the membrane manufacturer's equipment, unless otherwise noted.
 - b. Hoist equipment above the membrane tanks for installation and removal of the membrane modules.
 - c. Air Compressor Systems and Receiver Tank(s).
 - d. Fine Screens.
 - e. Connection points will be provided by CONTRACTOR, unless otherwise noted, for each membrane manufacturer's equipment for the following:
 - 1) Membrane Effluent (Permeate) header.
 - 2) Membrane Influent (Mixed Liquor) header.
 - 3) Recycled Activated Sludge pumps and piping.
 - 4) Agitation Air Scour Blower header.
 - f. Installation materials for instrumentation and automatic valves including but not limited to air/sample line tubing, fittings, and mountings.
 - 3. Electrical:
 - a. Electrical wiring interconnections (including wiring, conduit and other appurtenances required to provide power connections as needed) from the electrical power source to the membrane equipment and PLC control panel.
 - b. Ethernet communications connection to the CITY's Plant Control System.
 - 4. Other:

- a. Receiving, unloading and safe storage of equipment at site or a storage facility until ready for installation.
- b. Raw materials, chemicals and utilities during equipment testing.
- c. Laboratory services, operating and maintenance personnel during equipment checkout, startup and operations.
- d. Any onsite painting or touch-up painting of equipment supplied.

PART 2 PRODUCTS

2.01 GENERAL

- A. Membrane equipment shall be provided complete, with all necessary components, accessories and appurtenances required to make a complete and operable system. Equipment will be shipped loose by the SUPPLIER. Interconnecting piping and wiring will be installed by the CONTRACTOR.
- B. Membrane modules and equipment shall be prefabricated, preassembled, and tested before shipment to the site.
- C. SUPPLIER shall provide the equipment as described in these specifications:
 - 1. Items shall be new and unused, and shall be SUPPLIER's most current product line at the time of product submittal.
 - 2. Designed to use the membrane modules based on the membrane technology presented in the proposal.
 - 3. Furnished as a complete and operable system including all piping and valves.
- D. Any carbon steel components provided are to be coated with a coating that is suitable for the intended service and contact with concentrated chemicals.

2.02 MEMBRANE EQUIPMENT SUPPLIER

- A. Membrane systems shall be hollow fiber to minimize footprint of the installation. Alternate technologies may be considered if the system is able to fit within the available membrane system footprint shown on the drawings. The membrane system shall be manufactured by one of the following manufacturers or approved equal:
 - 1. GE-Water -Zenon - ZeeWeed-500D.
 - 2. Koch Puron PSH 1800.
 - 3. Or approved qualified equal.

2.03 SUPPLEMENTAL INFORMATION

- A. Membrane Equipment System requirements specified herein shall be met when mixed liquor flows and characteristics comply with the following:
 - 1. Wastewater Temperature: Minimum of 12 degrees C; maximum of 22 degrees C.
 - 2. Average Mixed Liquor (ML) Solids Concentration in the Membrane Tank: 8,000 to 12,000 mg/L.
 - 3. Biological Total Solid Retention Time (SRT): Normally between 10 days and 14 days. Average mixed liquor in the aeration process (provided by others), shall be between 6,000 mg/L and 8,000 mg/L.
 - 4. Effluent Ammonia-N: Less than 0.9 mg/L.

5. Total Inorganic Nitrogen (TIN): Less than 10 mg/L.
 6. Alkalinity: 50 mg/L as CaCO₃.
- B. The equipment furnished under this section shall be a complete membrane equipment system for a membrane bioreactor.
1. The system shall contain four membrane trains within four membrane tanks for the GE Zenon system.
 2. The system shall contain four membrane trains within four membrane tanks for the Koch system.
- C. The membrane tank will be a concrete structure provided by the CONTRACTOR.
- D. Floor space has been allowed in the treatment facility to accommodate membrane tanks, permeate pumps, backpulse tank and pumps, drain pumps and associated piping, valves, air scour blowers, pumps, chemical feed and storage systems, electrical, instrumentation and controls. Refer to the Drawings for available space.
- E. Membrane modules shall house hollow fiber type membranes. All the modules in each membrane tank shall be connected to a common permeate header, which shall be connected to the permeate pump. The permeate shall move through the membranes by applying a suction force with the permeate pump to the inside of the membrane fibers. The permeate flow during normal operation shall be from the outside of the membrane fibers to the inside.
- F. If a backwash system is required, the system shall be capable of automatically backwashing the membrane modules using the backpulse pumps (either by reversing the rotary lobe pumps or by using separate backpulse pumps as specified in section 11500B). The system shall include tanks (sized by SUPPLIER but furnished by CONTRACTOR) and chemical metering pump equipment and accessories to allow chemical cleaning in place (CIP).
- G. The mixed liquor shall flow by gravity to the membrane tanks from the aeration basins and return activated sludge (RAS) shall be pumped back to the aeration basins. RAS pumps to be supplied by CONTRACTOR.
- H. The SUPPLIER under this Contract shall provide the following in accordance with the appropriate Specification:
1. Permeate pumps (one pump furnished per membrane train plus one uninstalled spare pump and motor), vacuum system, air separation system and equipment (including and all valves, ejectors, instrumentation and controls).
 2. Membrane air scour blowers (one blower per membrane train plus one uninstalled spare manifolded together).
 3. Piping header, control and isolation valves, instruments, fittings, instrumentation and controls for the supplied membrane air blower.
 4. Membrane modules, cassettes/racks, cassette support frames and beams, cassette lifting frame, process instrumentation and associated equipment.
 5. Supports for aluminum checkered plates above membrane cassettes/racks.
 6. Membrane backwash system, including backpulse pumps, single backwash tank sizing (tank supplied by CONTRACTOR), valves, fittings, instrumentation and controls.
 7. Membrane cleaning in place (CIP) feed and distribution system providing all chemical systems necessary for proper continued operation of furnished

membranes, including feed pumps, chemical storage tanks sizing (tank(s) furnished by CONTRACTOR), valves, fittings, instrumentation and controls. The CIP system shall include sufficient piping and valves to allow automatic flushing of all manifolds with cleaning chemicals.

8. Process control panels, PLC(s), Operator Interface(s), and associated software programming and SCADA screens.
9. All supports for membrane cassettes/racks and plates.

2.04 MEMBRANE TANKS

- A. The membrane tanks shall be concrete tanks provided by the CONTRACTOR. Four membrane tanks will be provided for Phase I (seven tanks for buildout).
- B. SUPPLIER shall assist ENGINEER in the preparation of the Final Drawings for layout of the tank and space available for the membrane system inside the tank.
- C. The membrane tank will be designed with aluminum checkered plate or aluminum removable decking on top of each tank. Support and configuration of decking to be determined and designed by ENGINEER with the assistance of SUPPLIER. Decking and support configuration shall allow for the removal of membrane cassettes without removal of the entire deck.
- D. If required, provide design recommendations to assist ENGINEER in the preparation of the Final Drawings for inlet baffle plate to dissipate energy of mixed liquor entering each tank. Baffle plate shall be made of 316L stainless steel and supplied by CONTRACTOR.

2.05 MEMBRANE EQUIPMENT

- A. Membranes:
 1. Use hollow-fibers having a nominal pore size of 0.05 micrometer or less.
 2. Flow from the outside to the inside of the fiber.
 3. Membranes shall be constructed of chemically resistant materials and shall be capable of being washed in high chlorine solutions (minimum 1,000 mg/L) for 10 hours, and low pH (range 2 to 3) and high pH wash solutions (range 10 to 11) for 10 hours respectively.
 4. Membranes shall be physically strong enough to withstand the operating conditions associated with continuous operation in an aerated tank of mixed liquor at concentrations of up to 12,000 mg/L.
 5. For systems which use backpulsing, membranes shall be able to withstand backwash flow (from inside to outside) as proposed by SUPPLIER, without any indication of damage.
- B. Membrane Modules:
 1. The membranes shall be assembled into a housing called a membrane module.
 2. The membrane module shall be constructed such that the membranes are held vertically and bonded firmly at the top and/or bottom of the module.
 3. For hollow-fiber type membranes, the internal lumens of the membrane fibers shall connect into a common area at the top and/or bottom of each module.
 4. The materials used to hold the membrane fibers in place shall be chemical resistant to high concentrations of chlorine (minimum 1,500 mg/L) for

- 10 hours, and low pH (range 2 to 3) and high pH wash solutions (range 10 to 11) for 10 hours respectively.
5. The top and bottom sections of the module shall be connected with corrosion resistant materials and allow permeate to be withdrawn from the top of each module.
 6. The base of each module shall contain diffusers, jets, or other device to allow compressed air to escape and travel upwards past and between the membrane fibers creating an agitation effect.
 7. All non-steel components of the membrane modules shall be UV resistant and have a chemical resistance at least equal to that of the membranes.

C. Membrane Cassette/Rack:

1. The membrane modules shall be assembled into a unit called a cassette or rack.
2. The support structure for each cassette or rack assembly shall be manufactured of Type 316L stainless steel.
3. Provide a means for isolation of the permeate and agitation air to provide means to isolate and remove individual cassettes/racks from the remainder of system, without draining the basin or train, and enabling the system to produce permeate with one or more cassettes out of service.
4. Each frame shall be fitted with two lifting eyes (one at each end) to allow the entire membrane cassette/rack to be lifted into and out of the mixed liquor and transported away from the aeration basin.
5. All fasteners, including nuts, bolts, screws, cables, washers and other appurtenances, associated with the membrane cassette/rack and housing shall be manufactured from Type 316 stainless steel.
6. Each cassette or rack assembly shall be provided with extended supports for the decking to be located on the top of the membrane tank. Supports shall be manufactured of 316-L stainless steel. Extended supports shall be provided by the CONTRACTOR.

2.06 PERMEATE (MEMBRANE EFFLUENT) SYSTEM

A. Permeate Suction Piping:

1. Each membrane basin shall have a suction header for permeate collection. The header shall have a connection for a pressure gauge at each end.
2. All cassettes/racks in a membrane basin or train shall be connected to the suction header, which is provided by the SUPPLIER.
3. The pipe connections between the membrane cassettes and the manifold header pipework shall be capable of operating at the positive and negative pressures expected for this system.

B. Permeate Pumps: (refer to Section 11312R)

1. Provide a pumped permeate collection system including pumps, isolation valves, flow meters, and pressure gauges as required by SUPPLIER to meet performance requirements.
2. Pumps shall be either rotary lobe positive displacement type in accordance with Section 11312R. Required materials of construction shall be clearly indicated in SUPPLIER's proposal.
3. Number: Minimum of one per train and one uninstalled spare pump and motor.

4. Each pump shall have sufficient capacity to operate one membrane tank and meet the design flow rates. This requirement shall be met at the maximum transmembrane pressure and allow for all other system losses.
 5. Each pump shall be able to maintain a constant permeate flow regardless of transmembrane pressure up to the maximum transmembrane pressure.
 6. The permeate pump shall deliver sufficient total dynamic head to drive downstream processes (maximum 20 psig). Downstream process is the ultraviolet disinfection system (provided by others).
- C. An air extraction system or air eductor system, if required, shall be provided by the SUPPLIER.
- C. Instrument Air: Instrument air compressors and associated appurtenances to operate pneumatic valves and instrumentation shall be sized by the SUPPLIER and furnished by CONTRACTOR.

2.07 CLEANING SYSTEMS

- A. Agitation Air System:
1. Agitation air blower system shall be sized by SUPPLIER. The Agitation Air Blowers (Rotary Lobe as specified in Spec Section 11376B) will be connected to a piping manifold forming a single air supplied header to provide air for the membrane agitation air system designed by SUPPLIER.
 2. Control panels, isolation valves, check valves, pressure gauges, discharge pressure safety valves, flow transmitters, low flow switches, high pressure switches flow meters, and other associated appurtenances, as required to be provided to meet their Performance Requirements.
 3. Blowers shall provide airflow to scour the membranes for control of fouling, and to assist in keeping the mixed liquor in a membrane basin in suspension.
 4. Provide air distribution header(s) for each membrane basin, including air pneumatic control valves.
 5. Rated Capacity and Pressure: As required by SUPPLIER.
- B. Backwash or Backpulse System (if required): (refer to Section 11312R)
1. Provide pumps, isolation valves, check valves, chemical injection connection and mixing systems, meters and controls, and other components to provide an automated backwash system.
 2. Pumps shall be rotary lobe positive displacement type in accordance with Section 11312R. Required materials of construction shall be clearly indicated in SUPPLIER's proposal.
 3. The Backwash Pumps shall deliver the required backwash flow at worst case hydraulic conditions (maximum system headloss and maximum transmembrane pressure).
 4. The Membrane System SUPPLIER shall size the backpulse tank (furnished by CONTRACTOR), appurtenances, and all the piping and control elements (valves, pressure sensors, flow meters, etc.), required to automatically operate the Backwash System.
- C. Maintenance Clean and Recovery Clean Systems:
1. Metering systems for sodium hypochlorite, citric acid and any chemicals required for dechlorination and/or neutralization of spent CIP solution for chemical cleaning shall be provided by the SUPPLIER per Section 11500C.

2. Chemical metering pumps will be controlled by SUPPLIER as part of PLC controls.
 3. Sodium hypochlorite, citric acid, and any other chemical required for dechlorination and/or neutralization of spent CIP solution, will be provided by the CITY.
 4. The SUPPLIER shall supply all the control valves and control elements at the Membrane Tanks required to perform automatic Maintenance Clean or Recovery Clean cycles including switching from normal operation to cleaning operation, and from cleaning operation to normal operation.
 5. The SUPPLIER shall determine the concentration of the chemical solutions to be delivered to the membranes during cleaning cycles, dechlorination and/or neutralization of spent CIP solution.
- D. Membrane Tank Drain Pump System: (refer to Section 11500B)
1. Provide pumps, isolation valves, check valves, meters and controls, and other components to provide an automated membrane tank drain system.
 2. The drain pumps shall completely drain the MBR tanks in 15 minutes or less as required by the SUPPLIER.
 3. The Membrane Equipment System SUPPLIER shall supply all the pump appurtenances, valves, and control elements required for the membrane tank drain system.

2.08 PIPING AND VALVES

- A. Provide piping and valves per requirements of Division 15:
1. SUPPLIER shall provide permeate headers, air headers, and any other piping required to connect the membrane cassettes to the headers to provide an operating system. SUPPLIER shall provide all piping and valves required to interconnect membrane cassettes within the membrane area limits identified on the Drawing.
- B. Terminal point connections to membrane filtration equipment will be ANSI standard flanges.
- C. Piping:
1. Per Sections 15255.
 2. Type 316 stainless steel.
 3. Install true union fittings where future disconnection may be required.
 4. Piping will be designed to limit maximum flow velocities to 8 feet per second (fps). If unable to meet 8 fps flow criteria, indicate and describe locations where velocities are greater than 8 fps. Velocities greater than 8 fps shall be considered as part of the noncost factor evaluation.
- D. SUPPLIER shall supply all check valves, control valves, and isolation valves required for a completely functional system. SUPPLIER shall provide valves suitable for intended service and relevant chemical exposure, in accordance with Section 15100.
- E. Provide actuators in accordance with Section 15100:
1. Electric Actuators: Use for typical OPEN/CLOSE application except as noted below.
 2. Pneumatic Actuators: Use for OPEN/CLOSE application where fast action is required.

2.09 ELECTRICAL

- A. Electrical components shall be provided in accordance with the requirements of Division 16.
- B. Three-phase, 3-wire, 60-Hz, 480 VAC power will be available for the membrane bioreactor equipment.
- C. Unless otherwise noted, motor control centers, adjustable frequency drives, panel boards, transformers, and other equipment necessary to provide power distribution and control for all equipment shall be provided by CONTRACTOR.
- D. Electrical material and equipment shall have UL listing wherever standards have been established by that agency.
- E. Complete electrical assembly shall meet all requirements of the National Electrical Code, the National Electrical Manufacturers Association (NEMA), the National Fire Protection Association (NFPA), all applicable state and local codes.

2.10 CONTROL SYSTEM

- A. General: Provide control panels, PLCs, OITs and Operator Interface hardware and software, Membrane Control System software package, data links among control panels and ETHERNET network link with the CITY'S Plant Control system, graphic display and configuration, instruments, and instrumentation and control components in accordance with Division 17.
- B. Provide and program PLCs and configure Operator Interface Terminal (OIT) to control the operation of the Membrane Equipment System:
 - 1. PLCs shall include an Uninterruptible Power Supply (UPS), as well as memory sufficient to implement all application software plus 100 percent spare capacity.
 - 2. PLCs shall be per Division 17, with I/O racks as needed. Provide and design PLC and I/O racks – in such a way that a maximum of one train only may be removed from service when a panel is opened or otherwise taken out of service.
 - 3. The PLCs shall communicate with the CITY's Plant Control system via Ethernet links.
 - 4. Upon loss of communication between the Plant Control System and the Membrane Control System, each train PLC shall continue to operate its train using, as a minimum, the current permeate flow setpoint and, preferably, a fully-functional flow control algorithm such as one based on liquid level in the aeration basin.
- C. CONTRACTOR will install the Ethernet cable for connecting the Master Membrane Control System PLC to the - PLCs of other Control Panels and to the Plant Control System.
- D. All controls and monitoring shall be accessible from a remote location via CITY's network. Provide means for data exchange with CITY's network as specified.
- E. Provide an Uninterruptible Power - Supply (UPS) for each individual PLC, capable of a minimum of 1-hour backup at full load.

- F. PLC Programming and OIT Configuration:
1. Provide and program/configure PLCs and Operator Interface Terminals as shown on the Process Control System Block Diagram.
 2. Control functions required to coordinate the operation of individual membrane trains and tanks shall be implemented in one Master PLC.
 3. Provide a panel mounted Operator Interface Terminal (OIT) in the Master MBR PLC Panel. Control and monitoring shall be provided at the OIT for all MBR tanks and trains.
- G. Functional Description: SUPPLIER's Control System will be designed to perform the following functions as a minimum and as specified in Div 17 Specifications:
1. General:
 - a. Communicate data to the Plant Control System for historical storage (historical trends, alarm logs, operating data, cleaning and backwash information).
 - b. Provide other features as required for unattended operation or to meet specified performance requirements.
 - c. Control system shall include necessary features to enable remote monitoring of system parameters and performance from SUPPLIER's factory support office. Modem will be allowed as a means of remote monitoring, at the CITY's discretion.
 2. Permeate System:
 - a. Monitor and record operational data for permeate and other membrane system components including the following at a minimum:
 - 1) Transmembrane (vacuum) pressure.
 - 2) Permeate production rate per train.
 - 3) Total (system) permeate production rate.
 - 4) Hours of operation for each permeate pump/train.
 - 5) Permeate temperature for combined permeate flow.
 - 6) Permeate turbidity for each train.
 - 7) Perform calculations of permeability and temperature corrected permeability for each train and plot both parameters as a function of run time.
 - b. Permeate Pumps:
 - 1) Adjust permeate production rate through membrane train in response to two selectable parameters: a manual input through the control system or effluent flow control that matches permeate flow rate to effluent flow rate with a trim based on effluent pipe pressure.
 - 2) Forward/reverse selection for normal Membrane Permeate Operation or for periodic cleaning Backwash Operation.
 - 3) START/STOP and flow-pace permeate pumps in Membrane Permeate Operation.
 - 4) Start/stop permeate pumps in Backwash Operation.
 3. Cleaning Systems:
 - a. General:
 - 1) PLC shall control sequence of backwashing and chemical cleanings. The SUPPLIER shall supply the control functions for the cleaning system required.
 - 2) Record backwashes (if required), air and water backwash duration, backwash flow, and perform calculations to determine permeate production rate for reference to start cleaning cycles.

- b. Agitation air flow shall be monitored and controlled by the PLC and stored by the plant control system.
 - c. Backwash or backpulse; if required. The backwash system shall perform the backwash function automatically at the end of every production cycle, with the option of the operator selecting whether the train return to production or relax at the end of every cycle.
 - d. Maintenance Clean System: Designed for automatic operation controlled by the PLCs. Shall be automatically initiated based on time or an operator-entered number of backwashes/backpulses. The system shall also allow operator to initiate a backwash manually.
 - e. Recovery Clean System:
 - 1) Designed for automatic operation once a cleaning cycle has been initiated by the operator.
 - 2) Sequence shall permit an operator-initiated recovery clean abort in which the system will automatically stop the cleaning sequence and start the membrane basin.
 - 3) Monitor the pH value at CIP tank outlet.
 - 4. Alarms:
 - a. Interrupt operation or alarm for high transmembrane pressure, high permeate turbidity, failed membrane integrity test, low permeate flow (low permeability), low agitation air flow, and permeate pump failure. Alarms shall be sent to the Plant Control System.
 - b. Shutdown train, and alarm upon failure of any defined critical parameter or component.
 - c. Record and alarm power failures, and transfers to and from backup power.
 - 5. Other Inputs/Outputs (I/O):
 - a. PLC shall have the capability to accept I/O from other unit processes with the plant. Number of spare I/O to be defined.
 - b. All PLC programming and human machine interface (HMI) graphics required to accommodate additional I/O will be performed by others.
- H. Data Exchange with Plant Control System: Make available and receive in contiguous PLC data registers the following data to and from the plant control system:
- 1. Output Data to the Plant Control System:
 - a. Status of each piece of equipment.
 - b. Alarms.
 - c. Process variable values, and historical data to meet requirements specified herein.
 - d. Chemical feed pump selection and status for membrane permeation operation or for cleaning backwash operation.
 - 2. Input Data from the Plant Control System:
 - a. Remote start/stop of the membrane Control System.
 - b. RE-START command on return of power following a power outage.
 - c. Effluent flow rate and pressure.
 - d. Return activated sludge flow rate.
 - e. Permeate system setpoints.
 - f. Backwash time intervals, number of backwashes and manual backwash commands.

3. Organize and structure data registers to match the requirements of the overall plant control system.

2.11 INSTRUMENTATION

- A. General Requirements:
 1. Provide instrumentation in accordance with Div 17 Specifications.

2.12 FACTORY QUALITY CONTROL FOR MEMBRANE SYSTEM EQUIPMENT

- A. Factory Inspections: Inspect equipment and control panels for required construction, electrical connection, and intended function.
- B. Factory Tests and Adjustments:
 1. Test equipment and control panels actually furnished as a complete system.
 2. Provide written certification of tests to ENGINEER prior to shipping equipment.
 3. Test for proper alignment of membrane supplier's equipment, mounted equipment, quiet operation, proper connection, pumping capacity, and satisfactory performance.
 4. Witnessed factory test of the entire PLC based control system and HMIs is mandatory. Entire system must be set up and tested as specified in Division 17. Upon completion, and prior to shipping equipment to the site, provide electronic copies of all PLC ladder logic and control programs fully documented and suitable for downloading into the PLCs.

PART 3 EXECUTION

3.01 INSTALLATION

- A. SUPPLIER shall furnish installation instructions and recommendations to CONTRACTOR.
- B. CONTRACTOR will install the Membrane Equipment System membrane cassette, and membrane supplier's equipment in accordance with SUPPLIER's instructions and recommendations.

3.02 TESTING AND COMMISSIONING

- A. Following the SUPPLIER's calibration of instruments, the SUPPLIER shall perform Component, System, and Operational Tests, on the Membrane Equipment System. It will be the responsibility of the SUPPLIER and CONTRACTOR to communicate to arrange the times for testing and startup activities, however, the CONTRACTOR must confirm that these times are acceptable to the CITY.
- B. Calibration:
 1. Approximately 30 days prior to the Initial Performance Test, the SUPPLIER shall calibrate all instrumentation associated with the performance testing.
 2. If retesting is required, the SUPPLIER shall recalibrate instruments associated with the retest if they have not been calibrated within the previous 30 days and submit that information to the ENGINEER prior to retesting.

- C. **Energy Consumption Measurement:** Measure the energy consumption, in kilowatts-hours (kWh), for Membrane Equipment System at the power meter of the circuit feeding the membrane system motor control center or other location as directed by ENGINEER.
- D. **Data Collection:**
 - 1. Direct readings from the instruments shall be used in the calculations to determine conformance with the guaranteed performance requirements.
 - 2. Readings shall be obtained from digital trends from the Membrane Equipment System PLC and by manually recording the values directly from the instrument.
 - 3. Record (and round if necessary) to the level of accuracy of the instrument before any calculations.
 - 4. Collect manual instrument readings at 4-hour intervals during the Initial Performance Test and at 1-hour intervals during the Average Power Consumption Test.
 - 5. There shall be no adjustment to readings or calculations due to random or systematic instrumentation error or accuracy limitations.
 - 6. The SUPPLIER shall document all modifications, changes, or additions and amend the operations and maintenance manuals and record drawings to reflect the modifications.
 - 7. All modifications required as a result of Initial Performance Test failure must be completed within 90 days of the start of the original Performance testing period.
- E. **Retesting:** The SUPPLIER shall be responsible for all retesting. SUPPLIER shall recalibrate all instrumentation associated with the retest in accordance with this Section, if the instrumentation has not been calibrated within the 30 days immediately prior to the retest.
 - 1. Reimburse the CITY for all CITY's costs associated with the retesting, including engineering fees and administration costs.
- F. **Permeate/Filtrate Flow Rate Deviation:** Permeate/Filtrate flow rate during the Initial Performance Test and Average Power Consumption Test shall be at or above the design conditions. The Final Acceptance Test can be conducted by operating one membrane System train (selected by the ENGINEER) at design conditions and determining the Net Production Capacity based on the number of identical membrane filtration trains installed. Adjust the permeate flow rate for actual feed water temperature such that the selected membrane train units operate at the temperature compensated design flux.

3.03 FUNCTIONAL TEST

- A. Once written certification of proper installation has been issued, the SUPPLIER shall coordinate with the CONTRACTOR to perform functional testing of the Membrane Equipment System.
- B. To perform the FUNCTIONAL TEST, the SUPPLIER and the CONTRACTOR shall operate all Membrane Equipment System valves, controls, and other devices to ensure they are functional and ready for performance testing.
- C. The CONTRACTOR will provide raw water for use in the FUNCTIONAL TEST.

- D. The SUPPLIER to provide necessary material (Schedule 80 PVC pipe or other) as required to allow the CONTRACTOR to test the permeate pump before membrane cassettes/modules are delivered.
- E. The SUPPLIER and the CONTRACTOR shall complete all functional testing to the satisfaction of the ENGINEER and the CITY prior to commencing the INITIAL PERFORMANCE TEST.
- F. The purpose of the FUNCTIONAL TEST shall be to demonstrate the effectiveness of the following system components and features:
 - 1. Automatic START/STOP and flow control of membrane trains using SCADA.
 - 2. Manual flow control using membrane train HMI(s) and PLC(s).
 - 3. Automatic backpulsing (normal and with chemical) at various time intervals.
 - 4. Automatic shutoff and alarm for various failure modes for each membrane train and for entire Membrane Equipment System.
 - 5. START and STOP of low-pressure air system for backwashing/cleaning membranes.
 - 6. Determination of clean water permeability of each membrane train and temperature correction of the clean water permeability for each train.
 - 7. Monitoring and recovery of operating data.
 - 8. Monitoring and control from remote workstation.
 - 9. All control functions, both at local system and remote workstation.
 - 10. Operation of chemical cleaning systems including chemical waste neutralization.
 - 11. Operation of all monitoring instruments.
 - 12. Visual inspection of membrane trains for integrity (bubble point testing).

3.04 INITIAL PERFORMANCE TEST

- A. Following completion of the FUNCTIONAL TEST and calibration of all instruments, the SUPPLIER and the CONTRACTOR shall conduct the INITIAL PERFORMANCE TEST (IPT).
- B. The SUPPLIER and the CONTRACTOR shall provide the IPT Report within 10 working days of completion of the test period.
- C. To perform the test, the SUPPLIER and the CONTRACTOR shall operate the system continuously over a 7-day test period, and collect and summarize data to demonstrate that the system meets the performance test requirements for the parameters listed below. In all cases, compliance with the requirements of this Specification shall be determined for each calendar day, and to successfully pass the test, the Membrane Equipment System must comply with the following requirements for each of the 7 days of the IPT:
 - 1. Net Production Capacity: System meets daily design production capacity requirements adjusted for actual feed water temperature as defined in Paragraph 1.05 PERFORMANCE REQUIREMENTS, and Production Capacity, when operated at or below the SUPPLIER's guaranteed instantaneous flux rate. Net production capacity shall be met under all operating conditions including when one unit is out of service for backwashing.
 - 2. Pressure Limitations: System operates within the TMP limit that is specified under all operating conditions, and system provides adequate permeate discharge pressure to discharge to the plant clearwell as specified.

3. Maximum Instantaneous Flux Rate: Flux rate shall not exceed the SUPPLIER guaranteed limits specified in the BID FORM. Normal backwash, reverse flow, relaxation cycles, shall be included in the determination of instantaneous flux rate as specified. Flux rate for system shall not exceed instantaneous flux rate while maintaining specified net production capacity under normal operation over a 24-hour period.
 4. Membrane Permeate Water Quality: Membrane permeate water meets requirements for turbidity as specified in Paragraph 1.05 PERFORMANCE REQUIREMENTS, above.
 5. Maintenance Clean: Perform the Maintenance Clean at the frequency equal to or less than specified in the Performance Requirements in this Section.
 6. Clean-in-Place (CIP): Perform the CIP clean at the end of the 7-day IPT period on one membrane train.
 7. CIP Spent Solution Neutralization: Following a CIP, the SUPPLIER shall dechlorinate and/or neutralize the cleaning solutions as required. Each discharge shall comply with the requirements for discharge to the plant sewer as specified.
 8. Energy Usage: Monitor average power consumption for Membrane Equipment System for the duration of the test period.
- D. Successful completion of the IPT shall be defined as 7 continuous days of operation without a major failure in the system and demonstration that system meets all performance requirements established herein. Downtime resulting from CITY's operation will not be counted against the criteria of "continuous days of operation." If an individual train has a production capacity below 50 percent of its design production capacity for more than 24 hours, the IPT will be considered a failure if sufficient flow is provided.
- E. If, at the discretion of the CITY, the Membrane Equipment System is operated at less than design production capacity during the IPT, a minimum of one train shall be operated at design (train) production capacity throughout the IPT. The performance of this train, and any other train also operated at design production capacity throughout the IPT, shall be used to determine the successful completion of the IPT. Trains operated at less than design (train) production capacity throughout the IPT Period shall meet all Performance Requirements listed in this subsection except for production capacity, which shall only be met on days where these trains are operated at design (train) production capacity.
- F. During the IPT, the CITY shall have the option of collecting samples for independent analyses to confirm measurements and analyses conducted by the SUPPLIER and the CONTRACTOR. The ENGINEER and the CITY shall have the option of witnessing all testing performed by the SUPPLIER and the CONTRACTOR. The SUPPLIER shall notify the ENGINEER a minimum of 2 weeks in advance of testing.
- G. If the Membrane Equipment System fails to successfully complete the IPT, the SUPPLIER shall have the option of repeating the test two more times as specified in AGREEMENT, Document 00522, Article 18. If the system fails and subsequent performance tests are performed, the SUPPLIER shall pay for all laboratory costs associated with these tests.
- H. Consequences to the SUPPLIER for failure to successfully complete the IPT are specified in the AGREEMENT Document 00522, Article 18.

3.05 MEMBRANE EQUIPMENT SYSTEM MONITORED TEST PERIOD (MTP)

- A. Compliance with the requirements for production capacity, CIP interval, membrane filtered water quality, and energy use shall be determined during a MONITORED TEST PERIOD (MTP).
- B. The MTP shall begin upon successful completion of the IPT period. During the MTP, the membrane system shall continuously over a 6-month test period, and collect and summarize data to demonstrate that the system meets the MTP test requirements for the parameters listed below.
- C. The MTP shall be conducted at net production capacity of 3.2 mgd.
- D. The CITY shall operate the plant during the MTP, however, the SUPPLIER shall provide onsite assistance as requested by CITY to address warranty issues, and if the system fails to meet the guaranteed performance requirements at no additional cost. If services by the SUPPLIER are required for failure of the Membrane Equipment System to comply with the guaranteed performance requirements specified herein, the additional services shall be considered part of the bid price. Refer to General Conditions Section 00701, Article 10.
- E. The CITY is responsible for monitoring the operating conditions and performance during the MTP, and providing data to the SUPPLIER.
- F. The SUPPLIER shall summarize the data and provide the CITY with raw data and a summary every 4 weeks and at the end of the MTP, and report the results in writing to the CITY and the ENGINEER. The report shall include a narrative description, tables and graphs of flux, temperature corrected permeability, TMP versus time, energy use, CIP frequency, and other parameters to document the performance of the system. The SUPPLIER shall submit the final report within 30 days following the end of the MTP.
- G. The CITY and the ENGINEER may conduct their own monitoring and record keeping during the MTP.
- H. The following parameters will be evaluated to determine compliance with the SUPPLIER's stated performance in the Bid and submittals:
 - 1. Membrane filtered water quality.
 - 2. Clean-in-place frequency.
 - 3. Chemically enhanced backwash frequency.
 - 4. Power use for equipment provided by SUPPLIER as part of the MBR System, including the Agitation Blowers.
 - 5. Production capacity.
- I. If, at the discretion of the CITY, the Membrane Equipment System is operated at less than design production capacity during any or all of the MTP, a minimum of one train shall be operated at design (train) production capacity throughout the MTP. The performance of this train, and any other train also operated at design production capacity throughout the MTP, shall be used to determine the successful completion of the MTP. Trains operated at less than design (train) production capacity during the MTP shall meet all performance requirements listed in this subsection except for production capacity, which shall only be met on days where these trains are operated at design (train) production capacity.

- J. If the Membrane Equipment System fails to successfully complete the MTP on the first attempt, the SUPPLIER shall have the option to remedy those conditions that the SUPPLIER believes may be causing unsatisfactory performance. Successful operation shall be defined as meeting the performance requirements specified herein, using the operational and cleaning strategies specified herein.
- K. Consequences to the SUPPLIER for failure to successfully complete the MTP are specified in the General Conditions.

3.06 AVERAGE POWER CONSUMPTION (APC) TEST

- A. Verification of average power consumption (APC) as submitted with the BID shall be documented by energy consumption testing. This performance testing is separate and independent from the IPT and MTP and shall be conducted during the MTP at a time as selected by ENGINEER.
- B. Energy consumption testing shall consist of an 8 consecutive hour measurement of kW usage and power factor on the MBR system:
 - 1. A record of electrical power usage shall be monitored and recorded by SUPPLIER, and witnessed by ENGINEER. If the SUPPLIER wishes to provide alternate metering to verify performance verification of the equipment, the SUPPLIER shall provide suitable metering equipment and install temporarily on site. If such equipment is provided, submit calibration records of the equipment showing calibration by a third party calibration lab prior to use on this project.
- C. Test Protocol:
 - 1. Operate the Membrane Equipment System at the temperature compensated net flux corresponding to guaranteed net production rate of 5.7 mgd at 15 degrees C throughout the entire APC Test. Adjust net production capacity for actual feed water temperature. Monitor all water flow rates of each membrane train and the total membrane system. Totalize all membrane system flow rates over the entire performance test to verify that the net production capacity is being met.
 - 2. Produce tertiary effluent with a water quality at or better than the guaranteed requirements throughout the entire performance test.
 - 3. During this performance test, the power consumption and power factor at maximum power shall be measured and continuously recorded using a watt-hour meter and power factor meter. The meters shall provide accuracy of ± 0.25 percent, shall operate at frequencies between 47 to 63 Hz, and shall be furnished with a statement from the meter Manufacturer attesting to its accuracy. Measure the rate of energy consumption at the power meter of the motor control center feeding the entire MBR system or a location acceptable to the ENGINEER sufficient to measure the MBR system power consumption. This measurement includes all loads associated with the MBR system including, but not limited to, pumping systems, air system, valve actuators, and process control and electrical equipment. Average the rate of energy consumption for the MBR system over the specific testing period to determine the Average-KW. Normalize Average-KW (APC) based on the actual net filtration production to determine the Average-KW that corresponds to the Daily Production Capacity of 3.4 mgd.

4. In the event that the SUPPLIER disputes results of the electrical performance testing, the SUPPLIER shall bear the entire cost of re-testing by a third party mutually acceptable to the CITY and the SUPPLIER.
- D. In the event that the APC measured is greater than 5 percent of the APC as stated in **Section 00320**, then SUPPLIER shall pay penalty to CITY per Section 00522. If the APC is less than the bid APC, there is no penalty or bonus to the SUPPLIER.

3.07 TRAINING OF CITY'S PERSONNEL

- A. Provide operations and maintenance training for items of mechanical, electrical and instrumentation equipment. Utilize SUPPLIER's representatives to conduct training sessions.
- B. Coordinate training sessions to prevent overlapping sessions. Arrange sessions so that individual operators and maintenance technicians do not attend more than 3 sessions per week.
- C. Provide Draft Operation and Maintenance Manual for specific pieces of equipment or systems prior to training session for that piece of equipment or system.
- D. Satisfactorily complete Functional Testing before beginning operator training.
- E. Following CITY's acceptance of Certificate of Proper Installation, the SUPPLIER shall perform a comprehensive training of CITY's personnel at the site or a classroom designated by the ENGINEER.
- F. The training provided by the SUPPLIER's representative shall consist of both classroom and field training:
 1. The classroom training shall consist of a minimum of 40 hours of lectures on the Membrane Equipment System operation and the maintenance requirements.
 2. Hands-on training shall take place before the Initial Performance Test and shall consist of a minimum of 24 hours of training devoted to operation and maintenance of the Membrane Equipment System, including membrane chemical cleaning and membrane integrity repair processes.
- G. Six months after successful completion of the MTP, the SUPPLIER shall perform a two-day training session (travel time excluded) at the site. The purpose of this session is to review the first six months of operation and respond to any questions or concerns raised by the operation staff.
- H. Eleven months after successful completion of the MTP, the SUPPLIER shall perform a one-day review session, (travel time excluded) at the site. The purpose of this session is to review the first eleven months of operation and respond to any questions or concerns raised by the operation staff.
- I. The SUPPLIER shall give the CITY a minimum of 30 days notice prior to initiation of training.
- J. The SUPPLIER shall videotape all training sessions and provide a DVD copy for the CITY.

- K. The SUPPLIER shall provide a copy of the presentation material in pdf format.
- L. The SUPPLIER shall designate and provide one or more persons to be responsible for coordinating and expediting his/her training duties. The person or persons so designated shall be present at all training coordination meetings with the CITY.
- M. The SUPPLIER's coordinator shall coordinate the training periods with CITY personnel and shall submit a training schedule for each component of the Membrane Equipment System for which training is to be provided. Such training schedule shall be submitted not less than 30 calendar days prior to the time that the associated training is to be provided and shall be based on the current plan of operation.

3.08 SUPPLIER'S ONSITE SERVICES

- A. SUPPLIER's Representative:
 - 1. In addition to the time necessary to complete the requirements established elsewhere within these Specifications, the SUPPLIER's representative shall also provide onsite services at times designated by the CITY, for the minimum person-days listed below, travel time excluded.
 - 2. 10 person-days during unloading of membrane filtration equipment system (assume three trips).
 - 3. 20 person-days for providing installation assistance for the Membrane Equipment System (assume six trips).
 - 4. 60 person-days for assistance during startup activities (assume ten-trips).
 - 5. Time as required to provide CITY with initial performance test as specified in Paragraph 3.04.
 - 6. Time as required to provide CITY training as specified in Paragraph 3.07.
- B. The SUPPLIER shall plan and include in lump sum price separate trips for each item as listed above.
- C. The SUPPLIER's representative shall be a qualified individual who has previously provided onsite services for the installation, testing, and startup of the SUPPLIER's identical system at a minimum of one wastewater treatment plant of similar size.
- D. During the Membrane Equipment System MONITORED TEST PERIOD, upon CITY's request, such services for assistance other than to address deficiencies or failures will be provided on a "time and materials" basis per the rates submitted in SUPPLIER's Bid.
- E. Telephone: Include the following in lump sum price:
 - 1. Provide telephone support by means of a toll-free phone number for a minimum period of 10 years following installation and startup.
 - 2. Provide a list of three or more names of individuals qualified to support operation, and provide pager numbers for these individuals, if available. At least one of the listed individuals shall be available at all times including nights, weekends, and holidays in the event of an emergency.

END OF SECTION

SECTION 11500C

CHEMICAL CLEANING SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

- A. The SUPPLIER as specified under Section 11500 - Membrane Equipment System, shall provide the equipment specified under this section.
- B. SUPPLIER shall provide chemical systems for membrane cleaning. The systems will consist of air-operated diaphragm or variable speed electric driven pumps, calibration columns, pulsation damper and appropriate PVC ball valves. System shall also include chemical storage tanks, and interconnection piping and valves. Provide one redundant pump for each chemical system.
- C. Coordination: To ensure that all the equipment is properly coordinated and will function properly, the SUPPLIER shall size the chemical system for the process and obtain all the chemical metering pumps and motor equipment specified from a single pump supplier.
- D. Related Sections:
 - 1. Section 01330 - Submittal Procedures.
 - 2. Section 01756 - Testing, Training, and Facilities Start-Up.
 - 3. Section 09960 - Coatings.
 - 4. Section 11500 - Membrane Equipment Systems.
 - 5. Section 15050 - Basic Mechanical Materials and Methods.
 - 6. Section 15100 - Valves.
 - 7. Section 15958 - Mechanical Equipment Testing.
 - 8. Div. 16 Specifications.
 - 9. Div. 17 Specifications.

1.02 DESIGN REQUIREMENTS

- A. Membrane Cleaning:
 - a. Membrane modules shall be cleaned in place using chemical solutions to meet production capacity and other performance requirements specified within this document and as stated in Documents 00420 and 00440 by the Supplier.
 - b. Maintenance Cleans shall not be performed more frequently than once every 4 days.
 - c. Recovery Cleans shall not be performed more frequently than once every 90 days.
- 2. The following chemicals will be provided by the Owner for the chemical cleaning operation:
 - a. Sodium hypochlorite at 12.5 percent by weight concentration.
 - b. Citric Acid at 50 percent by weight concentration.
 - c. Sulfuric Acid at 98.8 percent by weight concentration for Siemens membrane system only.

3. Additional chemicals, both generic and proprietary, required for membrane cleaning as identified by SUPPLIER in their Bid Proposal shall be provided by the SUPPLIER for start-up and testing.
 4. Chemical Metering Pump Performance Characteristics:
 - a. As required by the SUPPLIER.
 - b. Performance tolerances shall be the same as the test tolerances specified in Section 15958.
 5. Motor Characteristics: As specified by the SUPPLIER.
 6. All chemical metering pumps shall be specifically designed, adapted, and fully guaranteed for their respective intended use.
- B. Chemical metering pumps shall be furnished by the SUPPLIER and shall be coordinated with the requirements of the MBR system.
- C. SUPPLIER to provide chemical storage tank (one tank per chemical required).

1.03 SUBMITTALS

- A. Submit as specified in Section 15050.
- B. Detail drawings showing dimensions and weight of the chemical skids.
- C. Provide proof of compatibility for all materials with the chemical contact.

1.04 QUALITY ASSURANCE

- A. As specified in Section 15050.
- B. Provide chemical metering pumps in this Section from same manufacturer.
- C. Require chemical metering pump manufacturer to furnish and coordinate pump, driver, drive, and pump components as specified and scheduled and to provide written installation and check out requirements.
- D. Manufacturer Qualifications: The manufacturer shall be a qualified and experienced in providing diaphragm metering pumps for use in skid/package applications the same as or similar to the specified task in this document. The manufacturer shall be the provider of all the components for the pump and skid/package and have documented experience in projects of similar scope.
- E. Manufacturer shall test and certify the system on their shop floor.
- F. Manufacturer shall have a local authorized service center to provide service and support to the skid/package system. The service center shall have and maintain factory-authorized service technicians for installation, maintenance and repair as necessary and specified by this document.
- G. Manufacturer shall have the ability and means to provide all skid/package system, parts, components and related services, and be responsible for proper assembly and delivery of the skid/package.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 15050. Storage and Protection: Pack equipment and apply protective coatings to protect equipment for an estimated storage time of 6 months. Provide instructions for required maintenance during storage such as rotating shafts regularly.

1.06 PROJECT CONDITIONS

- A. Environmental Requirements: As specified in Section 15050.

1.07 MAINTENANCE

- A. Special Tools: Deliver one set for each furnished pump type and size needed to assemble and disassemble pump system.
- B. Spare Parts: Deliver the following:
 - 1. A complete set of ball check valves (balls, seats and gaskets).
 - 2. A diaphragm for each pump.

1.08 PROCESS SYSTEM DESIGN AND PERFORMANCE

- A. The specifications describe a packaged system for chemical feed applications. The system is to be matched to the manufacturers' pump offering to maximize the efficiency of chemical delivery by the manufacturers' product. The specified systems must be pre-engineered and configured to the required application.
- B. Systems shall be sized using the SUPPLIER's design criteria.
- C. Product Qualifications: The skid/package system shall be matched to the required piping for the specified application including expected NPSH and chemicals to be handled. All components shall be of the type and quality to properly complement the skid/package system for maximum performance.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: One of the following or equal:
 - 1. Prominent Duodos Air Operated Diaphragm Pump.
 - 2. Milton Roy.
- B. Pumps shall be hydrostatically tested at 150 percent of their operating pressure for 30 minutes and a 5-point curve generated for their accuracy. Metering pumps shall have a repeatability of +/- 2 percent or less, be able to be securely mounted on the base of the skid/package and be aesthetically compatible to the system as a whole.
- C. The skid/package system must be provided as an entire unit, specified as a standard product and to the pressures and flows as required by this document. Systems are to be pre-engineered to the pump requirements matching the chemical delivery demands. All backpressure valves, calibration columns, Y-type strainers, pressure gauges and isolation valves must be defined and matched to the

specifications required for this application. The skid/package system must accommodate the size and capacity of the pump specified in this document in a manner maximizing chemical delivery.

2.02 EQUIPMENT AND COMPONENTS

- A. General:
 - 1. The system shall be pre-engineered and configured so the size and capacity of each component adequately matches the specification stated herein.
 - 2. All piping shall be PVC Schedule 80 or piping as necessary to properly convey the chemical for dosing with no harm to the system.
- B. Pump Requirements: Manufacturer shall be a reputable provider of air-operated diaphragm metering pumps and an engineer of skid/package systems. The pumps shall have the following general requirements:
 - 1. Operation to be supplied by 90 psig compressed air or DC type variable speed drives. Drives shall be totally enclosed.
 - 2. Stroke length control shall be from 0 to 100 percent in 1 percent increments.
 - 3. Pump shall have a repeatability of within 2 percent or less for the application.
 - 4. Pump shall have a minimum of 10:1 turndown.
 - 5. Liquid end shall be physically separate of the drive fastened by bolts for diaphragm maintenance as necessary.
 - 6. Have the ability to be hydrostatically tested to 150 percent of its rated operating pressure.
 - 7. Be part of a family of accessories that match and optimize its operation in a skid/package environment.
- C. Skid/Package Qualifications: The specified pre-engineered skid/package system shall contain at a minimum the following components:
 - 1. Frame to properly mount the pump, mountings, piping, accessories and utilities as necessary for proper operation.
 - 2. A calibration column as offered by the pump manufacturer sized to provide adequate capacity during a minimum 30-second draw down test.
 - 3. A pulsation dampener, single diaphragm capable of arresting water hammers and similar undesirables in metering pump operations. The dampener shall have the ability of removing 95 percent of any pulse or hammer produced within the system as would naturally occur.
 - 4. A pressure gauge installed on each pulsation dampener sized to the calculated and desired pressures of the system.
 - 5. Isolation valves for system cleaning and maintenance.
- D. Chemical Storage Tanks and Accessories: To be supplied by the CONTRACTOR. The SUPPLIER shall recommend the size of chemical storage tanks necessary for all chemicals required.
- E. Material shall be compatible with intended use.
- F. Control panels shall be provided for the chemical cleaning system including metering pumps, based on Division 17 requirements.

2.03 CONTROL SYSTEM

- A. Provide control system with equipment protective devices for safe operation in a local control panel and with remote inputs and outputs to provide control functions as specified in Section 11500, and as required by SUPPLIER.

2.04 FINISHES

- A. Prepare surfaces and apply protective coatings as specified in Section 09960.

PART 3 EXECUTION

3.01 INSTALLATION

- A. The SUPPLIER with the CONTRACTOR shall inspect all equipment immediately upon delivery to site. If damaged, notify the resident Engineer and manufacturer.
- B. The CONTRACTOR shall not install damaged equipment until repairs are made in accordance with the manufacturer's written instructions by the SUPPLIER.
- C. The CONTRACTOR shall complete the installation in accordance with the manufacturer's instructions and recommendations.

3.02 COMMISSIONING

- A. The SUPPLIER shall inspect and verify proper installation. The CONTRACTOR shall make any adjustments required to place the system in proper operating condition.
- B. The SUPPLIER and the CONTRACTOR shall conduct functional tests of the equipment.

3.03 SUPPLIER'S FIELD SERVICES

- A. SUPPLIER shall inspect system before initial start-up and certify that system has been correctly installed and prepared for start-up as specified in this Section and Sections 15050 and 15958.
- B. Training: As specified in Section 01756.

END OF SECTION

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SECTION 11500E

AIR COMPRESSORS

PART 1 GENERAL

1.01 DESCRIPTION

- A. The SUPPLIER as specified under Section 11500 - Membrane Equipment System, shall provide the equipment specified under this section.
- B. SUPPLIER shall provide all packaged air compressors, air receiver, and accessories to operate the air actuated components of the membrane system with all necessary accessories, for a complete working package.
- C. Coordination: To ensure that all the equipment is properly coordinated and will function properly, the SUPPLIER shall size the air compressor packages for the process and obtain all the equipment specified from a single equipment supplier.
- D. Related Sections:
 - 1. Section 01330 - Submittal Procedures.
 - 2. Section 01756 - Testing, Training, and Facilities Start-Up.
 - 3. Section 09960 - Coatings.
 - 4. Section 11500 - Membrane Equipment System.
 - 5. Section 15050 - Basic Mechanical Materials and Methods.
 - 6. Section 15100 - Valves.
 - 7. Section 15958 - Mechanical Equipment Testing.
 - 8. Section 16222 - Motors.
 - 9. Section 17100 - Control Strategies.

1.02 QUALITY ASSURANCE

- A. SUPPLIER shall provide air compressor package(s) built by a manufacturer who has experience in producing similar type equipment, and shows evidence of five installations in satisfactory operation for at least five years.

1.03 SUBMITTALS

- A. Shop drawings: Submit the following for approval:
 - 1. Submit for approval with shop drawings required under Section 11500 - Membrane Equipment System.
 - 2. Submit detailed drawings and data for compressor and air receiver and accessories.
 - 3. Submit compressor and air receiver sizing calculations.
 - 4. Manufacturer's data and drawing describing the equipment in sufficient detail, including materials of construction.
 - 5. Detail drawings showing dimensions and weight of the air compressor package unit and the motor.
 - 6. Provide proof of compatibility for all materials with the intended use.

7. The submittals shall consist of a bill of material listing all components the packager will deliver; component Manufacturer's catalog cut sheets listing materials of construction, cut-away or exploded view drawings, performance curves/charts, standards of design, warranty statement; prime/paint coating system plus the following information:
 - a. Compressor BHP at: normal system operating conditions.
 - b. L10 bearing life calculations for each bearing.
 - c. Motor: 1/2, 3/4, full load efficiencies and power factors.
8. Shop drawings of assembled package.
9. V-belt and/or coupling drive calculations. All work must be shown.

B. Submit as specified in Section 15050.

1.04 PRODUCTION, DELIVERY, STORAGE, AND HANDLING

- A. Delivery, Storage and Handling of Materials: All materials shall be delivered to the site, stored, and handled in accordance with the manufacturer's instructions. The Construction Contractor shall inspect shipments for damage and content well in advance of the date scheduled for incorporation in the Work.
- B. As specified in Section 15050. Storage and Protection: Pack equipment and apply protective coatings to protect equipment. Provide instructions for required maintenance during storage such as rotating shafts regularly.

1.05 PROCESS SYSTEM DESIGN AND PERFORMANCE

- A. The air compressors shall be sized by the SUPPLIER with capacities such that the air supply requirements of the membrane equipment system can be satisfied with one compressor out of service.

1.06 PROJECT CONDITIONS

- A. Environmental Requirements: As specified in Section 15050.

1.07 WARRANTY

- A. As specified in Section 15050.

1.08 MAINTENANCE

- A. Special Tools: Deliver one set for each furnished system type and size needed to assemble and disassemble system.

PART 2 PRODUCTS

2.01 MANUFACTURER

- A. One of the following or equal:
 1. Atlas-Copco.
 2. Quincy.

2.02 EQUIPMENT AND COMPONENTS

A. General Description:

1. The air compressor system shall be two single stage, air-cooled, oil-injected rotary screw compressor packages and one large separate air receiver tank.
2. Each compressor system includes the compressor, drive motor, oil system, air system, integrated refrigerated air dryer with integrated PDX (particulate and coalescing) filter and electro-pneumatic regulating controls.
3. Each compressor shall be equipped with sound attenuating enclosure and are tank mounted on a 60-gallon ASME tank.

B. Compressor Element:

1. The compressor element shall be a rotary screw design consisting of:
 - a. Male rotor with 5 lobes.
 - b. Female rotor with 6 flutes.
 - c. Patented asymmetric rotor design.
 - d. Cycloid profile at the pitch diameter.
2. V-Belt power transmission drives the male rotor.

C. Drive Motor:

1. The drive motor shall be a horizontal AC squirrel cage induction type consisting of:
 - a. Foot mounted.
 - b. Service factor: 1.25.
 - c. Insulation: Class F, Class B rise.
 - d. Enclosure: TEFC.
 - e. Motor speed: 3600 RPM.
 - f. Voltage: 60 HZ/3 phase/ 460 V.
2. Motor construction:
 - a. Rugged cast frame.
 - b. Cast rotor.
 - c. Non-hygroscopic insulation.
 - d. Corrosion resistant hardware.

D. Starter Cubicle:

1. All packaged units shall be equipped with a CSA/UL listed control cubicle consisting of:
 - a. Direct on-line motor starter: 460 V.
 - b. Control circuit transformer for 115V AC controls.

E. Oil System:

1. The oil system shall be of the differential pressure type consisting of:
 - a. Approved air/oil separator reservoir tank with:
 - 1) Inverted spin-on separator element.
 - 2) Oil fill tube with pressure relieving plug.
 - 3) Minimum pressure/check valve.
 - 4) Oil level sight glass.
 - 5) Oil drain valve.
 - b. Oil filter inverted spin-on type rated at 10 microns.
 - c. Air-cooled units with an aluminum oil cooler which is cooled by a dedicated fan with TEFC motor.

- F. Air System:
1. The air system consists of:
 - a. Dry type air intake filter rated at 3 microns.
 - b. Minimum pressure/check valve.
 - c. Air/oil separator tank with oil separator element.
 - d. Moisture separator/trap including both automatic and manual drain lines.
- G. Assembly:
1. The packaged units shall include all of the standard equipment mounted on a fully enclosed metal floor/base, made from industrial grade steel that is tank mounted on a 60-gallon ASME tank. The units shall be completely piped and assembled, including the control cubicle (with starter) and aftercooler with separator/trap. The units shall also include the necessary sound attenuated panels yielding a maximum 65 dB (A) at 3 feet.
- H. Electro-Pneumatic Control Panel:
1. The electro-pneumatic control panel shall include the following gauges and indicators for simple efficient operation:
 - a. Pressure Gauge.
 - b. Hour meter.
 - c. Dry on/off switch.
 - d. Compressor Start/Stop Emergency Switch.
 - e. Reset button.
 - f. Alarm Indicator.
- I. Integral Refrigerated Dryer:
1. An integral refrigerated dryer shall be supplied with the compressor. The dryer module consists of:
 - a. Evaporator.
 - b. Refrigerant compressor.
 - c. Capillary tube.
 - d. R134a refrigerant.
 2. Pressure dew point gauge:
 - a. Integrated PDX (particulate and coalescing) filter (0.01 micron, 0.01 ppm).
- J. Air Receiver:
1. The air receiver shall be a vertical tank of all welded construction with semi-ellipsoidal heads and leg supports for mounting on a concrete base. The receiver shall be designed and constructed in accordance with the ASME Code for Unfired Pressure Vessels and shall bear a code stamp.
 2. The minimum receiver size shall be 500 gallons.
 3. The receiver shall be provided with piping connections for an inlet, outlet, drain, pressure relief valve, and pressure gauge.
 4. Receiver shall be provided with pressure gauge, pressure relief valve, and automatic drain valve.
 5. Manufacturer: Silvan or equal.
- K. Pressure Regulator:
1. Norgren model R17 regulator shall be provided as required by the SUPPLIER.

2.03 CONTROL SYSTEM

- A. Provide control system with equipment protective devices for safe operation in a local control panel and with remote inputs and outputs to provide control functions as specified in Section 17100.

2.04 FINISHES

- A. All equipment shall be factory painted prior to installation.
- B. Prepare surfaces and apply protective coatings as specified in Section 09960.

PART 3 EXECUTION

3.01 INSTALLATION

- A. The Construction Contractor will not install damaged equipment until repairs are made in accordance with the manufacturer's written instructions by the SUPPLIER.
- B. The Construction Contractor will complete the installation in accordance with the manufacturer's instructions and recommendations.

3.02 COMMISSIONING

- A. The SUPPLIER shall inspect and verify proper installation. The Construction Contractor shall make any adjustments required to place the system in proper operating condition.
- B. The SUPPLIER and the Construction Contractor shall conduct functional tests of the equipment.

3.03 SUPPLIER'S FIELD SERVICES

- A. SUPPLIER shall inspect system before initial start-up and certify that system has been correctly installed and prepared for start-up as specified in this Section and Sections 15050 and 15958.
- B. Training: As specified in Section 01756.

3.04 UNLOADING & HANDLING

- A. Care must be taken during unloading and handling of equipment to ensure against undue strain to the air compressor package. **DO NOT** use lifting straps or chains under the air compressor or motor. Lift from under the mainframe, base or use base mounted lifting lugs (if provided).

END OF SECTION

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SECTION 13238A
ALUMINUM COVERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes: Prefabricated aluminum covers for aeration basins and membrane basins.

1.02 REFERENCES

- A. Aluminum Association:
 - 1. Aluminum Design Manual.
 - 2. Aluminum Standards and Data.
- B. ASTM International (ASTM):
 - 1. ASTM C864-90 - Standard Specifications for Preformed Gasket and Sealing Material.

1.03 DESIGN CRITERIA

- A. Design covers in accordance with Aluminum Association Specifications for Aluminum Structures.
- B. The load cases to be considered are different for the aeration basins and the membrane basins and shall be those described herein. The aeration basins are located outdoors, and the membrane basins are located inside the Treatment Building.
- C. Design Loads for the Aeration Basins:
 - 1. Twenty pounds per square foot live load plus dead load.
 - 2. Concentrated load of 500 pounds.
 - 3. Wind Vertical Load: In accordance with building code as specified in Section 01410 and Section 01614.
 - 4. Design cover panels for a live load generated by a 1 inch water column.
 - 5. Maximum deflection of L/180 for loads.
- D. Design Loads for the Membrane Basins:
 - 1. Dead Load: The dead load shall be defined as the weight of the structure and all the material permanently attached to and supported by the structure.
 - 2. Live Load:
 - a. Load Case 1: 100 psf downward over entire cover.
 - b. Load Case 2: 65 psf upward over entire cover.
 - c. Load Case 3: 40 psf downward over entire cover plus 700 pound downward concentrated load over a 1-foot square area.
 - d. Unbalanced Live Load: The live loads above shall be patterned in a way to create maximum shear, movements, and deflections.
 - 3. Vacuum Load: 1-inch of water column vacuum.

4. Panel Design Load: In addition to the above mentioned loads, the aluminum panels shall be designed for a 700-pound load distributed over one square foot at any location and 40-psf load distributed over the entire area of the panel. These loads are to be taken as acting separately from one another and not simultaneously with other design loads.
 5. Membrane Cassette Load: Each panel shall be designed to support the loading from one membrane cassette/module. Each membrane cassette/module shall be considered to weigh 10,000 pounds when fully wet (to be verified by Supplier).
 6. Load Combinations - The loads described above shall be applied to the flat cover in the following combinations:
 - a. Dead Load
 - b. Dead Load, Uniform Live Load, and Vacuum Load
 - c. Dead Load, Unbalanced Live Load, and Vacuum Load
 - d. Dead Load, Unbalanced Live Load, and Membrane Cassette Load.
 7. Deflections - For the above loads and load combinations, the deflection of all components shall not exceed $L/240$, with L equal to the short span of the component. This deflection limit applies not only to the flat cover as whole, but also to the skin of the cover spanning between the supporting edges of each panel or module.
- E. Temperature - The load combinations listed above shall be considered for a temperature range of 40 degrees F to 120 degrees F.

1.04 SUBMITTALS

- A. Shop Drawings: Include the following:
1. Deck dimensions, sizes, thicknesses, gauges, materials, finishes.
 2. Attachment and erection procedures.
 3. Number and location of penetrations.
 4. Penetration details, including size of penetrating conduits.
 5. Access hatch locations, including location of hinges and handles.
 6. Special details not specifically indicated on the Drawings.
- B. Product Data: Include standard details and specifications.
- C. Calculations: Design calculations verifying conformance to design loads and deflection limits shall be submitted. Design calculations are required for structural members as well as walking surface. Calculations shall be signed by a qualified Professional Engineer registered in the State of Arizona.
- D. Evidence of Manufacturer Qualifications: Include personnel experience, physical facilities, management capacity, and minimum 5 letters of reference from owners of wastewater facilities similar to Project.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
1. Manufacturer of aluminum covers for minimum 5 years with minimum 5 installations under satisfactory operation at wastewater treatment facilities for minimum 3 years.

2. No equipment shall be supplied by any manufacturer not regularly engaged in the manufacturing and production of aluminum covers in the size and character specified herein.
- B. Erector Qualifications: Mechanics skilled and experienced in fabrication and erection of aluminum structures with minimum 5 installations under satisfactory operation.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Aluminum Covers: One of the following or equal:
1. Conservatek Temcor, Conroe, TX.
 2. Hallsten, Sacramento, CA

2.02 MATERIALS

- A. Aluminum Sheet: 5052-H36, 6061-T6, 6005A-T6 or 6063-T6 alloy, minimum 0.1 inches thick, mill-finished.
- B. Aluminum Extrusions: 6061-T6, 6005A-T6 or 6063-T6 alloy, mill-finished.
- C. Sealant: Silicone: As specified in Section 07900.
- D. Bitumastic Coating: As specified in Section 09960.
- E. Threaded Fasteners and Concrete Anchors: Type 316 stainless steel as specified in Section 05120.
- F. Closure Flashing Anchors and Hardware: Type 316 stainless steel, 3/8-inch diameter with 1/4 inch by 2 inch by 2- inch minimum stainless steel washer, as specified in Section 05120.
- G. Gaskets:
1. Aeration Basin Covers: Closure-flashing-to-panel seals shall be 3/8 inch Hypalon gaskets.
 2. For the Membrane Basins: All gaskets shall be neoprene conforming to ASTM C 864-90.
- H. Access Hatch Door and Frame Materials: Same as for cover panels.
- I. Access Hatch Hinges, Handles, Prop Rods, and Latches: Type 316 stainless steel.
- J. Nameplates, Manufacturer's Name, or Other Identifications: Maximum 6 inches by 6 inches in size. No more than one per cover.

2.03 FABRICATION OF AERATION BASIN COVERS

- A. Cover Configuration: Free-standing, flat, one-piece, interlocking, supported at each end only, without intermediate supports, removable, arranged as indicated on the Drawings, with flat, planar surface exposed and welded reinforcing ribs and

stiffeners facing downward toward water surface. The use of structural members in contact with the contents of the basin is prohibited.

- B. Covers Components: Panels able to safely sustain specified downward and upward loads without permanent deformation or evidence of failure.
- C. Joints Between Panels: Horizontal tongue and groove type.
- D. Construction and Clearances Between Adjacent Panels: Close enough to not permit maximum 0.5 cubic feet per minute infiltration of air into or loss of air from beneath cover assembly.
- E. Panels Size and Weight: Able to be lifted at 4 corners by 2 workers, maximum 80 pounds.
- F. Access Hatches:
 - 1. Reinforcement: Aluminum structural members able to prevent bowing, warping or other distortions.
 - 2. Doors: Able to be lifted and locked open by one person.
 - 3. Mounting: Curb mounted and flashed.
 - 4. Curbs: Minimum 3/16 inch thick with welded corners.
 - 5. Door Seal: Gasket against curb.
- G. Penetration Reinforcement: Minimum 1/4 inch thick aluminum stiffeners, able to prevent bowing, sagging, warping, or other distortions.
- H. Penetration Flashing and Sealant: Manufacturer's standard, able to prevent intrusion of air and allow for removal of covers without disassembly of equipment, piping, or duct.
- I. Pressure and Vacuum Relief: By non-latching access hatches, able to open and allow escape of water or air when covered areas become pressurized.
- J. Panel Top Surface: Non-slip, manufactured as part of panels or applied to surfaces.
- K. Edge Reinforcement: Minimum 1/4 inch thick aluminum stiffeners, able to prevent bowing, sagging, warping, or other distortions.

2.04 FABRICATION OF MEMBRANE BASIN COVERS

- A. The aluminum cover manufacturer must coordinate with the membrane equipment system SUPPLIER for design of the covers, design of supporting structural members, and coordination of cover cutouts to accommodate membrane equipment system piping. The membrane basin aluminum cover design must be fully integrated with the membrane equipment system design.
- B. The extruded flat covers shall be supported by the peripheral tank structure and structural members extending the interior width of the tank that are provided by the aluminum cover manufacturer or the membrane equipment system supplier. The use of structural members in contact with the contents of the tank is prohibited. The location and dimensions of the structural members shall permit easy installation and removal of the membrane cassettes without interference from the cover supporting structural members. The location and dimensions of the covers shall allow for their

easy removal and reinsertion without interference from adjacent pipe or membrane equipment supports.

- C. The flat cover shall consist of removable panels, each weighing no more than 300 pounds. The required lifting force per panel shall not exceed the dead weight of the panel.
- D. Each panel shall be sized and coordinated such that removal of one panel shall permit complete access to one membrane cassette. The cover system shall be designed such that each cover panel must be able to be removed without needing to remove any adjacent panels.
- E. The flat cover shall have an integral bi-directional slip resistant surface, which extends a minimum of 0.1-inch above the panel surface. Raised surfaces without the use of texturing to achieve slip resistance is not acceptable. The use of checkered plate, paint, tape, sandblasting, or other applied systems to achieve slip resistant surface is prohibited.
- F. All metal components of the flat cover structure shall be aluminum or 316 stainless steel. No galvanized, painted, or plated steel shall be used. Dissimilar materials in the supporting structure shall be isolated from the aluminum flat cover by means of a compatible elastomeric gasket.
- G. The design shall prevent water pooling, which may result in over-stressing the flat cover.
- H. Elastomeric weatherseal gasket shall form a continuous watertight seal along all panel edges. The gaskets shall be fully enclosed.
- I. One cover on each membrane basin shall be equipped with a mechanism for pressure and vacuum relief, to be approved by the ENGINEER. Minimum 16-inch diameter opening in cover.
- J. Each cover shall be equipped with two (2) access hatches no smaller than 18 inches x 18 inches to permit viewing of the contents of the tank. Access hatches shall be able to be lifted and locked by one person. Location of access hatches as shown on the Drawings.
- K. Each cover shall be equipped with four (4) flush mounted lifting points to allow the cover to be removed by an overhead crane. The location of the lifting points shall not interfere with the ability to place a membrane cassette/module on top of the cover.

PART 3 EXECUTION

3.01 ERECTION

- A. Erect covers in accordance with manufacturer's instructions.
- B. Plumb and erect flat covers in proper alignment.

- C. Install closure flashing, including seal between flashing lip and tops of panels continuously around entire perimeter of cover assembly.
- D. Secure closure flashing to existing concrete walls and slabs with drilled and epoxied anchors as specified in Section 05120.
- E. Secure closure flashing to new concrete with cast-in-place anchor bolts as specified in Section 05120.
- F. Place anchors at each corner of each panel and at 16 inches on center along concrete walls.
- G. Anchor Embedments: Minimum 4 inches.
- H. Isolate panel bearing ends, closure flashing, and other aluminum from concrete and dissimilar metals with bitumastic coating.

3.02 WARRANTY

- A. The flat cover manufacturer shall warrant that the Work described herein shall be free from defects, workmanship, and material. The flat cover manufacturer shall replace or repair faulty workmanship or defective materials within 2 years from the date of completion of this scope work.

END OF SECTION

SECTION 13445A

HYDRAULIC AND PNEUMATIC CYLINDER OPERATORS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Hydraulic and pneumatic operators, hydraulic and pneumatic control valves, and control stations for the following equipment:
 - 1. Fabricated slide gates.
 - 2. Plug valves.
 - 3. Butterfly valves.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01612 - Seismic Design Criteria.
 - b. Section 01614 - Wind Design Criteria.
 - c. Section 05190 - Mechanical Anchoring And Fastening To Concrete And Masonry.
 - d. Section 09910 - Painting.
 - e. Section 15050 -Common Work Results for Mechanical Equipment.
 - f. Section 15472 - Hydraulic Power Supply Systems.
 - g. Section 17710 - Control Systems - Panels, Enclosures, and Components.
 - h. Section FILL-IN - FILL-IN.
- C. Furnish hydraulic and pneumatic operators, control valves, and control stations as an integrated package designed by the manufacturer of the operated equipment.

1.02 REFERENCES

- A. American Water Works Association (AWWA):
 - 1. C504 - Standard for Rubber Seated Butterfly Valves.
 - 2. C541 - Hydraulic and Pneumatic Cylinder and Vane-Type Actuators for Valves and Slide Gates.
- B. National Electrical Manufacturer's Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
- C. National Fire Protection Association (NFPA):
 - 1. 79 - Electrical Standard for Industrial Machinery.

1.03 DEFINITIONS

- A. NEMA:
 - 1. Type 4X enclosure in accordance with NEMA 250.
 - 2. Type 7 enclosure in accordance with NEMA 250.
 - 3. Type 12 enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION

- A. Design requirements:
 - 1. Water-hydraulic and pneumatic cylinder operators:
 - a. In accordance with AWWA C541.
 - b. Valve operator cylinder sizing and system design in accordance with AWWA C504 for all types of valves.
 - c. Gate operator cylinder sizing and design:
 - 1) Size based on maximum opening or closing force required.
 - 2) Safety factors and other design criteria in accordance with AWWA C504.
 - d. Minimum operating pressure at control valve for cylinder:
 - 1) FILL-IN pounds per square inch gauge.
 - 2) Cylinder sizing to account for losses, including valve losses and line losses from control valve to cylinder.
 - e. Cylinder pressure rating:
 - 1) Water-hydraulic: 150 pounds per square inch gauge.
 - 2) Pneumatic: 120 pounds per square inch gauge.
 - f. Design valve and gate operating conditions: As specified in Sections FILL-IN and FILL-IN.
 - 2. Oil-hydraulic cylinder operators:
 - a. In accordance with AWWA C541.
 - b. In accordance with NFPA 79.
 - c. Maximum operating pressure: 2,500 pounds per square inch gauge.
 - d. Minimum bursting pressure: 10,000 pounds per square inch gauge.
 - e. Design system working pressure at the hydraulic power unit: As specified in Section 15472.
 - f. Calculate the system working pressure at the hydraulic cylinder based on the submitted oil-hydraulic power system layout.
 - 1) Pressure losses from oil-hydraulic power unit to cylinder shall include:
 - a) Line losses.
 - b) Valve and fitting losses.
 - c) Filter losses.
 - d) Changes in volume/pressure of accumulators.
 - g. Size cylinders for 1.5 times the maximum operating force of the operated equipment.
 - 3. Provide internal stops as required to protect bearings and rod in cylinders with long actuation length.
- B. Performance requirements:
 - 1. Open or close gates at a rate of 30 inches per minute.
 - 2. Open or close valves in 15 seconds.

3. Total unthrottled valve pressure loss for oil hydraulic valves in a circuit at maximum flow and minimum hydraulic fluid temperature shall not exceed 150 pounds per square inch, or the valve manufacturer's recommendations, whichever is lower.

1.05 SUBMITTALS

- A. Shop drawings:
 1. Include connection details with the submittals.
 2. System layout drawings.
 3. Process schematics.
- B. Product data.
- C. Design data:
 1. Sizing calculations for cylinder and rod based on force and torque requirements.
 2. Rod bending and column load calculations.
 3. System pressure loss calculations.
 4. Calculations to substantiate in accordance with AWWA C504.
 5. Anchor and anchor bolt sizing calculations.
 6. Other calculations necessary to substantiate conformance with this specification.
- D. Test reports:
 1. Proof of design test in accordance with AWWA C541.
 2. Performance test in accordance with AWWA C541.
- E. Certificates:
 1. Certification of compliance with proof of design and performance test in accordance with AWWA C541.
 2. Affidavit of compliance in accordance with AWWA C541.
- F. Operation and maintenance data.

1.06 QUALITY ASSURANCE

- A. Unit responsibility:
 1. The hydraulic and pneumatic cylinders shall be supplied by the manufacturer of the equipment actuated by the cylinder.

1.07 SPARE PARTS

- A. Provide the following spare parts:
 1. 1 valve or valve assembly for each set of identical valves or valve assemblies furnished.
 2. 1 additional valve or valve assembly for each whole lot of ten identical valves or valve assemblies furnished.
 3. 1 complete set of seals, gaskets, and expendable hardware required for installation of each spare valve or valve assembly.
 4. 1 repair kit, including seals, gaskets, and expendable hardware, for each size and type of hydraulic cylinder furnished.

5. 1 additional repair kit, including seals, gaskets, and expendable hardware, for each whole lot of 6 hydraulic cylinders of each size and type.
- B. Package spare parts as specified in Section 15050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Pneumatic cylinder operators: One of the following or equal:
1. FILL-IN.
 2. FILL-IN.
- B. Hydraulic cylinder operators: One of the following or equal:
1. Atlas Cylinder Corporation.
 2. Sheffer.
 3. Parker Hannifin.
 4. Rexroth Corporation.
- C. Hydraulic control valves: One of the following or equal:
1. Parker.
 2. Vickers.

2.02 MATERIALS

- A. Water-hydraulic and pneumatic:
1. In accordance with AWWA C541.
 2. Non-metallic materials shall be limited to seals only.
 - a. Non-metallic cylinders are not acceptable.
- B. Oil-hydraulic cylinders:
1. Cylinder head, cap barrel, and tie rods: Steel, unless otherwise specified.
 2. Piston rod: Chrome plated stainless steel.
 3. Tail rods, where required: Chrome plates.
 4. Seals and O-rings: Non-metallic and made of a material that is compatible with the system hydraulic fluid.

2.03 EQUIPMENT

- A. Cylinder construction:
1. Hydraulic cylinders: Heavy duty, double acting type with cushions at both ends.
 2. Hydraulic cylinder operators: Tie rod construction type with heavy-duty front flange mounting.
 3. Pistons: Equip with lip type seals.
 4. Rod cartridge: Removable without the use of special tools.
 5. Support rods with bell crank, cross head, internal stops, or other device to give support to extended piston rods and to reduce rod's effective unsupported length.
 6. Provide tail rods when specified or indicated on the Drawings.

- B. Mounting:
1. Mount cylinders to valves at the factory in accordance with the manufacturer's recommendations. Support cylinders at both ends.
 2. Mount gate cylinders in field on heavy flanged pipe pedestals or spacers to be mounted and anchored to floor slab above gates.
 3. Pedestals:
 - a. Approximately 12 inches high.
 - b. Four cutouts to allow access to lower packing gland without requiring removal of cylinder.
 - c. Capable of preventing transfer of lateral strain to gate stem, stem guides, or operating cylinder.
 - d. Withstand maximum upthrust and downthrust of cylinder if gate does not move when operated.
 4. Anchor bolts:
 - a. Capable of withstanding maximum upthrust or downthrust if gate does not move when operated.
 - b. Suitable for seismic and wind loading as specified in Section 01612 and 01614.
 - c. Anchor bolts: As specified in Section 05190.
- C. Equipment with open/close indication:
1. Provide limit switches to indicate open and close positions on cylinder-actuated equipment.
 2. Limit switch enclosures:
 - a. Where explosion-proof construction is indicated on the Drawings, provide NEMA Type 7 enclosures.
 - b. Other locations: Provide NEMA Type 4X enclosures.
 3. Limit switches for gates: End-of-travel proximity switches mounted in the head and cap of the cylinder.
 4. Mount limit switches for valves on the valve.
- D. Gates with continuous position indication:
1. Provided on gates as specified in the Gate Schedule in Section **FILL-IN**.
 2. Transmitter enclosures:
 - a. Where explosion-proof construction is indicated on the Drawings, provide NEMA Type 7 enclosures.
 - b. Other locations: Provide NEMA Type 4X enclosures.
 3. Continuous position indicators:
 - a. Magnetically coupled position transducer mounted on cylinder head.
 - b. Incorporate transmitter to convert position sensor output to a 4-20 milliamps signal.
 - c. Powered from a 2-wire signal transmitter circuit.
- E. Control valves:
1. Mounted local control valves for the cylinders mounted on aluminum mounting plates, post or wall-mounted as indicated on the Drawings. Install valves within a lockable enclosure.
 2. Control valve assemblies: Modular, stackable construction, rated, designed, and manufactured for service intended.
 3. Use directional control valves to direct the flow of oil, water, or air to the operating cylinder.

- a. Valve: 4-way, 3-position type, solenoid-actuated or manual, as indicated on the Drawings.
 - b. Solenoid-actuated valves: Suitable for 110 volts alternating current, 60 hertz power, spring-centered, and manually operable.
 - c. Solenoid valves in outdoor locations: NEMA Type 4X rated.
 - d. Solenoid valves in indoor locations: NEMA Type 12 rated, except where explosion-proof construction is indicated on the Drawings or required: NEMA Type 7 rated.
 - e. Manually operated valves: 3-position detented or spring-centered, as indicated on the Drawings.
 - 4. Provide pilot operated check valves to maintain intermediate positioning of the cylinder.
 - 5. Provide pressure regulating valves to permit adjustment of opening and closing thrust of the cylinder.
 - 6. Provide speed control valves with ball check bypass to regulate operating speed of the cylinder.
 - 7. Install isolation ball valves on the oil, water, and air supply and return sides of each control valve assembly, with a union-type or flanged connection between the isolation valve and the control valve assembly.
 - 8. Other valves and accessories: Provided as required to meet the necessary performance requirements.
- F. Cylinder connections: Flexible connection with isolation ball valve.
- G. Local control stations:
- 1. Meet requirements of this Section, as specified in Section 17710, and as indicated on the Drawings.
 - 2. Nonmodulating equipment: Incorporate:
 - a. "LOCAL-OFF-REMOTE" selector control, with dry contact for "Remote" selection indication.
 - b. "OPEN-STOP-CLOSE" or "RAISE-STOP-LOWER" local pushbutton controls as indicated on the Drawings.
 - c. "OPEN-CLOSE" or "RAISED-LOWERED" status lights as indicated on the Drawings.
 - 3. Modulating equipment: Incorporate:
 - a. Continuous position indicating gauge.
 - 4. Enclosures for local control station enclosures in outdoor locations: Rated NEMA Type 4X.
 - 5. Enclosure for local control station enclosures in indoor locations: Rated NEMA Type 12, except that where explosion-proof construction is indicated on the Drawings or required, provide NEMA Type 7 enclosures.
- H. Fittings:
- 1. Water-hydraulic or pneumatic systems: Stainless steel, bronze, or copper.
 - 2. Oil-hydraulic systems: Stainless steel.
 - 3. Do not connect galvanized pipe fittings to bronze or copper.
- I. Coatings:
- 1. Prime coat for exposed metal surfaces including operator, support and position indicating devices: As specified in Section 09910.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Mount and adjust cylinders on valves at the factory.
- B. Field mounted cylinders: Installed as directed by the manufacturer of the actuated equipment.
- C. Coordinate installation and startup of the water-hydraulic, oil-hydraulic, or pneumatic system and components.

3.02 FIELD QUALITY CONTROL

- A. Functional testing as specified in Section 15050.

3.03 CYLINDER OPERATOR SCHEDULE

- A. Abbreviations relating to valve or gate type:
 - 1. BFV = Butterfly Valve.
 - 2. RBFV = Rectangular Butterfly Valve.
 - 3. BV = Ball Valve.
 - 4. DV = Diaphragm Valve.
 - 5. PV = Plug Valve.
 - 6. SLG = Sluice Gate.
 - 7. SG = Slide Gate.
- B. Abbreviations relating to operator function:
 - 1. O/C = Open and Close Service.
 - 2. MOD = Modulating Service.
- C. Schedule:

Valve Tag	Valve or Gate Type	Operator Function	Service Fluid (Air, Water, Oil)	Notes

END OF SECTION

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SECTION 13448
INTELLIGENT ACTUATORS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Electric motor-driven actuators for valves and gates **[as identified in the valves and gates schedule as EAM, EDM, OR EDR][, except for specialty actuators specified with individual valves]**.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. **[Section 11293 - Slide Gates.]**
 - b. **[Section 15111 - Ball Valves.]**
 - c. **[Section 15112 - Butterfly Valves.]**
 - d. **[Section 15115 - Gate, Globe, and Angle Valves.]**
 - e. **[Section 15116 - Plug Valves.]**

1.02 REFERENCES

- A. American Water Works Association (AWWA):
 - 1. C504 – AWWA Standard for Rubber-Seated Butterfly Valves.
 - 2. C540 – AWWA Standard for Power-Actuating Devices for Valves and Slide Gates.
- B. National Electrical Manufacturers Association (NEMA):
 - 1. 250 – Enclosures for Electrical Equipment (1000 V Maximum).

1.03 DEFINITIONS:

- A. NEMA:
 - 1. Type 4X enclosure in accordance with NEMA 250.
 - 2. **[Type 6P enclosure in accordance with NEMA 250.]**
 - 3. **[Type 7 enclosure in accordance with NEMA 250.]**

1.04 SUBMITTALS

- A. Product data:
 - 1. Electrical ratings:
 - a. Voltage and number of phases.
 - b. Starting and running current.

- c. Voltage levels and source for control and status.
 2. Description of integral control interface.
 3. **[Remote control station components.]**
 4. Environmental ratings, including NEMA enclosure rating and submergence capabilities.
 5. Gear ratios for both manual and motorized actuation.
 6. Opening and closing directions.
 7. Allowable starts per hour.
 8. List of all included options and accessories.
 9. Full travel times.
 10. Gearbox data including gear ratio, and gearbox efficiency.
 11. Affidavit in accordance with AWWA C540.
- B. Shop drawings:
1. Wiring diagrams:
 - a. Include all options and expansion cards furnished with each actuator.
 2. Dimensioned drawings of each valve and actuator combination.
 3. Dimensioned drawings of each valve gearbox.
 4. Electric motor data.
- C. Calculations: Submit the following for each valve/gate size and class:
1. Operating torque calculations.
 2. Maximum torque calculations for seating and unseating.
 3. Maximum operating torque at starting and normal operation.
- D. Test reports:
1. Factory test report and certificate.
- E. Manufacturer's instructions:
1. Include manufacturer's instructions, description of system operation, start-up data and troubleshooting checklists.
- F. Operations and maintenance data:
1. Include manufacturer's literature; cleaning procedures, replacement part lists, wiring diagrams, and repair data.
 2. Include a list of all configurable parameters, and the final values for each.
 3. List of recommended spare parts.
 4. List of special tools necessary for proper operation and/or maintenance.
 5. Exploded view drawings that illustrate all assemblies, sub-assemblies, and components.
 6. Routine test procedures for all electronic and electrical circuits.
 7. Troubleshooting chart covering the complete valve and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.
 8. Certified factory and field-test results.

1.05 QUALITY ASSURANCE

- A. Obtain required information from the valve/gate supplier, including but not limited to:
1. Interface to gate or valve.
 2. Operating range:
 - a. Quarter turn or multi-turn.
 - b. Required turns for full travel on multi-turn applications.

3. Direction of rotation for opening and closing.
4. Maximum and normal torque requirements.
5. Additional sizing requirements indicated in the following Specifications:
 - a. **[Section 11293 - Slide Gates.]**
 - b. **[Section 15111 - Ball Valves.]**
 - c. **[Section 15112 - Butterfly Valves.]**
 - d. **[Section 15115 - Gate, Globe, and Angle Valves.]**
 - e. **[Section 15116 - Plug Valves.]**

- B. All motorized, intelligent actuators shall be the product of a single manufacturer for all valve and gate applications on this project, regardless of gate or valve type, manufacturer, or supplier.

1.06 SPARE PARTS

- A. Provide the following spare parts (minimum 10 percent of total number of actuators of each model type furnished, but not less than 1 for each model of actuator furnished):
 1. Stem nut.
 2. Worm shaft subassembly.
 3. Drive sleeve subassembly.
 4. Complete actuator seal kit.
 5. Actuator gearbox oil (sufficient quantity to fill 4 gearboxes).
 6. Encoder.
 7. Control module.
- B. Provide 1 spare motor for each size motor furnished.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 1. Rotork Controls, Inc.:
 - a. IQ (multi-turn).
 - b. IQT (quarter-turn).
 2. Limitorque Corporation:
 - a. Accutronix MX.
 3. Auma:
 - a. **[SA] [SAR]** (multi-turn) with Aumatic AC controls.
 - b. **SG** (quarter-turn) with Aumatic AC controls.

2.02 CHARACTERISTICS

- A. Provide actuators complete and operable with all components and accessories required for operation.
- B. Power supply:
 1. Voltage and phases as indicated in the Schedule.
 2. Valve or gate motion independent of power supply phase rotation.
 3. Provide an internal backup power source to maintain settings and track valve position when main power is off.

- C. Size actuator to move gates or valves from full open to closed position within the time indicated in the Schedule:
 - 1. If an operating time is not indicated on the Schedule, size the actuator to move gates or valves at minimum 12 inches per minute under maximum load. Measure rate of closure for valves at maximum diameter of disc, plug, or ball.
 - 2. Size actuators so that gear boxes are not required where possible.

- D. Control interface:
 - 1. Configuration:
 - a. Provide a non-intrusive, non-contacting interface for configuring all input and output settings, control values, ranges, torque switch settings, valve positions switch settings, and options.
 - 1) Configurable from a hand-held configuring tool or input devices on the actuator.
 - 2. Local interface, integral to actuator:
 - a. Non-intrusive, non-contacting selector switches:
 - 1) LOCAL-STOP-REMOTE:
 - a) Motor actuator operation is prevented with the switch in STOP.
 - 2) OPEN-CLOSE:
 - a) Controls the valve when LOCAL-STOP-REMOTE is in LOCAL.
 - b) Spring return to center.
 - c) Configurable between maintained (actuator runs until end of travel, high torque, or a LOCAL-STOP-REMOTE is switched to STOP) and momentary (actuator stops when lever is released).
 - b. Local display:
 - 1) Valve fully open and fully closed indicators.
 - 2) Numerical display showing actual valve or gate position in percent of travel.
 - 3. **[Remote control station - (VCP).**
 - a. **Provide remote control stations for all actuators located more than 5 feet above finished floor/grade or where indicated on the Drawings or [Valve and Gate][Intelligent Actuator] Schedule.**
 - 1) **NEMA rating as listed in the [Valve and Gate][Intelligent Actuator] Schedule.**
 - a) **Where the rating is not listed, use NEMA Type 4X enclosures for non-hazardous areas, and explosion proof (XP) Class I Division 1 for hazardous areas.**
 - b) **All pilot devices shall 30 mm and pilot lights shall be illuminated by LEDs.**
 - 2) **LOCAL-STOP-REMOTE selector switch.**
 - 3) **LOCAL mode control devices:**
 - a) **Operate valve when LOCAL-STOP-REMOTE integral to actuator is in REMOTE and LOCAL-STOP-REMOTE on remote control station is in LOCAL.**
 - b) **OPEN-STOP-CLOSE maintained switch or OPEN, STOP and CLOSE pushbuttons where Maintained operation is indicated in the [Valve and Gate][Intelligent Actuator] Schedule.**
 - c) **OPEN-CLOSE spring-return switch or OPEN and CLOSE pushbuttons where momentary operation is indicated in the [Valve and Gate][Intelligent Actuator] Schedule.**

- 4) **Pilots lights to indicate valve position:**
 - a) **Fully open.**
 - b) **Fully closed.]**
4. Control inputs:
 - a. Capable of using 120 VAC or 24 VDC inputs.
 - b. Controls the valve when LOCAL-STOP-REMOTE is in REMOTE.
 - c. Isolated inputs capable of operating from external control voltage source or internal power supply:
 - 1) Furnish 120 VAC and 24 VDC control power supplies within the actuator.
 - d. Provide the following inputs:
 - 1) OPEN.
 - 2) CLOSE.
 - 3) STOP.
 - e. OPEN and CLOSE inputs configurable between maintained (actuator runs until end of travel, high torque, or a STOP input) and momentary (actuator stops when command is removed).
5. Status outputs:
 - a. Monitor relay output: Dry contact, normally closed, opens when actuator is not in REMOTE or in the event of any internal fault or alarm condition.
 - b. Dry contact outputs configured for the functions indicated on the Drawings. Provide the following outputs for all actuators:
 - 1) Fully closed.
 - 2) Fully open.
 - 3) LOCAL-STOP-REMOTE in REMOTE position.
 - c. **[Capable of being configured for the following additional functions:**
 - 1) **Communications failure.**
 - 2) **High motor temperature.**
 - 3) **Valve opening or closing.**
 - 4) **Valve moving (continuous or pulsing)**
 - 5) **Motor tripped on torque in mid-travel.**
 - 6) **Motor stalled.**
 - 7) **Actuator being operated by hand wheel.**
 - 8) **Open or close interlock active.**
 - 9) **ESD active.**
 - 10) **Motor tripped on torque in mid-travel.**
 - 11) **Motor tripped on torque going open.**
 - 12) **Motor tripped on torque going closed.**
 - 13) **Pre-set torque exceeded.**
 - 14) **Valve jammed.**
 - 15) **Lost main power phase.**
 - 16) **Control supply lost.**
 - 17) **Battery low.**
 - 18) **Internal failure detected.]**
 - d. All output contacts rated for 5 amps, 120 VAC and 24 VDC.
6. **[Analog input:**
 - a. **Provide a 4-20 milliampere analog input for analog modulating valves when indicated on the Drawings.**
 - b. **Modulate valve to maintain position based on analog input value.**
 - c. **Maximum input impedance 250 ohms.**

7. **Analog output[s]:**
 - a. **Provide an isolated 4-20 milliampere analog output[s] when indicated on the Drawings.**
 - 1) **Loop power sourced from the actuator power supply.**
 - 2) **Capable of driving into a load up to 500 ohms.**
 - 3) **Output proportional to process value(s) indicated on the Drawings:**
 - 4) **Valve or gate position.**
 - 5) **Operating torque.]**
8. **[Network communications:**
 - a. **Communications and control between the actuator and plant's control system shall utilize the following protocol:**
 - 1) **Profibus PA.**
 - 2) **Profibus DP.**
 - 3) **Foundation FieldBus H1.**
 - 4) **DeviceNet.**
 - 5) **Modbus RTU (RS-485).]**

2.03 FEATURES

- A. Time delay on reversal: Incorporate time delay between stopping actuator and starting in opposite direction to limit excessive current, torque, and heating from instantaneous reversal.
- B. Data logging:
 1. Store diagnostic data and reference data.
 - a. **[Time-stamped] historical operating data, including number of operations [and most recent operations].**
 - b. **[Torque profiles showing actual torque at each valve position through the operating range] [Starting torque, maximum running torque, and end of travel torque].**
 - 1) Store reference data (recorded during commissioning) and data from last operation.
 2. Provide display of logged data on the actuator, or provisions to download to a personal computer.

2.04 MATERIALS

- A. Construct motorized actuators of materials suitable for the environment in which the valve or gate is to be installed.

2.05 COMPONENTS

- A. Motors:
 1. Specifically designed for valve actuator service with high starting torque, totally enclosed non-ventilated construction.
 2. Torque ratings equal to or greater than that required for valve seating and dynamic torques with a 25 percent factor of safety.
 - a. Design requirements for rubber-seated AWWA butterfly valves:
 - 1) Design actuators for maximum gate or valve operating torque, in accordance with and using safety factors required in AWWA C504 and AWWA C540.

- a) Valve actuator torque requirement for open-close service: Not less than the required valve-seating and dynamic torques under design operating conditions in accordance with AWWA C504.
 - b) Valve actuator torque requirement for modulating service: Not less than twice the required valve dynamic torque under design operating conditions in accordance with AWWA C504.
 - b. Design requirements for slide gates, gate valves, knife gate valves, globe valves, and diaphragm valves:
 - 1) Design valves and actuators for maximum operating torque, in accordance with and using safety factors required in AWWA C540.
 - 2) Design for the maximum torque and thrust running load over the full cycle.
 - 3) Maximum torque or thrust rating: The actuator stall torque or maximum thrust output shall not exceed the torque or thrust capability of the valve or gate, as determined by the valve or gate manufacturer.
 - 3. Capable of being removed and replaced without draining the actuator gear case.
 - 4. Motor bearings shall be amply proportioned of the anti-friction type and permanently lubricated.
 - 5. Rated for operating under the following conditions without exceeding temperature limits with ambient temperature of 40 degrees Celsius.
 - a. Continuous operation for 15 minutes or twice the open-to-close operating time (whichever is greater) at normal operating torque or 33 percent of maximum torque (whichever is greater)
 - b. 60 starts per hour for open/close service or 1,200 starts per hour for modulating service.
 - 6. Provide the following motor protection features:
 - a. Jammed valve (no valve motion detected through a time delay).
 - b. High motor temperature (sensed by an embedded thermostats).
 - c. High torque.
 - d. Single phasing protection.
- B. Enclosures:
- 1. Actuator housing ratings as indicated in the Schedule.
 - 2. Stainless steel external fasteners.
 - 3. Provide 'O' ring seals for each of the following areas:
 - a. Between the terminal compartment and the internal electrical elements
 - b. Between the mechanical and electrical portions to protect from the ingress of oil, and to protect the mechanical components of oil from dust and moisture when the electrical terminal is open.
 - 4. Provide the following minimum enclosure ratings:
 - a. NEMA Type 4X enclosure for general applications.
 - b. **[NEMA Type 6P rated for actuators in underground vaults or where possible submergence is indicated in the Drawings.**
 - 1) **Suitable for a minimum of 48 hours submerged under 3 meters of water.]**
 - 5. **[NEMA Type 7 certified by FM for Class I, Division 1, Groups C, D, E, F and G, for actuators installed in Class I, Division 1 and 2 areas.]**
- C. Position sensing:
- 1. Electronic and adjustable using a solid-state encoder wheel.

- a. Mechanical limit switches and potentiometers are not acceptable.
 - 2. Capable of retaining position and monitoring valve or gate motion when valve is manually actuated and when main power is not present.
 - 3. Valve range and position switch outputs field adjustable.
- D. Torque sensing:
- 1. Torque shutdown setting: 40 percent to 100 percent rated torque.
 - a. Adjustable in 1 percent increments.
 - 2. **[Torque display: 0 to 100 percent-rated torque.]**
 - 3. Capable of interrupting control circuit during both opening and closing and when valve torque overload occurs.
 - 4. Electrical or electronic torque sensing:
 - a. **[Extrapolating torque from mechanically measured motor speed is not acceptable due to response time.]**
 - 5. Independent of variations in frequency, voltage, or temperature.
 - 6. **[The actuator shall store actual operational torque curves for retrieval by plant maintenance staff.]**
 - 7. Provide a temporary inhibit of the torque sensing system during unseating or during starting in mid-travel against high inertia loads.
 - 8. Provide visible verification of torque switch status without any housing disassembly.
- E. Manual actuators:
- 1. Hand wheel for manual operation.
 - a. Maximum **[80]** pound pull on rim when operating gate or valve under maximum load.
 - b. Provide pull chain when motorized actuator is located more than 6 feet above floor surface.
 - 1) Chain shall be of sufficient length to reach approximately 4 feet above the operating level.
 - 2) Where the chain obstructs an aisle or walkway, provide holdback or other means to ensure chain does not create a nuisance or hazard to operating personnel.
 - 2. Declutch lever: Padlockable, capable of mechanically disengaging motor and related gearing and freeing hand wheel for manual operation.
- F. Gearing: Hardened alloy steel spur or helical gears and self-locking, alloy bronze worm gear set.
- 1. Accurately cut to assure minimum backlash.
- G. Bearings:
- 1. Anti-friction bearing with caged balls or rollers throughout.
 - 2. Sealed-for-life type thrust bearings housed in a separate thrust base.
- H. Drive bushing:
- 1. Easily detachable for machining to suit the valve stem or gearbox input shaft.
 - 2. Positioned in a detachable base of the actuator.
- I. Lubrication:
- 1. Provide totally enclosed actuator gearing with oil filled gear case suitable for operation at any angle.
 - 2. Suitable for standard SAE80EP gear oil.

3. Actuators requiring special or exotic lubricants are not acceptable.

2.06 ACCESSORIES

A. **[Master station:**

1. **FILL-IN**.]

B. Software:

1. Furnish PC-based diagnostic and configuration software to display diagnostic data **[and configure actuators]**.
2. Provide software communications to the valve actuator **[and hand-held setting tool]** using **[Bluetooth wireless][or][IrDA infrared]** communications.
 - a. Provide all accessories and drivers required for operation and communications with a standard personal computer running Microsoft Windows XP **[or Vista]**.
 - b. **[Where infrared communications are used,][furnish an IrDA to USB adapter with a mounting device to secure the infrared element to the valve actuator IrDA port:**
 - 1) **Provide with a minimum cable length of 3 feet, capable of being extended with a standard USB extension cable.]**

C. Setting tool:

1. **[If required for setting or configuring the actuator, provide a hand-held setting tool.][Provide a hand-held setting tool capable of non-intrusive calibration and interrogation of the actuator.]**
 - a. Furnish 1 setting tool for every 10 actuators.
 - b. **[Capable of communicating with PC-based configuration software, and transferring the following in either direction between the computer and programmer and setting tool, and between the setting tool and actuator:**
 - c. **Actuator configurations.**
 - 1) **Capable of storing up to 10 different configurations.**
 - d. **Diagnostic data.**
 - 1) **Capable of storing 4 complete sets of diagnostic data.]**

D. Termination Module Cover:

1. For actuators on a valve network provide a means to keep the valve network in service, in the event where the actuator must be removed.

2.07 SOURCE QUALITY CONTROL

A. Factory test:

1. Test each actuator in the factory, and submit an individual test certificate for each actuator.
2. Perform a high potential test and record the following information:
 - a. Test voltage.
3. Simulate a maximum and typical valve loads and record the following information:
 - a. Current and power factor at maximum and set torque values.
 - b. Torque as measured by the actuator.
 - c. Actuator output speed or operating time.

4. Performance testing: Conduct performance test for each actuator simulating valve operating torque from full-open to full-close and from full-close to full-open. The following information shall be recorded during each performance test:
 - a. Torque at maximum torque setting.
 - b. Current at maximum torque setting.
 - c. Test voltage and frequency.
 - d. Actuator output speed and operating time for full-open to full-close.
 - e. Amperage draw on motors at breakaway and under normal operation.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install actuators in accordance with manufacturer's instructions.

3.02 MOTORIZED ACTUATOR SCHEDULE

- A. Provide all actuators required by the Drawings.
 1. Major process actuators are listed in the Intelligent Actuator Schedule **[in this section]** [indicated on the Drawings].
 2. The schedule does not include all number and types of actuators required for the Project.
- B. Abbreviations relating to type:
 1. BFV = Butterfly Valve.
 2. BV = Ball Valve.
 3. PV = Plug Valve.
 4. SG = Slide Gate.
- C. Abbreviations relating to actuator type:
 1. O/C = Open and Close Service.
 2. MOD = Modulating Service.
- D. Abbreviations relating to controls:
 1. PA = Profibus PA.
 2. DP = Profibus DP.
 3. DN = DeviceNet.
 4. FF = Foundation Fieldbus H1.
 5. MB = Modbus RTU (RS-485).
 6. NET = Manufacturer's proprietary network.
 7. A = Analog (4-20mA) control, modulating duty.
 8. D = Discrete control, modulating duty.
 9. D-O/C = Discrete Open/Close.

END OF SECTION

Notes:

- (1) Provide actuators with remote control station.
- (2) New motorized actuator to be installed on existing equipment. Field verify characteristics prior to sizing motor actuator.

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SECTION 15050

COMMON WORK RESULTS FOR MECHANICAL EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Basic design and performance requirements for mechanical equipment.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01610 - Project Design Criteria.
 - b. Section 01612 - Seismic Design Criteria.
 - c. Section 01756 - Testing, Training, and Facility Start-Up.
 - d. Section 01782 - Operating and Maintenance Data.
 - e. Section 05120 - Structural Steel.
 - f. Section 09960 - High-Performance Coatings.
 - g. Section 15958 - Mechanical Equipment Testing.
 - h. Section 17950 - Testing Calibration and Commissioning.

1.02 REFERENCES

- A. American Gear Manufacturer's Association (AGMA) Standards:
 - 1. AGMA 2001-B88 – Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth.
 - 2. AGMA 6000-A88 – Specification for Measurement of Linear Vibration on Gear Units.
 - 3. AGMA 6001-E08 – Design and Selection of Components for Enclosed Gear Drives.
 - 4. AGMA 6010-E88 – Standard for Spur, Helical, Herringbone, and Bevel Enclosed Drives.
 - 5. AGMA 6019-E89 – Standard for Gear motors using Spur, Helical, Herringbone, Straight Bevel or Spiral Bevel Gears.
 - 6. AGMA 6025-C90 – Sound for Enclosed Helical, Herringbone, and Spiral Bevel Gear Drives.
- B. American Society of Mechanical Engineers (ASME):
 - 1. ASME PTC 8.2 – Performance Test Code for Centrifugal Pumps.
 - 2. ASME PTC 10 – Performance Test Code – Compressors and Exhausters.
 - 3. ASME PTC 17 – Performance Test Code – Reciprocating Internal Combustion Engines.

- 4. ASME PTC 11 – Performance Test Code – Measurement of Shaft Horsepower – Instruments and Apparatus.
- C. American Bearing Manufacturers Association (ABMA) Standards:
 - 1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
 - 2. 11 - Load Ratings and Fatigue Life for Roller Bearings.
- D. American Petroleum Institute (API):
 - 1. 682 - Shaft Sealing Systems for Centrifugal and Rotary Pumps.
- E. ASTM International (ASTM):
 - 1. A 36 - Standard Specification for Carbon Structural Steel.
 - 2. A 48 - Standard Specification for Gray Iron Castings.
 - 3. A 125 - Standard Specification for Steel Springs, Helical, Heat-Treated.
 - 4. A 526 – Standard Specification for Steel Sheet, Zinc Coated by the Hot DIP Process, Commercial Quality.
 - 5. A 536 - Standard Specification for Ductile Iron Castings.
 - 6. A 653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
 - 7. B 61 - Standard Specification for Steam or Valve Bronze Castings.
 - 8. B 62 - Standard specification for Composition Bronze or Ounce Metal Castings.
 - 9. B 505 - Standard Specification for Copper Alloy Continuous Castings.
 - 10. B 584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
 - 11. E 527 – Standard Practice for Numbering Alloys and Metals (UNS).
- F. Food and Drug Administration (FDA).
- G. Hydraulic Institute (HI):
 - 1. HI 1.1-1.5 – Centrifugal Pumps – Nomenclature, Definitions, Application, and Operation.
 - 2. HI 1.6 – Centrifugal Pump Tests.
 - 3. HI 3.1-3.5 – Rotary Pumps - Nomenclature, Definitions, Application, and Operation.
 - 4. HI 3.6 – Rotary Pump Tests.
 - 5. HI 4.1-4.6 – Sealless Rotary Pumps - Nomenclature, Definitions, Application, Operation and Test.
 - 6. HI 6.1-6.5 – Reciprocating Power Pumps - Nomenclature, Definitions, Application, and Operation.
 - 7. HI 7.1-7.5 – Controlled Volume Pumps - Nomenclature, Definitions, Application, and Operation.
 - 8. HI 9.1-9.5 – Pumps – General Guidelines for Types, Definitions, Application and Sound Measurement.

H. NSF International (NSF).

1.03 DEFINITIONS

- A. Special tools: Tools that have been specifically made for use on unit of equipment for assembly, disassembly, repair, or maintenance.

- B. Resonant frequency: That frequency at which a small driving force produces an ever-larger vibration if no dampening exists.
- C. Rotational frequency: The revolutions per unit of time usually expressed as revolutions per minute.
- D. Critical frequency: Same as resonant frequency for the rotating elements or the installed machine and base.
- E. Peak vibration velocity: The root mean square average of the peak velocity of the vibrational movement times the square root of 2 in inches per second.
- F. Rotational speed: Same as rotational frequency.
- G. Maximum excitation frequency: The excitation frequency with the highest vibration velocity of several excitation frequencies that are a function of the design of a particular machine.
- H. Critical speed: Same as critical frequency.
- I. Free field noise level: Noise measured without any reflective surfaces (an idealized situation); sound pressure levels at 3 feet from the source unless specified otherwise.
- J. Operating weight: The weight of unit plus weight of fluids or solids normally contained in unit during operation.

1.04 SYSTEM DESCRIPTION

- A. General:
 - 1. Provisions specified under each technical equipment specification prevail over and supersede conflicting provisions as specified in this Section.
 - 2. Provide equipment and parts that are suitable for stresses, which may occur during fabrication, transportation, erection, and operation.
 - 3. Provide equipment that has not been in service prior to delivery, except as required by tests.
 - 4. Like parts of duplicate units are to be interchangeable.
 - 5. When 2 or more units of equipment for the same purpose are required, provide products of same manufacturer.
 - 6. Equipment manufacturer's responsibility extends to selection and mounting of gear drive units, motors or other prime movers, accessories, and auxiliaries required for proper operation.
 - 7. When necessary, modify manufacturer's standard product to conform to specified requirements or requirements indicated on the Drawings and contained in Laws and Regulations.
- B. Material requirements:
 - 1. Materials: Suitable for superior corrosion resistance and for services under conditions normally encountered in similar installations.
 - 2. Dissimilar metals: Separate contacting surfaces with dielectric material.

- C. Power transmission systems:
 - 1. Power transmission equipment: V-belts, sheaves, shaft couplings, chains, sprockets, mechanical variable-speed drives, variable frequency drives, gear reducers, open and enclosed gearing, clutches, brakes, intermediate shafting, intermediate bearings, and U-joints are to be rated for 24 hour-a-day continuous service or frequent stops-and-starts intermittent service, whichever is most severe, and sized with a minimum service factor of 1.5:
 - a. Apply 1.5 service factor to nameplate horsepower and torque of prime source of power and not to actual equipment loading.
 - b. Apply service factors higher than 1.5 when recommended for continuous 24 hour per day operation and shock loadings in accordance with AGMA 6001-E08, other applicable AGMA standards, or other applicable referenced standards.
 - c. When manufacturer recommends service factor greater than 1.5, manufacturer's recommendation takes precedence.
- D. Vibration:
 - 1. Resonant frequency:
 - a. For single speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the operating rotational frequencies or multiples of the operating rotational frequencies that may be excited by the equipment design.
 - b. For variable speed equipment, ensure there are no natural resonant frequencies within 25 percent above or below the range of operating frequencies.
 - 2. Design, balance, and align equipment to meet the vibration criteria specified in Section 15958.
- E. Equipment mounting and anchoring:
 - 1. Mount equipment on cast iron or welded steel bases with structural steel support frames.
 - a. Utilize continuous welds to seal seams and contact edges between steel members.
 - b. Grind welds smooth.
 - 2. Provide bases and supports with machined support pads, dowels for alignment of mating of adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits.
 - 3. Provide jacking screws in bases and supports for equipment weighing over 1,000 pounds.
 - 4. Anchorage of equipment to concrete: Perform calculations and determine number, size, type, strength, and location of anchor bolts or other connections.
 - 5. Provide bolt sleeves for anchor bolts for heavy equipment.
 - a. Adjust bolts to final location and fill sleeve with non-shrink grout.
 - 6. Anchorage of equipment to metal supports: Perform calculations and determine number, size, type, strength, and location of bolts used to connect equipment to metal supports.
 - 7. Design equipment anchorage, supports, and connections for dead load, running loads, loads during start-up, seismic load, and other loads as required for proper operation of equipment.

- F. Seismic design:
 - 1. Design equipment anchorage and related details for seismic design criteria as specified in Section 01612.
 - 2. For equipment with operating weight of 400 pounds or more, provide calculations for:
 - a. Determine operating weight and centroid of equipment.
 - b. Calculate forces and overturning moments.
 - c. Calculate shear and tension forces in equipment anchorages, supports, and connections.
 - d. Design equipment anchorage, supports, and connections based on calculated shear and tension forces.
- G. Equipment units weighing 50 pounds or more: Provide with lifting lugs or eyes to allow removal with hoist or other lifting device.

1.05 SUBMITTALS

- A. Product data:
 - 1. For each item of equipment:
 - a. Design features.
 - b. Load capacities.
 - c. Efficiency ratings.
 - d. Material designations by UNS alloy number or ASTM Specification and Grade.
 - e. Data needed to verify compliance with the Specifications.
 - f. Catalog data.
 - g. Name plate data.
 - h. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
 - 2. Gear reduction units:
 - a. Engineering information in accordance with applicable AGMA standards.
 - b. Gear mesh frequencies.
- B. Shop drawings:
 - 1. Drawings for equipment:
 - a. Drawings that include outline drawings, cut-away drawings, parts lists, material specification lists, and other information required to substantiate that proposed equipment complies with specified requirements.
 - 2. Outline drawings showing equipment, driver, driven equipment, pumps, seal, motor(s) or other specified drivers, variable frequency drive, shafting, U-joints, couplings, drive arrangement, gears, base plate or support dimensions, anchor bolt sizes and locations, bearings, and other furnished components.
 - 3. Installation and checkout instructions including leveling and alignment tolerances, grouting, lubrication requirements, and initial start-up procedures.
 - 4. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer based controls.
 - 5. Recommended or normal operating parameters such as temperatures and pressures.
 - 6. Alarm and shutdown set points for all controls furnished.

- C. Calculations:
1. Calculations and other information to substantiate equipment base plates, supports, bolts, anchor bolts, and other connections meet minimum design strength requirements and seismic design criteria specified in Section 01612.
 2. ABMA 9 or ABMA 11 L_{10} life for bearings calculation methods for drivers, pumps, gears, shafts, motors, and other driveline components with bearings.
 3. Calculations and other information to substantiate that operating rotational frequencies meet the requirements of this Section.
 4. Torsional analysis of power transmission systems: When torsional analysis specified in the equipment sections, provide:
 - a. Sketch of system components identifying physical characteristics including mass, diameter, thickness, and stiffness.
 - b. Results of analysis including first and second critical frequencies of system components and complete system.
 5. Calculations shall be signed and stamped by a civil or structural engineer registered to practice in the state where the Project is located.
- D. Quality control submittals:
1. Source quality control reports and certified test data as specified in Section 15958.
 2. Submit factory test reports before shipment.
 3. Certified static and dynamic balancing reports for rotating equipment.
 4. Field quality control reports and test data as specified in Section 15958.
 5. Start-up plan: Proposed plan for field-testing equipment as specified in Section 01756.
 6. Certificate of Proper Installation: As specified in Section 01756.
 7. Submit material test reports as specified in the equipment sections.
- E. Operation and maintenance manuals:
1. As specified in Section 01782.
 2. Submit prior to training of Owner's personnel.
 3. Make available at project site complete copy of manuals for use by field personnel and Engineer during start-up and testing of equipment.
 4. Include manufacturer and model number of every bearing; include calculated ball pass frequencies of the installed equipment for both the inner and outer raceways.
 5. Include motor rotor bar pass frequencies.

1.06 QUALITY ASSURANCE

- A. Manufacturer's field service:
1. Furnish services of authorized representative specially trained in installation of equipment:
 - a. Visit project site and perform tasks necessary to certify installation.
 - b. Furnish Certificate of Proper Installation as specified in Section 01756.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Packing and shipping:
1. Equipment: Pack in boxes, crates, or otherwise protect from damage and moisture, dust, or dirt during shipment, handling, and storage.
 2. Bearings: Separately pack or otherwise suitably protect during transport.

3. Spare parts: Deliver in boxes labeled with contents, equipment to which spare parts belong, and name of Contractor.
- B. Storage:
 1. Equipment having bearings:
 - a. Store in enclosed facilities.
 - b. Rotate units at least once per month or more often as recommended by the manufacturer to protect rotating elements and bearings.
 2. Gear boxes: Oil filled or sprayed with rust preventive protective coating.
- C. Protection:
 1. Equipment: Protect equipment from deleterious exposure.
 2. Painted surfaces: Protect against impact, abrasion, discoloration, and other damage.

1.08 SEQUENCING AND SCHEDULING

- A. Equipment anchoring: Obtain anchoring material and templates or setting drawings from equipment manufacturers in adequate time for anchors to be cast-in-place when concrete is placed.
- B. Coordinate details of equipment with other related parts of the Work, including verification that structures, piping, wiring, and equipment components are compatible.
- C. General start-up and testing of equipment:
 1. Perform general start-up and testing procedures after operation and maintenance manuals for equipment have been received.
 2. Conduct functional testing of mechanical or electrical systems when each system is substantially complete and after general start-up and testing procedures have been successfully completed.
 3. Functional testing requirements as specified in Sections 01756, 15958, 16950, and 17950 and the equipment sections.

1.09 MAINTENANCE

- A. Special tools:
 1. When specified, provide special tools required for operation and maintenance.
 2. Mark or tag and list such tools in maintenance and operations instructions. Describe use of each tool.
- B. Spare belts:
 1. When spare belts are specified, furnish 1 spare belt for every different type and size of belt-driven unit:
 - a. Where 2 or more belts are involved, furnish matched sets.
 - b. Identify as to equipment, design, horsepower, speed, length, sheave size, and use.
 - c. Package in boxes labeled with identification of contents.
- C. Spare parts:
 1. Assume responsibility until turned over to Owner.
 2. Store in enclosed facilities.
 3. Furnish itemized list and match identification tag attached to every part.

4. List parts by generic title and identification number.
5. Furnish name, address, and telephone number of supplier and spare parts warehouse.

1.10 WARRANTY

- A. Warrant equipment free of defects in material and workmanship for 1 year from the date of acceptance or date of first beneficial use of the equipment by the City, cover parts and labor.
- B. Where an extended warranty beyond 1 year is required by the detailed equipment specification Section, manufacturer's extended warranty shall be issued in the Owner's name.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Ferrous materials:
 1. Steel for members used in fabrication of assemblies: ASTM A 36.
 2. Iron castings: ASTM A 48, tough, close-grained gray iron, free from blowholes, flaws, and other imperfections.
 3. Ductile iron castings: ASTM A 536, Grade 65-45-12, free from flaws and imperfections.
 4. Galvanized steel sheet: ASTM A 653, minimum 0.0635 inch (16 gauge).
 5. Expanded metal: ASTM A 36, 13 gauge, 1/2-inch flat pattern expanded metal.
- B. Nonferrous materials:
 1. Stainless steel: Type 304 or 316 as specified. Provide L grade where welding required.
 2. Bronze in contact with liquid: Composition of not more than 2 percent aluminum nor more than 6 percent zinc; UNS Alloy C83600, C92200 or C93700 in accordance with ASTM B 61, B 62, B 505, or B 584, when not specified otherwise.
- C. Dielectric materials for separation of dissimilar metals:
 1. Neoprene, bituminous impregnated felt, heavy bituminous coatings, nonmetallic separators or washers, or other materials.
- D. Anchor bolts: As specified in Section 05190; minimum 0.5-inch diameter.

2.02 SHAFT COUPLINGS

- A. General:
 1. Type and ratings: Provide nonlubricated type, designed for not less than 50,000 hours of operating life.
 2. Sizes: Provide as recommended by manufacturer for specific application, considering horsepower, speed of rotation, and type of service.
 3. Use: Use of couplings specified in this Section does not relieve Contractor of responsibility to provide precision alignment of driver-driven units as required by equipment manufacturer and alignment criteria specified elsewhere in this Section.

- B. Shaft couplings - close coupled: Shaft couplings for close coupled electric motor driven equipment 1/2 horsepower or larger and subject to sudden torque reversals or shock loading:
 - 1. Manufacturers: One of the following or equal:
 - a. T.B. Woods, Dura-Flex, L-Jaw C-Jaw or G-Jaw.
 - b. Lovejoy, S-Flex.
 - 2. Provide flexible couplings designed to accommodate angular misalignment, parallel misalignment, and end float.
 - 3. Manufacture flexible component of coupling from synthetic rubber, or urethane.
 - 4. Provide service factor of 2.5 for electric motor drives and 3.5 for engine drives.
 - 5. Do not allow metal-to-metal contact between driver and driven equipment.
 - 6. Examples of loads where sudden torque reversals may be expected:
 - a. Reciprocating pumps, blowers, and compressors.
 - b. Conveyor belts.
 - c. Reversing equipment.
- C. Shaft couplings - direct connected: Shaft couplings for direct connected electric motor driven equipment 1/2 horsepower or larger and subject to normal torque, non-reversing applications:
 - 1. Manufacturers: One of the following or equal:
 - a. Rexnord - Falk.
 - b. T.B. Woods, Dura-Flex, Sure-Flex or Form-Flex.
 - 2. Provide flexible couplings designed to accommodate shock loading, vibration, and shaft misalignment or offset.
 - 3. Provide flexible connecting element of rubber and reinforcement fibers.
 - 4. Connect stub shafts through collars or round flanges, firmly keyed to their shafts with neoprene cylinders held to individual flanges by through pins.
- D. Spacer couplings: Where cartridge type mechanical seals or non-split seals are specified, provide a spacer type coupling of sufficient length to remove the seal without disturbing the driver or driven equipment unless noted otherwise in the individual equipment specifications.
- E. Specialized couplings: Where requirements of equipment dictate specialized features, supply coupling recommended for service by manufacturer.

2.03 STUFFING BOX, SEAL CHAMBER, AND SHAFT SEALS

- A. General:
 - 1. Unless otherwise noted in the equipment section, provide cartridge type, double mechanical shaft seals for pumps.
 - 2. Provide a stuffing box large enough for a double mechanical seal.
 - 3. Where packing is specified, provide stuffing box large enough to receive a double mechanical seal.
 - 4. Provide seal or packing flush connections, (3/4-inch size unless another size is indicated on the Drawings).
 - 5. Provide and route leakage drain line to nearest equipment floor drain indicated on the Drawings.
 - 6. For pumps with packing, design packing gland to allow adjustment and repacking without dismantling pump except to open up packing box.

7. Seal or packing flush requirements shall be in accordance with API Standard 682 requirements. Unless otherwise indicated, specified or required by the equipment and seal manufacturers, the following API flushing Plan arrangements shall be utilized as appropriate for the application:
 - a. Single seal, clean water applications: Plan 11 (Discharge bypass to seal).
 - b. Single seal, vertical pump applications: Plan 13 (Seal bypass to suction).
 - c. Single seal, clean hot water (greater than 180 degrees Fahrenheit) applications: Plan 23 (Seal cooler and pumping ring).
 - d. Single seal, solids, or contaminants containing water applications: Plan 32 (External seal water- see Carollo typical detail # M262).
 - e. Double seal applications: Plan 54 (External seal water- see Carollo typical detail # M262).
- B. Packing: When specified in the equipment section of the specifications, provide the following type of packing:
 1. Wastewater, water, and sludge applications:
 - a. Asbestos free.
 - b. PTFE (Teflon) free.
 - c. Braided graphite.
 - d. Manufacturers: One of the following or equal:
 - 1) Chesterton, 1400.
 - 2) John Crane Inc., equivalent product.
 2. Drinking water service:
 - a. Approved by the FDA or NSF.
 - b. Asbestos free.
 - c. Material: Braided PTFE (Teflon).
 - d. Manufacturers: One of the following or equal:
 - 1) Chesterton, 1725.
 - 2) John Crane, Inc., equivalent product.
- C. Mechanical seals: Provide seal types specified in the equipment sections and as specified.
 1. Provide seal types meeting the following requirements:
 - a. Balanced hydraulically.
 - b. Spring: Stationary, out of pumping fluid, Hastelloy C; Type Elgiloy or 17-7 PH stainless steel for split seals.
 - c. O-ring: Viton 747.
 - d. Gland: Type 316L stainless steel.
 - e. Set screws: Type 316L stainless steel.
 - f. Faces: Reaction bonded, Silicon Carbide.
 - g. Seal designed to withstand 300 pounds per square inch gauge minimum differential pressures in either direction; no requirement for seal buffer pressure to be maintained when pump is not operational even though process suction head may be present in pump.
 2. Cartridge type single mechanical: Manufacturers: One of the following or equal:
 - a. Chesterton, S10.
 - b. John Crane, 5610 Series.
 3. Cartridge type double mechanical: Manufacturers: One of the following or equal:
 - a. Chesterton, S20.
 - b. John Crane, 5620 Series.

4. Split face single mechanical: Manufacturers: One of the following or equal:
 - a. Chesterton, 442.
 - b. John Crane, 3740.

2.04 GEAR REDUCTION UNITS

- A. Type: Helical or herringbone, unless otherwise specified.
- B. Design:
 1. Made of alloys treated for hardness and for severe service.
 2. AGMA Class II service:
 - a. Use more severe service condition when such is recommended by unit's manufacturer.
 3. Cast iron housing with gears running in oil.
 4. Anti-friction bearings.
 5. Thermal horsepower rating based on maximum horsepower rating of prime mover not actual load.
 6. Manufactured in accordance with applicable AGMA standards.
- C. Planetary gear units are not to be used.

2.05 BELT DRIVES

- A. Sheaves:
 1. Separately mounted on bushings by means of at least 3 pull-up bolts or cap tightening screws.
 2. When 2 sheave sizes are specified, provide separate belts sized for each set of sheaves.
 3. Statically balanced for all; dynamically balanced for sheaves that operate at peripheral speed of more than 5,500 feet per minute.
 4. Key bushings to drive shaft.
- B. Belts: Anti-static type when explosion-proof equipment or environment is specified.
- C. Manufacturers: One of the following or equal:
 1. Dodge, Dyna-V belts with matching Dyna-V sheaves and Taper-Lock bushings.
 2. T.B. Wood's, Ultra-V belts with matching Sure-Grip sheaves and Sure-Grip bushings.

2.06 BEARINGS

- A. Type: Oil or grease lubricated, ball or roller antifriction type, of standard manufacture.
- B. Oil lubricated bearings: Provide either pressure lubricating system or separate oil reservoir splash type system:
 1. Size oil lubrication systems to safely absorb heat energy generated in bearings when equipment is operating under normal conditions and with the temperature 15 degree Fahrenheit above the maximum design temperature as specified in Section 01610.

2. Provide an external oil cooler when required to satisfy the specified operating conditions.
 - a. Provide air cooled system if a water-cooling source is not indicated on the Drawings.
 - b. Equip oil cooler with a filler pipe and external level gauge.
- C. Grease lubricated bearings, except those specified to be factory sealed: Fit with easily accessible grease supply, flush, drain, and relief fittings.
 1. Lubrication lines and fittings:
 - a. Lines: Minimum 1/4-inch diameter stainless steel tubing.
 - b. Multiple fitting assemblies: Mount fittings together in easily accessible location.
 - c. Use standard hydraulic type grease supply fittings:
 - 1) Manufacturers: One of the following or equal:
 - a) Alenite.
 - b) Zerk.
- D. Ratings: Rated in accordance with ABMA 9 or ABMA 11 L₁₀ life for bearings rating life of not less than 50,000 hours:
 1. Higher ratings, when specified in other Sections, supersede preceding requirement.

2.07 SAFETY GUARDS

- A. Drive assemblies: Enclose sprockets, belts, drive chains, gearings, couplings, and other moving parts on drive assemblies in safety enclosures that are in compliance with applicable Laws and Regulations.
- B. Shafts: Provide guards that protect personnel from rotating shafts or components within 7.5 feet of floors or operating platforms.
- C. Hot surfaces: Insulate all surfaces with normal operating temperatures above 120 degrees Fahrenheit when surface is within 7.5 feet height from any operating floor or level; insulation thickness such that temperature is below 120 degrees Fahrenheit; cover insulation with moisture-proof protective jacket; insulation Type 3 and cover Type 5.
- D. Guard requirements:
 1. Allow visual inspection of moving parts without removal.
 2. Allow access to lubrication fittings.
 3. Prevent entrance of rain or dripping water for outdoor locations.
 4. Size belt and sheave guards to allow for installation of sheaves 15 percent larger and addition of 1 belt.
- E. Materials:
 1. Sheet metal: Carbon steel, 12 gauge minimum thickness, hot-dip galvanized after fabrication.
 2. Fasteners: Type 304 stainless steel.

2.08 SPRING VIBRATION ISOLATORS

- A. Design requirements:
 - 1. Telescopic top and bottom housing with vertical stabilizers to resist lateral and vertical forces.
 - 2. Use steel coil springs.
 - 3. Design vibration isolators in accordance with seismic design criteria as specified in Section 01612.
- B. Performance requirements: Minimum spring deflection of [1] [] inch under static load and capable of limiting transmissibility to [10] [15] [] percent maximum at design operating load.
- C. Manufacturers: One of the following or equal:
 - 1. California Dynamics Corporation, Type RJSD.
 - 2. Mason Industries, equivalent product.
- D. Materials:
 - 1. Fabricate isolators using welded steel or shatterproof ductile iron in accordance with ASTM A 536 Grade CS-45-12.
 - 2. Spring steel: ASTM A 125.

2.09 WARNING SIGNS

- A. Provide for equipment that starts automatically or remotely.
- B. Material: Metal.
- C. Colors: Black lettering on yellow background.

2.10 FABRICATION

- A. Structural steel members: As specified in Section 05120.
- B. Nameplates:
 - 1. Engraved or stamped on Type 304 stainless steel and fastened to equipment at factory in an accessible and visible location.
 - 2. Indicate following information as applicable:
 - a. Manufacturer's name.
 - b. Equipment model number and serial number.
 - c. Maximum and Normal rotating speed.
 - d. Horsepower.
 - e. Rated capacity.
 - f. Service class per applicable standards.
 - 3. Nameplates for pumps: Include:
 - a. Rated total dynamic head in feet of fluid.
 - b. Rated flow in gallons per minute.
 - c. Impeller, gear, screw, diaphragm, or piston size.
 - 4. Gear reduction units: Include:
 - a. AGMA Class of service.
 - b. Service factor.
 - c. Input and output speeds.

- C. Bolt holes in equipment support frames:
 - 1. Do not exceed bolt diameter by more than 25 percent, up to limiting maximum diameter oversize of 1/4 inch.
- D. Shop finishing:
 - 1. Provide factory and field coating as specified in Section 09960. If not specified in Section 09960, provide coating as follows:
 - a. Bases and support frames in contact with concrete or other material: Coat contacting surfaces with minimum of 2 coats of zinc chromate primer before installation or grouting.
 - b. Shop primer for steel and iron surfaces, unless specified otherwise:
 - 1) Manufacturers: One of the following or equal:
 - a) Ameron, Amercoat 185 Universal Primer.
 - b) Cook, 391-N-167 Barrier Coat.
 - c) Kop-Coat, Pug Primer.
 - d) Tnemec, 37-77 Chem-Prime.
 - e) Valspar, 13-R-28 Chromox Primer.
 - c. Coat machined, polished, and nonferrous surfaces which are not to be painted with rust-preventive compounds:
 - 1) Manufacturers: One of the following or equal:
 - a) Houghton, Rust Veto 344.
 - b) Rust-Oleum, R-9.
 - d. Coating for ferrous metal surfaces, except stainless steel: High solids polyamine epoxy.
 - e. Finish painting of motors: Shop finish paint with manufacturer's standard coating, unless otherwise specified in Section 09960.

2.11 SOURCE QUALITY CONTROL

- A. As specified in Section 15958 for testing requirements and the individual equipment sections of the Specifications.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Inspect all components for shipping damage, conformance to specifications, and proper torques and tightness of fasteners.

3.02 PREPARATION

- A. Metal work embedded in concrete:
 - 1. Accurately place and hold in correct position while concrete is being placed.
 - 2. Clean surface of metal in contact with concrete immediately before concrete is placed.
- B. Concrete surfaces designated to receive non-shrink grout:
 - 1. Heavy sandblast concrete surface in contact with non-shrink grout.
 - 2. Clean concrete surfaces of sandblasting sand, grease, oil, dirt, and other foreign material that may reduce bond to non-shrink grout.
 - 3. Saturate concrete with water. Concrete shall be saturated surface damp at time non-shrink grout is placed.

- C. Field measurements:
 - 1. Prior to fabrication of equipment, take measurements for installation of equipment and verify dimensions indicated on the Drawings.
 - 2. Ensure equipment and ancillary appurtenances fit within available space.

3.03 INSTALLATION

- A. Install equipment in accordance with manufacturer's installation instructions and recommendations.
- B. Lubrication lines and fittings:
 - 1. Lines from fittings to point of use: Support and protect.
 - 2. Fittings:
 - a. Bring fittings to outside of equipment in manner such that they are readily accessible from outside without necessity of removing covers, plates, housings, or guards.
 - b. Mount fittings together wherever possible using factory-mounted multiple fitting assemblies securely mounted, parallel with equipment lines, and protected from damage.
 - c. Fittings for underwater bearings: Bring fittings above water surface and mount on edge of structure above.
- C. Alignment of drivers and equipment:
 - 1. Where drive motors or other drivers are connected to driven equipment by flexible coupling, disconnect coupling halves and align driver and equipment after complete unit has been leveled on its foundation.
 - 2. Comply with procedures of appropriate HI, AGMA Standards, alignment tolerances of equipment manufacturers and the following requirements to bring components into angular and parallel alignment:
 - a. Maximum total coupling offset (not the per plane offset): Not to exceed 0.5 mils per inch of coupling length for spacer couplings based on coupling length (not dial separation).
 - b. Utilize jacking screws, wedges, or shims as recommended by the equipment manufacturer and as specified in the equipment sections.
 - 3. Use reverse-indicator arrangement dial type or laser type alignment indicators: Mount indicators on the driver/coupling flange and equipment/coupling flange. Alignment instrumentation accuracy shall be sufficient to read angular and radial misalignment at 10 percent or less of the manufacturer's recommended acceptable misalignment.
 - 4. Alignment and calculations shall include measurement and allowance for thermal growth, spacer coupling length, indicator separation, and axial spacing tolerances of the coupling.
 - 5. When alignment satisfies most stringent tolerance of system components, grout between base and foundation.
 - a. Allow minimum 48 hours for grout to harden.
 - b. After grout hardens, remove jacking screws, tighten anchor bolts and other connections, and recheck alignment.
 - c. Correct alignment as required.
 - 6. After operational testing is complete, dowel motor or drivers and driven equipment.
 - a. Comply with manufacturer's instructions.

- D. Special techniques: Use applicable special tools and equipment, including precision machinist levels, dial indicators, and gauges as required in equipment installations.
- E. Tolerances:
 - 1. Completed equipment installations: Comply with requirements for intended use and specified vibration and noise tolerances.
- F. Warning signs: Mount securely with stainless fasteners at equipment that can be started automatically or from remote locations.

3.04 FIELD QUALITY CONTROL

- A. Test equipment as specified in Section 15958 and the individual equipment section of the Specifications.
- B. Perform operational testing as required by Section 01756.

3.05 MANUFACTURER'S REPRESENTATIVE

- A. Field checkout: Before field-testing and start-up, provide services of factory-trained field service representative to certify the equipment has been installed, aligned, and checked in accordance with the manufacturer's instructions and the Specifications.
- B. Testing: Provide services of factory trained representative to observe and advise the Contractor during field quality control testing.
- C. Training: When training is specified, provide services of factory-trained representative to perform training as specified in Section 01756.

END OF SECTION

SECTION 15052

COMMON WORK RESULTS FOR GENERAL PIPING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Basic piping materials and methods.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 09960 - High-Performance Coatings.
 - b. Section 11500 – Membrane Equipment System.
 - c. Section 15061 - Pipe Supports.
 - d. Section 15062 - Preformed Channel Pipe Support System.
 - e. Section 15255 – Stainless Steel Piping and Tubing.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 Through 24.
 - 2. B16.47 - Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard.
- B. American Water Work Association (AWWA):
 - 1. **[C105 – Standard for Polyethylene Encasement for Ductile-Iron Pipe Systems.]**
 - 2. C207 - Standard for Steel Pipe Flanges for Waterworks Services-Size 4 In. Through 144 In.
- C. ASTM International (ASTM):
 - 1. A 193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - 2. A 194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
 - 3. A 307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
 - 4. F 37 - Standard Test Methods for Sealability of Gasket Materials.

1.03 DEFINITIONS

- A. Buried pipe: Pipe that is buried in the soil, or cast in a concrete pipe encasement that is buried in the soil.
- B. Exposed pipe: Pipe that is located above ground, or pipe that is located inside a structure, supported by a structure, or cast into a concrete structure.
- C. Underground piping: Piping actually buried in soil or cast in concrete that is buried in soil.
- D. Underwater piping: Piping below tops of walls in basins or tanks containing water.
- E. Wet wall: Wall with water on at least 1 side.

1.04 SUBMITTALS

- A. Product data:
 - 1. Escutcheons.
 - 2. Flange bolts.
 - 3. Gaskets.
 - 4. Link -type seals.
 - 5. Certifications of compliance with reference standard for lead limits.

PART 2 PRODUCTS

2.01 ESCUTCHEONS

- A. Material: Chrome-plated steel plate.
- B. Manufacturers: One of the following or equal:
 - 1. Dearborn Brass Company, Model Number 5358.
 - 2. Keeney Manufacturing Company, Model Number 102 or Number 105.

2.02 LINK TYPE SEALS

- A. Characteristics:
 - 1. Modular mechanical type, consisting of interlocking neoprene or synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening.
 - 2. Assemble links solely with stainless steel bolts and nuts to form a continuous rubber belt around the pipe.
 - 3. Provide a nylon polymer pressure plate with Type 316 stainless steel hardware. Isolate pressure plate from contact with wall sleeve.
- B. Manufacturers: One of the following or equal:
 - 1. Calpico, Incorporated.
 - 2. Pipeline Seal and Insulator, Inc., Link-Seal.

2.03 FLANGE BOLTS

A. Ductile iron pipe:

1. Bolts and nuts for ductile iron pipe flanges located indoors, outdoors above ground, or in dry vaults and structures and where pressures do not exceed 150 pounds per square inch shall be hot-dip galvanized carbon steel, ASTM A 307, Grade B.
2. Bolts and nuts for ductile iron pipe flanges located indoors, outdoors above ground, or in dry vaults and structures where the pressures exceed 150 pounds per square inch shall be alloy steel, ASTM A 193, Grade B7.
3. Bolts and nuts for ductile iron pipe flanges submerged in water or wastewater, buried, in wet vaults or structures, adjacent to wet walls, or above open water-containing structures shall be Type 316 stainless steel in accordance with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.
4. **[Bolts and nuts for buried ductile iron pipe flanges shall be [Type 316 stainless steel in accordance with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.] [carbon steel bolts in accordance with ASTM A 307, Grade B and encased in 2 layers of loose polyethylene wrap in accordance with AWWA C105.][ASTM A 193, Grade B7 coated with high solids epoxy and encased in 2 layers of loose polyethylene wrap in accordance with AWWA C105.][Hastelloy C.]**
5. Provide a washer for each nut. Washer shall be of the same material as the nut.
6. Nuts shall be Heavy hex-head, Type 2H.
7. Cut and finish flange bolts to project a maximum of 1/4 inch beyond outside face of nut after assembly.
8. Tap holes for cap screws or stud bolts when used.

B. Plastic pipe:

1. Bolts and nuts for flanges on plastic pipe located indoors, outdoors above ground, or in dry vaults and structures shall be hot-dip galvanized carbon steel, in accordance with ASTM A 307, Grade B.
2. Bolts and nuts for flanges on plastic pipe submerged in water or wastewater, buried, in wet vaults or structures, adjacent to wet walls, or above open water-containing structures and plastic pipe carrying corrosive chemicals shall be Type 316 stainless steel in accordance with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.
3. Provide a washer for each nut. Washer shall be of the same material as the nut.
4. Nuts shall be Heavy hex-head.
5. Cut and finish flange bolts to project a maximum of 1/4 inch beyond outside face of nut after assembly.
6. Tap holes for cap screws or stud bolts when used.

C. Steel pipe:

1. Bolts and nuts for ASME B16.5 Class 150 flanges and AWWA C207 Class D flanges located indoors, outdoors above ground, or in dry vaults and structures shall be hot-dip galvanized carbon steel, ASTM A 307, Grade B.
2. Bolts and nuts for ASME B16.5 and B16.47 Class 300 flanges and AWWA C207 Class E and F flanges located indoors, outdoors above ground, or in dry

- vaults and structures in accordance with ASTM A 193, Grade B7 for bolts and in accordance with ASTM A 194, Grade 2H for nuts.
3. Bolts and nuts for flanges submerged in water or wastewater, buried, in wet vaults or structures, adjacent to wet walls, or above open water-containing structures shall be Type 316 stainless steel in accordance with ASTM A 193, Grade B8M for bolts and in accordance with ASTM A 194, Grade 8M for nuts.
 4. Provide a washer for each nut. Washer shall be of the same material as the nut.
 5. Nuts shall be Heavy hex-head, Type 2H.
 6. Cut and finish flange bolts to project a maximum of 1/4 inch beyond outside face of nut after assembly.
 7. Tap holes for cap screws or stud bolts when used.
- D. Lubricant for stainless steel bolts and nuts:
1. Chloride-free.
 2. Manufacturers: One of the following or equal:
 - a. Huskey FG-1800.
 - b. **FILL-IN**

2.04 GASKETS

- A. Gaskets for non-steam cleaned ductile iron and steel piping:
1. Suitable for pressures equal to and less than **[150]** [____] pounds per square inch gauge, temperatures equal to or less than **[250]** [____] degrees Fahrenheit, and raw sewage service.
 2. Gasket material:
 - a. Neoprene elastomer with minimum Shore A hardness value of 70.
 - b. Reinforcement: Inserted 13-ounce nylon fabric cloth for pipes 20 inch or larger.
 - c. Thickness: Minimum 3/32-inch thick for less than 10-inch pipe; minimum 1/8 inch thick for 10-inch and larger pipe.
 3. Manufacturers: One of the following or equal:
 - a. Pipe less than 20 inches in diameter:
 - 1) Garlock, Style 7797.
 - 2) John Crane, similar product.
 - b. Pipe 20 inches in diameter and larger:
 - 1) Garlock, Style 8798.
 - 2) John Crane, similar product.
- B. Gaskets for steam cleaned non glass-lined ductile iron and steel piping:
1. Suitable for pressures equal and less than **[150]** [____] pounds per square inch gauge, temperatures equal or less than **[360]** [____] degrees Fahrenheit, and raw sewage service.
 2. Material:
 - a. Neoprene elastomer, compressed, non-asbestos fiber reinforcement.
 3. Manufacturers: One of the following or equal:
 - a. Garlock, Bluegard 3300.
 - b. John Crane, similar product.

- C. Gaskets for steam cleaned glass lined ductile iron piping:
1. Suitable for pressures equal and less than **[150]** [] pounds per square inch gauge, temperatures equal and less than **[360]** [] degrees Fahrenheit, and sludge service.
 2. Material:
 - a. Teflon gasketing with 1/16-inch sheet thickness each side (1/8 inch total sheet thickness), filled with corrugated or perforated Type 316 stainless steel ring and non-asbestos filler material with minimum 5/16-inch overall thickness.
 3. Manufacturers: One of the following or equal:
 - a. Garlock, Style HP3561.
 - b. John Crane, similar product.
- D. Gaskets for flanged joints in polyvinyl chloride and polyethylene piping:
1. Suitable for pressures equal to or less than **[150]** [] pounds per square inch gauge, with low flange bolt loadings, temperatures equal and less than **[120]** [] degrees Fahrenheit, and polymer, chlorine, caustic solutions, and other chemicals, except chemicals which liberate free fluorine including fluorochemicals and gaseous fluorine.
 2. Material: 0.125-inch thick Viton rubber.
 3. Manufacturers: One of the following or equal:
 - a. Garlock.
 - b. John Crane, similar product.
- E. Gaskets for flanged joints in gas or liquefied petroleum gas piping:
1. Digester gas in stainless steel, or black steel piping: Suitable for pressures equal to or less than **[150]** [] pounds per square inch gauge, temperatures equal to or less than **[200]** [] degrees Fahrenheit, and digester gas and mild acid concentrations.
 2. Chlorine gas application in black steel piping: Suitable for pressures equal to or less than 300 pounds per square inch gauge, temperatures equal to or less than 100 degrees Fahrenheit, and chlorine gas application.
 3. Liquefied petroleum, propane, and natural gas applications in black steel piping: Suitable for pressures equal to or less than **[250]** [] pounds per square inch gauge, temperatures equal to or less than **[100]** [] degrees Fahrenheit, and liquefied petroleum gas, propane gas, and natural gas application.
 4. Material:
 - a. Microcellular Teflon outer layers with rigid center layer.
 - b. Sealability in accordance with ASTM F 37, less than 0.55 millimeters per hour leakage of iso-octane at 1,000 pounds per square inch gasket load and 9.8 pounds per square inch fluid pressure.
 5. Manufacturers: One of the following or equal:
 - a. Garlock, Style 3545.
 - b. John Crane, similar product.
- F. Gaskets for flanged joints in low pressure air piping:
1. Suitable for pressures equal to or less than **[150]** [] pounds per square inch gauge, temperatures equal to or less than **[300]** [] degrees Fahrenheit, and compressed air service.
 2. Material: EPDM elastomer, 1/8 inch thick, 60 Shore hardness, smooth surface.

3. Manufacturers: One of the following or equal:
 - a. Garlock, Style 8314.
 - b. John Crane, similar product.
- G. Gaskets for flanged joints in ductile iron or steel water piping:
 1. Suitable for hot or cold water, pressures equal to or less than 150 pounds per square inch gauge, and temperatures equal to or less than 160 degrees Fahrenheit.
 2. Material:
 - a. Neoprene elastomer, compressed, with non-asbestos fiber reinforcement.
 - b. **[Teflon ring; or Teflon envelope with non-asbestos filler.]**
 3. Manufacturers: One of the following or equal:
 - a. Garlock, Bluegard 3300.
 - b. John Crane, similar product.
- H. Provide gaskets suitable for the specific fluids and pressure and temperature conditions.

PART 3 EXECUTION

3.01 INSTALLATION

- A. General:
 1. Piping drawings: Supplier shall be responsible to design and coordinate layout of process piping required to interconnect all the process equipment associated with each train. Installation by Contractor.
 2. Piping alternatives:
 - a. Provide piping as specified in this Section, unless indicated on the Drawings or specified otherwise.
 - b. Alternative pipe ratings:
 - 1) Piping with greater pressure rating than specified may be substituted in lieu of specified piping without changes to the Contract Price.
 - 2) Piping of different material may not be substituted in lieu of specified piping.
 - c. Valves in piping sections: Capable of withstanding specified test pressures for piping sections and fabricated with ends to fit piping.
 - d. For flanged joints, where 1 of the joining flanges is raised face type, provide a matching raised face type flange for the other joining flange.
 3. Unless otherwise indicated on the Drawings, piping at pipe joints, fittings, couplings, and equipment shall be installed without rotation, angular deflection, vertical offset, or horizontal offset.
- B. Exposed piping:
 1. Install exposed piping in straight runs parallel to the axes of structures, unless otherwise indicated on the Drawings:
 - a. Install piping runs plumb and level, unless otherwise indicated on the Drawings.
 - 1) Slope plumbing drain piping with a minimum of 1/4 inch per foot downward in the direction of flow.
 2. Install exposed piping after installing equipment and after piping and fitting locations have been determined.

3. Support piping: As specified in Sections 15061 and 15062:
 - a. Do not transfer pipe loads and strain to equipment.
 4. In addition to the joints, provide unions, flexible couplings, flanged joints, flanged coupling adapters, and other types of joints or means which are compatible with and suitable for the piping system, and necessary to allow ready assembly and disassembly of the piping.
 5. Assemble piping without distortion or stresses caused by misalignment:
 - a. Match and properly orient flanges, unions, flexible couplings, and other connections.
 - b. Do not subject piping to bending or other undue stresses when fitting piping.
 - c. Do not correct defective orientation or alignment by distorting flanged joints or subjecting flange bolts to bending or other undue stresses.
 - d. Flange bolts, union halves, flexible connectors, and other connection elements shall slip freely into place.
 - e. Alter piping assembly to fit, when proper fit is not obtained.
 - f. Install eccentric reducers or increasers with the top horizontal for pump suction piping.
- C. Venting piping under pressure:
1. Lay piping under pressure flat or at a continuous slope without air traps, unless otherwise indicated on the Drawings.
 2. Install plug valves as air bleeder cocks at high points in piping.
 - a. Provide 1-inch plug valves for water lines, and 2-inch plug valves for sewage and sludge lines, unless otherwise indicated on the Drawings.
 3. Provide additional pipe taps with plug cocks and riser pipes along piping as required for venting during initial filling, disinfecting, and sampling.
 4. Before piping is placed into service, close plug valves and install plugs. Protect plugs and plug valves from corrosion in as specified in Section 09960.
- D. Restraining piping:
1. Restrain piping at valves and at fittings where piping changes direction, changes sizes, and at ends:
 - a. When piping is underground, use concrete thrust blocks, mechanical restraints, or push-on restraints.
 - b. When piping is aboveground or underwater, use mechanical or structural restraints.
 - c. Determine thrust forces by multiplying the nominal cross sectional area of the piping by design test pressure of the piping.
 2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
 - a. During testing, provide suitable temporary restraints where piping does not require permanent restraints.
 3. Place concrete thrust blocks against undisturbed soil.
 4. Place concrete so piping joints, fittings, and other appurtenances are accessible for assembly and disassembly.
 5. Provide underground mechanical restraints where specified in the Piping Schedule.

- E. Connections between ferrous and nonferrous metals:
 - 1. Connect ferrous and nonferrous metal piping, tubing, and fittings with dielectric couplings especially designed for the prevention of chemical reactions between dissimilar metals.
 - 2. Nonferrous metals include aluminum, copper, and copper alloys.
- F. Flanged connections between dissimilar metals such as ductile iron pipe and steel pipe:
 - 1. Provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

3.02 PIPING SCHEDULE

PIPING SCHEDULE											
Process Abbrev.	Service	Nominal Diameter (inches)	Material	Pressure Class Special Thickness Class Schedule Wall Thickness	Pipe Spec. Section	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Service Conditions	Comments
AA	Aeration Air										
	Aboveground - Over Membrane Basins	4-14	Type 304L SST	SCH 10S	15286	WLD or FL, FL where shown	15 psig/AM	None	None		
Chemical I	Chemical (Citric Acid, Hypochlorite, Sulfuric Acid)	0.5 – 3	PVC	SCH 80	15230	SW	125 psig/HH	None	EPP		
CD	Chemical Drain										
	Underground	1-6	PVC	SCH 80	15230	SW	50 psig/HH	None	None		
	Aboveground	1-6	PVC	SCH 80	15230	SW	50 psig/HH	None	EPP		
CHA	Channel Air										
	Underwater	3 and Less	Type 304L SST	SCH 10S	15286	WLD	15 psig/AM	None	None		
	Aboveground - External Wall Membrane Basins and Blower Building Interior and Exterior	3-4	Steel			WLD or FL, FL where shown	20 psig/AM	None	EPP		
	Aboveground-Over Membrane Basins	2-4	Type 304L SST	SCH 10S	15286	WLD or FL, FL where shown	15 psig/AM	None	None		
HPA	High Pressure Air	0.50-2	BSP	SCH 40		SCRD or FL or GE	45 psig/HH	None	EPP		

PIPING SCHEDULE											
Process Abbrev.	Service	Nominal Diameter (inches)	Material	Pressure Class Special Thickness Class Schedule Wall Thickness	Pipe Spec. Section	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Service Conditions	Comments
ML	Mixed Liquor										
	Underground	36-54	Steel			WLD or FL	20 psig/LH	CM	PTW		
PM	Permeate										
	Aboveground – Over Membrane Basins	4 – 12	Type 304L SST	SCH 10S	15286	WLD or FL	15 psig/AM	None	None		
2W	Non-Potable Water										
	Underground	1-3	PVC	SCH 80	15230	SW	125 psig /HH	None	None		
		4-10	DIP	150	15211	Mech Rest. MJ	125 psig/HH	CM	2 layers PEE		
	Aboveground	0.5-3	PVC	SCH 80	15230	SW	125 psig /HH	None	EPP		
3W	Reclaimed Water										
	Underground	1-3	PVC	SCH 80	15230	SW	200 v/HH	None	None		
		4-12	DIP	150	15211	Mech Rest. MJ	200 psig/HH	CM	2 layers PEE		
	Aboveground	0.5-3	PVC	SCH 80	15230	SW	200 psig /HH	None	EPP		
		4-12	DIP	CL 53	15211	FL	200 psig /HH	CM	EPP		

PIPING SCHEDULE											
Process Abbrev.	Service	Nominal Diameter (inches)	Material	Pressure Class Special Thickness Class Schedule Wall Thickness	Pipe Spec. Section	Joints/ Fittings	Test Pressure/ Method	Lining	Coating	Service Conditions	Comments
Abbreviations: 1. The following abbreviations used in the column of test method refer to the respective methods as specified in Section 15956. AM Air method GR Gravity method HH High head method LH Low head method SC Special case 2. Abbreviations to designate piping include the following: B&SP Bell and spigot CI Cast iron CISP Cast iron soil pipe CL Class, followed by the designation CM Cement mortar CTP Coal tar pitch DIP Ductile iron piping EPP Epoxy polyurethane coating FLFlange GA Gauge, preceded by the designation						GE Grooved end joint GL Glass lined GSP Galvanized steel pipe MJ Mechanical joint NPS Nominal pipe size, followed by the number in inches psi pounds per square inch psig pounds per square inch gauge PE Polyethylene PEE Polyethylene encasement PTW Polyethylene tape wrap PVC Polyvinyl Chloride SCH Schedule, followed by the designation SCRD Screwed-On SST Stainless steel SW Solvent welded VCP Vitrified clay piping WLD Weld					

END OF SECTION

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SECTION 15061

PIPE SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Supports for pipe, fittings, valves, and appurtenances.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01410 - Regulatory Requirements.
 - b. Section 01612 – Seismic Design Requirements.
 - c. Section 05120 - Structural Steel.
 - d. Section 09960 - High-Performance Coatings.

1.02 REFERENCES

- A. ASTM International (ASTM):
 - 1. A 123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 2. A 380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
 - 3. A 967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
- B. Manufacturer's Standardization Society (MSS):
 - 1. SP-58 - Pipe Hangers and Supports - Materials, Design, and Manufacture.
 - 2. SP-69 – Pipe Hangers and Supports – Selection and Application.

1.03 SUBMITTALS

- A. Shop drawings: Include schedule, indicating where supports will be installed, and drawings of pipe support system components.
- B. Calculations and other information to substantiate supports meet minimum design strength requirements and can withstand seismic loads as specified in Section 01612.

PART 2 PRODUCTS

2.01 MATERIALS

- A. General:
 - 1. Hot dip galvanized:
 - a. Fabricate as specified in Section 05120.
 - b. Hot dip after fabrication of support in accordance with ASTM A 123.
 - c. Repair galvanized surface as specified in Section 05120.
 - 2. Stainless steel.
 - a. Fabricate as specified in Section 05120.
 - b. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.
 - c. At the shop, perform pickling and passivation on all surfaces inside and out in accordance with ASTM A 380 or A 967.
 - 1) Passivation treatments using citric acid are not allowed.
 - d. Field welding is prohibited unless specifically allowed by the Owner. All field welds shall be passivated.
- B. Indoor areas: Areas exposed to an indoor environment including galleries and tunnels:
 - 1. **[Type 304 Stainless Steel] [Type 304L Stainless Steel] [Type 316 Stainless Steel] [Type 316L Stainless Steel][Hot Dip Galvanized].**
- C. Submerged, 3 feet or less above water level in a structure, or inside a water bearing structure:
 - 1. **[Type 304 Stainless Steel] [Type 304L Stainless Steel] [Type 316 Stainless Steel] [Type 316L Stainless Steel].**
- D. Stainless steel piping system:
 - 1. **[Type 304 Stainless Steel] [Type 304L Stainless Steel] [Type 316 Stainless Steel] [Type 316L Stainless Steel].**
- E. Chemical containment areas and chemical piping:
 - 1. **[Type 304 Stainless Steel] [Type 304L Stainless Steel] [Type 316 Stainless Steel] [Type 316L Stainless Steel].**
- F. Fasteners:
 - 1. As specified in Section 05120.

2.02 PIPE SUPPORTS

- A. Hanger rods: Sized to match suspended pipe hanger:
 - 1. Manufacturers: One of following or equal:
 - a. For stainless steel piping:
 - 1) Bergen-Power, Figure 133.
 - 2) Nibco-Tolco, Figure 103.
 - b. For all other piping:
 - 1) Anvil International, Figure 140.
 - 2) Bergen-Power, Figure 133.
 - 3) Cooper B-Line Systems, Inc., Figure B3205.

- B. Hanger rods, continuously threaded: Sized to match suspended pipe hanger:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Bergen-Power, Figure 94.
 - 2) FM Stainless Fasteners.
 - b. For steel and ductile iron piping:
 - 1) Anvil International, Figure 146.
 - 2) Bergen-Power, Figure 94.
- C. Eye bolts:
 - 1. For stainless steel piping:
 - a. Type 316 stainless steel, welded and rated equal to full load capacity of rod.
 - 2. For all other piping:
 - a. Welded and rated equal to full load capacity of rod.
- D. Welded eyebolt rod:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 101.
 - 2) FM Stainless Fasteners.
 - b. For all other piping:
 - 1) Anvil International, Figure 278.
 - 2) Bergen-Power, Figure 93.
 - 3) Cooper B-Line Systems, Inc., Figure B3210.
- E. Adjustable ring hangers: MSS SP-58, Type 7 or Type 9 (system dependent):
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 1C.I.
 - 2) Bergen-Power, Figure 100SS.
 - b. For all other piping:
 - 1) Anvil International, Figure 97.
 - 2) Cooper B-Line Systems, Inc., Figure B3172.
- F. Adjustable clevis hangers: MSS SP-58, Type 1:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Cooper B-Line Systems, Inc, Figure B3100 or B3102.
 - 2) FM Stainless Fasteners, Figure 60.
 - b. For all other piping:
 - 1) Anvil International, Figure 260 or Figure 590.
 - 2) Bergen-Power, Figure 100.
 - 3) Cooper B-Line Systems, Inc., Figure B3100 or B3102.
- G. Adjustable clevis hangers for insulated pipe: Oversize:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 1A.
 - b. For all other piping:
 - 1) Anvil International, Figure 300.
 - 2) Bergen-Power, Figure 100EL.

- 3) Cooper B-Line Systems, Inc. Figure B3108.
- H. Single rod hangers for steam pipe: MSS SP-58, Type 43; malleable iron or steel yoke and roller hangers; swivel to allow rotation of yoke on rod:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 324.
 - 2) Cooper B-Line Systems, Inc., Figure B3110.
 - 3) FM Fasteners, Figure 81.
 - b. For all other piping:
 - 1) Anvil International, Figure 181.
 - 2) Cooper B-Line Systems, Inc., Figure B3110.
- I. Double rod hangers for steam pipe: MSS SP-58, Type 41:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) FM Stainless Fasteners, Figure 71.
 - b. For all other piping:
 - 1) Anvil International, Figure 171.
 - 2) Cooper B-Line Systems, Inc., Figure B3114.
- J. Brackets: MSS SP-58, Type 32 with back plate; rated for 1,500 pounds:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 30M.
 - 2) Cooper B-Line Systems, Inc., Figure B3066.
 - 3) FM Stainless Fasteners, Figure 98.
 - b. For all other piping:
 - 1) Anvil International, Figure 195.
 - 2) Cooper B-Line Systems, Inc., Figure B3066.
- K. Standard U-bolt: MSS SP-58, Type 24:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 110.
 - 2) Cooper B-Line Systems, Inc., Figure B3188.
 - 3) FM Stainless Fasteners, Figure 37.
 - b. For all other piping:
 - 1) Anvil International, Figure 137.
 - 2) Bergen-Power, Figure 283.
 - 3) Cooper B-Line Systems, Inc., Figure B3188.
- L. Riser clamps: MSS SP-58, Type 8:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Cooper B-Line Systems, Inc., Figure B3373.
 - 2) FM Stainless Fasteners, Figure 61.
 - b. For all other piping:
 - 1) Anvil International, Figure 261.
 - 2) Bergen-Power, Figure 126.
 - 3) Cooper B-Line Systems, Inc., Figure B3373.

- M. Pipe clamps: MSS SP-58, Type 4:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 4.
 - 2) Cooper B-Line Systems, Inc., Figure 3140.
 - b. For all other piping:
 - 1) Anvil International, Figure 212.
 - 2) Bergen-Power, Figure 175.
 - 3) Cooper B-Line Systems, Inc., Figure B3140.
- N. Adjustable offset pipe clamp:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 4.
 - 2) Cooper B-Line Systems, Inc., Figure B3149.
 - 3) FM Stainless Fasteners, Figure 63.
 - b. For all other piping:
 - 1) Anvil International, Figure 100.
 - 2) Cooper B-Line Systems, Inc., Figure B3149.
- O. Offset pipe clamp:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 8.
 - 2) Cooper B-Line Systems, Inc., Figure 3148.
 - b. For all other piping:
 - 1) Anvil International, Figure 103.
 - 2) Cooper B-Line Systems, Inc., Figure B3148.
- P. Floor stand or stanchion saddles: MSS SP-58, Type 37. Provided with U-bolt hold down yokes:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 318.
 - 2) FM Stainless Fasteners, Figure 59.
 - b. For all other piping:
 - 1) Anvil International, Figure 259.
 - 2) Bergen-Power, Figure 125.
 - 3) Cooper B-Line Systems, Inc., Figure B3090.
 - b. Threaded pipe stand support stanchion. Match pipe support material.
 - 1) Anvil International, Figure 63T.
 - 2) Bergen Power, (None found)
 - 3) Cooper B-Line Systems Inc., Figure B3088ST
- Q. Spring hangers:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Bergen-Power, Figure 920.
 - b. For all other piping:
 - 1) Anvil International, Figure B-268, Type G.
 - 2) Bergen-Power, Figure 920.

- R. Welded beam attachment: MSS SP-58, Type 22:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 304.
 - 2) Cooper B-Line Systems, Inc., Figure 3083.
 - b. For all other piping:
 - 1) Anvil International, Figure 66.
 - 2) Bergen-Power, Figure 113A or 113B.
 - 3) Cooper B-Line Systems, Inc., Figure B3083.
- S. Heavy pipe clamp: MSS SP-58, Type 4:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 4H.
 - b. For all other piping, unless called out otherwise on the Drawings:
 - 1) Anvil International, Figure 216.
 - 2) Bergen-Power, Figure 298.
- T. PTFE pipe slide assembly: MSS SP-58, Type 35 with lateral and vertical restraint:
 - 1. Manufacturers: One of the following or equal:
 - a. For stainless steel piping:
 - 1) Nibco-Tolco, Figure 426.
 - b. For all other piping:
 - 1) Anvil International, Figure 257, Type 3.
 - 2) Cooper B-Line Systems, Inc., Figure B3893.
- U. Anchor bolts, concrete anchors, concrete inserts, powder-actuated fasteners, and sleeve anchors: As specified in Section 05120.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Properly support, suspend, or anchor exposed pipe, fittings, valves, and appurtenances to prevent sagging, overstressing, or movement of piping; and to prevent thrusts or loads on or against connected pumps, blowers, and other equipment.
- B. Field verify support location, orientation, and configuration to eliminate interferences prior to fabrication of supports.
- C. Carefully determine locations of inserts. Anchor to formwork prior to placing concrete.
- D. Use flush shells only where indicated on the Drawings.
- E. Do not use anchors relying on deformation of lead alloy.
- F. Do not use powder-actuated fasteners for securing metallic conduit or steel pipe larger than 1 inch to concrete, masonry, or wood.
- G. Suspend pipe hangers from hanger rods and secure with double nuts.

- H. Install continuously threaded hanger rods only where indicated on the Drawings.
- I. Use adjustable ring hangers or adjustable clevis hangers, for 4 inch and smaller diameter pipe.
- J. Use adjustable clevis hangers for pipe larger than 4 inches in diameter.
- K. Secure pipes with double nutted U-bolts or suspend pipes from hanger rods and hangers.
 - 1. For stainless steel piping, use stainless steel U-bolts.
 - 2. For all other piping, use galvanized U-bolts.
- L. Support spacing:
 - 1. Support 2-inch and smaller piping on horizontal and vertical runs at maximum 5 feet on center, unless otherwise specified.
 - 2. Support larger than 2-inch piping on horizontal and vertical runs at maximum 10 feet on center, unless otherwise specified.
 - 3. Support exposed polyvinyl chloride and other plastic pipes at maximum 5 feet on center, regardless of size.
 - 4. Support tubing, PVC pipe 1-inch and smaller, copper pipe and tubing, fiber-reinforced plastic pipe or duct, and rubber hose and tubing at intervals close enough to prevent sagging greater than 1/4 inch between supports.
 - 5. Do not suspend or support valves, pipe and fittings from another pipe or conduit.
- M. Install supports at:
 - 1. Any change in direction.
 - 2. Horizontal bends.
 - 3. Both sides of flexible pipe connections.
 - 4. Base of risers.
 - 5. Floor penetrations.
 - 6. Connections to pumps, blowers, and other equipment.
 - 7. Valves and appurtenances.
- N. Securely anchor plastic pipe, valves, and headers to prevent movement during operation of valves.
- O. Anchor plastic pipe between expansion loops and direction changes to prevent axial movement through anchors.
- P. Provide elbows or tees supported from floors with base fittings where indicated on the Drawings.
- Q. Support base fittings with metal supports or when indicated on the Drawings support on concrete piers.
- R. Do not use chains, plumbers' straps, wire, or similar devices for permanently suspending, supporting, or restraining pipes.
- S. Support plumbing drainage and vents in accordance with plumbing code as specified in Section 01410.

- T. Supports, clamps, brackets, and portions of support system bearing against copper pipe: Copper plated, copper throughout, or isolated with neoprene or polyvinyl chloride tape.
- U. Where pipe is insulated, install over-sized supports and hangers.
- V. Install insulation shield in accordance with MSS SP-58, Type 40. Shield shall be galvanized steel unless otherwise specified or indicated on the Drawings.
- W. Install riser clamps at floor penetrations and where indicated on the Drawings.
- X. Coat support system components as specified in Section 09960.

END OF SECTION

SECTION 15062

PREFORMED CHANNEL PIPE SUPPORT SYSTEM

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Preformed channel pipe support system consisting of preformed channels, fittings, straps, and fasteners engineered to support piping.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 01612 - Seismic Design Criteria.

1.02 REFERENCES

- A. American Institute of Steel Construction (AISC).
- B. American Iron and Steel Institute (AISI).
- C. Manufacturer's Standardization Society (MSS):
 - 1. SP-58 - Pipe Hangers and Supports - Materials, Design, and Manufacture.
 - 2. SP-69 - Pipe Hangers and Supports - Selection and Application.

1.03 SYSTEM DESCRIPTION

- A. Design responsibility:
 - 1. The manufacturer of the preformed channel pipe support system is responsible for the design of the support system.
 - 2. Prepare design calculations utilizing the design criteria included in these Specifications.
 - 3. Prepare detailed shop drawings illustrating the layout of the support system and identifying the components of the support system.
- B. Design criteria:
 - 1. Include live, dead, and seismic loads associated with piping, valves, and appurtenances. Consider the content of the pipes in load calculations.
 - 2. Minimum gauge thickness: 12-gauge.
 - 3. Allowable stress of channels:
 - a. Steel channels: The lesser of 25,000 pounds per square inch, or 0.66 times yield stress of steel.

- b. Stainless steel channels: 0.66 times the yield stress of the stainless steel alloy.
 - 4. Maximum deflection: 1/240 of span.
 - 5. Allowable column loads: As recommended by manufacturer in published instruction for column's unsupported height and "K" value for calculating effective column length of not less than 1.0.
 - 6. Future loads:
 - a. Support systems may include spaces intended to accommodate future pipes.
 - b. Assume such spaces are occupied by 6-inch diameter ductile iron pipes. Only the number of pipes that would physically fit into the space need be considered.
 - c. Include the weight of the pipe contents in determining future loads. Assume pipe contents are water.
 - 7. Seismic design criteria: As specified in Section 01612 as specified for mechanical equipment.
 - 8. Spacing of supports: As required to comply with design requirements but not more than 5 feet.
- C. Supports below the top of walls of water bearing structures: Use Type 316 stainless steel for support system components.
 - 1. Supports in other locations: Use hot-dipped galvanized components unless other materials are specifically as required by membrane Supplier.

1.04 SUBMITTALS

- A. Submit as specified in Section 01330.
- B. Shop drawings: Include layout of support system including pipe loads, selected channel size, fittings, and appurtenances.
- C. Structural design calculations.

1.05 QUALITY ASSURANCE

- A. Design preformed channel pipe support system for loads in accordance with applicable provisions of:
 - 1. AISC Manual of Steel Construction.
 - 2. AISI Cold-Formed Steel Design Manual.
- B. Product standards:
 - 1. Pipe support components: In accordance with MSS SP-69.
 - 2. Pipe support materials: In accordance with MSS SP-58.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Fabricate preformed channel pipe support system using, as a minimum, parts specified below and meeting the requirements specified under Design Criteria.
 - 1. Manufacturers: One of the following or equal:
 - a. Unistrut, Series P1000 or P1001; P5500 or P5501.

- b. Allied Support Systems, Power Strut, Figure PS-200 or PS-200 2TS; PS-150 or PS-150 2TS.
- c. Cooper B-Line, Channel Type B22 or B22A; B12 or B12A.

2.02 ACCESSORIES

- A. Preformed channel concrete inserts: Minimum 12 inches long.
 - 1. Manufacturers: One of the following or equal:
 - a. Unistrut, Series P-3200.
 - b. Allied Support Systems, Figure 282.
 - c. Cooper B-Line, Series B321.
- B. 90-degree angle fittings:
 - 1. Manufacturers: One of the following or equal:
 - a. Unistrut, P1026.
 - b. Allied Support Systems, Power Strut, P603.
- C. Pipe straps:
 - 1. For pipes 8 inches in diameter and smaller: Use 2-piece universal strap with slotted hex head screw and nut.
 - a. Manufacturers: One of the following or equal:
 - 1) Unistrut, Series P1109 through P1126.
 - 2) Allied Support Systems, PS1100.
 - 3) Cooper B-Line, Series B2000.
 - 2. For pipes greater than 8 inches in diameter: Unless different material is otherwise required by membrane Supplier, use 1-piece 1 inch wide by 1/8 inch thick steel strap, hot-dip galvanized after fabrication.
 - 3. For stainless steel pipes: Use type of strap required for the pipe sizes specified above, but use Type 316 stainless steel materials.
- D. Touch-up paint galvanized surfaces:
 - 1. Manufacturers: One of the following or equal:
 - a. Galvinox, Galvo-Weld.
- E. Touch-up paint for painted surfaces: Same formulation as factory paint.

2.03 FABRICATION

- A. Hot-dip galvanize support system components after fabrication to required length and shape.
- B. Do not galvanize or paint stainless steel components.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Support system for piping supplied by Supplier shall be designed by Supplier and installed by Contractor.
- B. Install preformed channel concrete inserts for vertical support, quantity based on manufacturer's structural design calculations.

- C. Fasten preformed channel pipe supports to existing walls using Z-fittings and concrete anchors as required by membrane Supplier.
- D. Fasten preformed channel pipe supports to preformed channel concrete inserts embedded in ceiling using U-shaped fittings.
- E. Suspend threaded rods from concrete inserts embedded in ceiling. Support preformed channel pipe supports with threaded rods.
- F. Touchup cut or damaged galvanized surfaces.
- G. Prevent contact between pipes and support components of dissimilar metals. Utilize rubber coated, plastic coated, or vinyl coated components, stainless steel components, or wrap pipe with PVC or polyethylene tape.
- H. Install support as near as possible to concentrated loads.
- I. Install support within 2 feet of horizontal and vertical changes in pipe alignment.
- J. Adjust supports or install shims to obtain specified slope or elevation.

END OF SECTION

SECTION 15100

VALVES

PART 1 GENERAL

1.01 DESCRIPTION

- A. Description of Work:
 - 1. Membrane Equipment Package Systems SUPPLIER shall provide all required control valves for piping and equipment as specified and required.
- B. Related Work Specified Elsewhere:
 - 1. Section 11500 - Membrane Equipment Package Systems.

1.02 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer(s) of the valves furnished under this Section shall have experience in providing similar type of valves and shall show evidence with his submittal of at least 10 installations where the valves of the same material and same application of the type specified herein have been in satisfactory operation for at least 5 years. All valves of the same type shall each be the product of 1 manufacturer.
- B. Reference Standards:
 - 1. American National Standards Institute (ANSI).
 - 2. ASTM International (ASTM):
 - a. A 126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
 - b. A 240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 - c. A 276 - Standard Specification for Stainless Steel Bars and Shapes.
 - d. A 351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
 - e. A 743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
 - f. B 30 - Standard Specification for Copper Alloys in Ingot Form.
 - g. B 584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
 - h. D 1418 - Standard Practice for Rubber and Rubber Latexes-Nomenclature.
 - 3. CSA International (CSA).
 - 4. National Electrical Manufacturer's Association (NEMA).
 - 5. Underwriters Laboratories, Inc. (UL).
- C. Design Criteria:
 - 1. The MFEM shall submit for approval the materials to meet the design conditions. Materials of all piping, valves, and appurtenances shall be compatible with the intended use and service.

1.03 SUBMITTALS

- A. Submit for approval with shop drawings required under Section 11500, Membrane Equipment Package Systems:
 - 1. Submit detailed drawings and data for valves.
 - 2. For electric and pneumatically actuated valves, prepare and submit a table of the torque requirements for the valve and the corresponding valve actuator to demonstrate that the valve actuator has been properly sized and will satisfy the minimum torque requirements.
- B. Certificates: Submit Certificates of Compliance with applicable referenced standards. Furthermore, the valve manufacturer and actuator manufacturer of the pneumatic actuated valve shall certify that the proposed valve are design and suitable for the intended purpose and are designed to open and close on a 10-sec cycle interval.
- C. Technical Manuals: Complete operation and maintenance instruction, lubrication schedules and troubleshooting guides shall be submitted for review in accordance with the procedures and requirements set forth in Division 1.
- D. For all tagged devices supplied, the SUPPLIER shall develop an "Equipment Cross Reference Schedule" that matches the Tag to the appropriate equipment manual. The equipment schedule shall include the pertinent information associated with the equipment including tag number, description, functional name location, component equipment model, part number, size, materials, accessories and range. The equipment cross-reference schedule shall be provided in the form of a Microsoft Excel (.XLS) Spreadsheet.

1.04 MAINTENANCE

- A. Special Tools: Deliver 1 set for each furnished valve and actuator type and size needed to safely assemble and disassemble valve and actuator assembly.
- B. Spare Parts: Deliver the following as specified in Section 01600:
 - 1. 1 set of seals and o-rings for each valve model.
 - 2. 10 spare valves pneumatic actuators.
 - 3. 1 set of special tools.

PART 2 PRODUCTS

2.01 VALVE DESIGN AND FABRICATION

- A. General:
 - 1. All valves shall have manufacturer's name and working pressure cast in raised lettering on valve body.
 - 2. All manual valve operators shall open counter-clockwise.
 - 3. All bolts, nuts and studs on valves shall be of Type 316 stainless steel.
 - 4. Bolts and nuts shall have hexagon heads.
 - 5. Gasket material and installation shall conform to valve manufacturer's recommendations.
 - 6. Unless otherwise shown or otherwise specified, all flanged valves shall have ends conforming to ANSI Class 125/150 flange.

7. Valve Tags: Each type of valve shall be provided with a tag as indicated in the Equipment Cross Reference Schedule. Tags shall be mounted to valve attachments.
8. Valve shall be capable of being installed with valve disc in the closed or any intermediate position without leading to valve or seat failure.
9. Not all valves listed herein may be required under this Contract. Refer to the Drawings for valve numbers and locations. Valves shall be of the type specified herein and as indicated on the Drawings. All valves of the same type shall be of the same make. Valves shall be in-line size except as indicated otherwise on the Drawings or otherwise specified. Ratings specified are minimum, and are water working pressure unless noted otherwise or otherwise specified.
10. Seats and Seals: Unless otherwise specified, provide valves with the following seats and seals:
 - a. Clean Water Service: EPDM.
 - b. Process Air: Fluorocarbon (Viton, RTFE, or Fluorinated Hydrocarbon Elastomer ASTM D 1418) rated for 350 degrees minimum or higher if required by process.
 - c. Waste Water Service: Buna-N.

2.02 STAINLESS THREE-PIECE BALL VALVES:

1. Service conditions:
 - a. General Service manual and automated isolation.
2. Design:
 - a. Full port 3-piece design (1/4 inch to 4 inches):
 - 1) Body: Type 316 stainless steel.
 - 2) Sets: reinforced PTFE.
 - 3) End connection: NPT.
 - 4) Stem seal: Adjustable reinforced PTFE.
 - 5) Ball and stem: Type 316 stainless steel. Stem shall be internal entry, blowout proof design.
 - 6) All body castings shall be marked with foundry heat number for full traceability. Actuator attachment shall be by integral mounting surface as part of the valve center section to eliminate the use of pressure-containing body bolts for actuator mounting. Dimension and design as per ISO-5211. Manual lever-handle shall be stainless steel with vinyl grip and locking capabilities. Valve shall be designed, manufactured and tested to meet applicable industry standards; such as: ANSI, ASME, MSS, ISO (as required).
3. Valves shall be Series 5000 Three Piece Ball Valves as manufactured by Flow-Tek or approved equal.

2.03 METAL BODY BALL VALVES, LESS THAN 6 INCH SIZE

- A. Manufacturers: One of the following, or equal:
 1. Apollo Valves as manufactured by Conbraco Industries, Inc.
 2. Metso Automation/Jamesbury.
 3. NIBCO, Inc.
- B. General:
 1. Type: Non-lubricated and capable of sealing in either direction.

2. End Connections:
 - a. Threaded or solder ends for sizes 3-inch and smaller.
 - b. Class 150 flanged for sizes larger than 3 inch. Flanges shall conform to ASME B16.1 standards.
 3. Stem Packing: Manually adjustable while valve is under pressure.
 4. Shafts: Rigidly connected to the ball by a positive means. The connection shall be designed to transmit torque equivalent to at least 75 percent of the torsional strength of the shaft.
 5. Handles: Stainless steel latch lock handle with vinyl grip and stainless steel nut designed to open and close the valve under operating conditions.
 6. Temperature Limits: Suitable for operation between minus 20 and 350 degrees Fahrenheit.
- C. Materials:
1. Valves in Copper Lines: Bronze body.
 2. Valves in Steel and Ductile Iron Piping: Ductile iron or cast steel body.
 3. Valves in Stainless Steel Piping: Stainless Steel body, material type to match piping material specified in Section 15052.
 4. Ball: Type 304 or 316 stainless steel, Type 316 in digester gas applications.
 5. Seats: TFE.
 6. Stem Seals: TFE or Viton.
 7. Bearings: Self-lubricated, corrosion resistant material that will not contaminate potable water.
 8. Valves for combustible fluid applications (digester gas, natural gas, fuel oil, etc.) shall be of fire safe design.

2.04 PLASTIC BODY BALL VALVES

- A. Manufacturers: One of the following or equal:
1. Asahi America.
 2. Chemtrol Division, NIBCO, Inc.
- B. General:
1. Type: Non-lubricated and capable of sealing in either flow direction.
 2. End Connections: True union; solvent or heat welded to piping.
 3. Operator Handle: Lever.
- C. Materials:
1. Body: Polyvinyl chloride (PVC).
 2. Ball: Polyvinyl chloride (PVC).
 3. Seats: TFE (Teflon).
 4. O-rings: FKM (Viton).

2.05 RESILIENT SEATED BUTTERFLY VALVES

- A. Service conditions: General Service/Chlorine/Citric Acid/Sulfuric Acid (Siemens only) solution manual and automated isolation:
- B. Design:
1. Butterfly Valves in sizes 2 to 20 inch shall be of the single flange, lug body style. All valves shall be suitable for use with ANSI 125 or 150 pound flanges:
 - a. Bodies shall be cast iron. Valves 2 inches to 12 inches shall be rated at 175 psi; 14 inch to 20 inch valves shall be rated at 150 psi. All valves shall

be bi-directional rated and tested to 110 percent of full pressure rating. Lug body valves shall have Tongue-and-groove seat design with primary hub seal and a molded O-ring suitable for weld-neck and slip-on flanges. Seat shall totally encapsulate the body with no flange gaskets required. All valves shall be furnished with non-corrosive bushing and self-adjusting stem seal. Stem shall be mechanically retained in body neck and no part of stem or body shall be exposed to line media. Seats shall be of resilient type and shall be field replaceable. Seats shall also act as a body liner to prevent flow from contacting the body casting. Seats shall provide a positive seal without use of flange gaskets.

- b. Seats: EPDM suitable for use with sodium hypochlorite, citric acid, and sulfuric acid.
- c. Shafts: Type 416 stainless steel and be of 1 piece through-stem direct drive double D design requiring no disc screws or pins to connect stem to disc with no possible leak paths in disc/stem connection.
- d. Discs: Type 316 stainless steel.

- C. Valves shall be Resilient Seated Butterfly, Tyco Series 222, Series 30 Bray or approved equal.

2.06 HIGH PERFORMANCE BUTTERFLY VALVES

- A. Service conditions: Modulating Aeration for Membrane system.
- B. Design: High performance butterfly valves, sizes 2 to 42 inch in ANSI Class 150 design shall be of the single flange lugged body style:
 - 1. Bodies: Type 316 stainless steel ASTM A 351 Gr. CF8M construction.
 - 2. Lug style valve shall provide zero leakage in bi-directional dead end service to full rated ANSI pressure. Retainer ring shall be fastened (bolted) to body. Retainer Ring fasteners must be isolated from the media. Valve shall be in compliance with the following industry standards, ANSI B16.5, B16.34, API 609 dimensions. Stainless steel body valves shall provide drip tight shutoff to 275 psi.
 - 3. Valve disc shall be cast stainless steel, ASTM A 351 Gr. CF8M. Disc shall be double offset to provide cam-like rotation to reduce seat wear and increase cycle life. The disc shall not have any contact with the seat in the open position. Disc shall protect the shaft from the media stream. Disc design shall minimize turbulence within the valve to increase Cv capacities. Seat shall have an "energizer" to be "live loaded". Sealing shall not depend upon and shall be capable of sealing without line pressure. Seat "Energizer" shall be non-wetted and isolated from the media.
 - 4. Seat shall be RPTFE (reinforced PTFE) for maximum temperature range for the greatest range of suitable applications. Seat shall be locked in position and shall not depend on flanging force to set its position. Seat shall be easily field replaceable by 1 person using standard hand tools.
 - 5. Stem shall be of 1-piece construction to maximize strength, using 17-4PH material or as required by the media. Stem must be of the Blow Out Proof design and meet without exception API 609 Revision 4.
 - 6. Bearing shall be stainless steel with PTFE/fiberglass mesh for strength and shock resistance to fully support the shaft/disc. Composite materials are not acceptable.

7. Packing for standard services shall be PTFE Packing fastener studs shall be stainless steel.
8. Valves shall be manufactured by TYCO; Bray - Series 41 or approved equal.

2.07 PNEUMATIC OPERATOR FOR BUTTERFLY VALVES (ON/OFF & MODULATING)

A. General:

1. The actuator shall be pneumatically operated, traveling a minimum of 90 degree in each direction and be able to over travel at 3 degree more in each direction past 90 degree. The actuator shall be totally enclosed and contained in a single enclosure with no external moving parts. All pneumatic passageways must be integral to the actuator housing eliminating the need for external tubing. Actuator shall be rack and pinion design with output torque linear throughout travel. Actuator shall be provided with 2 pistons having acetal guide rings thus greatly extending actuator life and reducing friction to the minimum. Actuator must be supplied with end of travel adjustments integral within actuator end caps. The actuator shall be provided with a mechanical visual position indicator, and the indicator must be able to be easily removed thus exposing the output shaft for the use of manually overriding actuator when needed. The output shaft and pinion must be 1 piece and manufactured from hardened alloy steel and zinc plated for corrosion protection. Actuator shall be able to mount in any position without loss of performance. The actuator shall bolt directly to Bray valve mounting flange without need for brackets.
2. Actuator housing shall be of anodized aluminum with all external fasteners made of zinc-plated carbon steel or stainless steel. Springs shall be coated spring steel, with zinc-plated retaining hardware for corrosion protection. All seals shall be of BUNA-N (nitrile) and bushings of acetal resin. The actuator shall be factory lubricated. Actuator design must have smooth housing lines for self-draining capabilities. The actuator shall be factory tested to ensure proper operation.
3. The actuator shall be factory lubricated. Actuator design must have smooth housing lines so it will self-drain. The actuator shall be factory tested to ensure proper operation. Actuators shall be sized for operation using 80-psig pneumatic supply.
4. Standard materials shall be:
 - a. Body: Aluminum alloy, extruded and anodized.
 - b. End Caps: Die cast, aluminum alloy with corrosion-resistant epoxy coating.
 - c. Output Shaft: Carbon Steel, zinc-plated (yellow).
 - d. Piston Guides: Acetal.
 - e. Fasteners: Carbon Steel, zinc-plated (yellow) or stainless steel.
 - f. Spring Cartridge: Coated Steel springs and yellow zinc-plated hardware.
 - g. O-Ring Seals: BUNA-N (Nitrile).
5. Service Data: Actuators shall be designed for extreme cycle duty (open/close every ten seconds) pneumatic operation up to a maximum pressure of 140 psig (10 Bar) and for temperature ranges of 13 degree Fahrenheit (-25 degree Celsius) to +200 degree Fahrenheit (+95 degree Celsius). Filtered air is recommended but not required. All double acting and spring return units shall be suitable for both on/off and throttling applications.
6. Actuator shall be manufactured by TYCO; Bray - Series 90 or approved equal.

- B. Solenoid:
 - 1. Actuator control shall include manifold mounted solenoid valve. Solenoid shall be watertight NEMA 4X housing with molded and potted coil with UL recognized components and CSA certification. Solenoid valve shall be provided as single coil type 120 V, 60hz, single phase. Solenoid shall have a 1/4 inch NPT pneumatic port and a 1/2 inch NPT electrical connection. Manual override control shall be integral to solenoid body. Speed control valves are to be provided on solenoid exhaust ports to independently control open and close speed of operation.
 - 2. Solenoid shall be Burkert, Bray series 63 or equal.
- C. Limit Switch:
 - 1. All pneumatically operated valves shall include 2 single pole double throw mechanical limit switches to indicate full open and closed positions. Two SPDT limit switches are to be integrated into a die cast epoxy coated aluminum NEMA 4X housing. Housing shall have visual position indication for local indication of valve position. Limit switch setting shall be accomplished by cam adjustment and shall be adjustable infinitely by finger touch or screwdriver. Cams shall be color-coded. Switches shall have 2 separately adjustable cams which can be adjustable through 90 degree of travel. Limit switches shall be rated at 15 amps at 125 VAC, The switches must be pre-wired to a terminal strip that is built into switch housing. The conduit entry shall be minimum 1/2 inch NPT.
 - 2. Limit switch monitor to be TYCO; Bray series 50 or equal.
- D. Modulating Valve Service:
 - 1. Modulating service valves shall be furnished with electro-pneumatic positioner which compares the set point and the valve position electronically in a microcontroller. The microcontroller shall utilize a 5-way switch procedure to control piezoelectric valves, to regulate the flow of air into and from the pneumatic actuator. The positioner output shall be a continuous signal in the area where there is a large control deviation (high-speed zone); and in areas of moderate control deviation (slow-speed zone) the output shall be a sequence of pulses. The positioner shall be powered via a 4 to 20 mA set point signal. Positioner shall be provided with pressure gauge block and feedback module for external position transmission. Air filter regulator shall be provided on air supply to positioner.
 - 2. Positioner shall be manufactured by TYCO; Siemens - SIPART PS2 or approved equal.

2.08 ELECTRIC ACTUATORS

- A. General:
 - 1. The electric actuator shall be as manufactured by Rotork, or equal. Actuator shall be compact and low-profile to greatly reduce space requirements. The actuator shall feature ease of access to field wiring and adjustment. The actuator shall be built to withstand line vibration and shock without failure and shall bolt directly to valve mounting flanges without using brackets:
 - a. Motor:
 - 1) A single-phase permanent split-capacitor reversible motor with voltages of 120 and 200 VAC 60 Hz shall be standard. Motor insulation shall be Class F or better. The motor shall contain a

built-in thermal overload protector of a bi-metallic strip in windings set at 338 degree Fahrenheit (170 degree Celsius) with automatic reset. DC motors shall be available upon request.

2. Duty Cycle:
 - a. The duty cycle for intermittent on-off operation shall be 25 percent. The continuous duty actuator with Servo shall be rated for 100 percent modulating operation at an ambient temperature of 104 degree Fahrenheit (40 degree Celsius).
3. Spur Gear Train System:
 - a. The actuator shall have a self-locking gear train consisting of a worm and worm gear output drive mechanism. The spur gear train shall have precision cut multi-staged gears, which will withstand locked rotor conditions. The spur gear train shall be permanently lubricated at the factory. The gear train shall drive a chromemoly steel worm, which drives the composite aluminum bronze segment gear / stainless steel output shaft.
4. Wiring:
 - a. Actuator switches shall be pre-wired to a terminal block for ease of access and all internal wiring shall range from 10-22 AWG.
5. Switches:
 - a. All travel switches shall be Single Pole, Double Throw, Double Break Form Z type 10A at 125/250 VAC, 4A at 28 VDC resistive load, UL and CSA approved. Travel Limit switches shall limit actuator in both the open and closed position of valve travel.
6. Cams:
 - a. Cams for each travel limit switch shall be infinitely adjustable by finger touch or screwdriver.
7. Conduit Entries:
 - a. All units shall have 2 conduit entries. Conduit entries for models 003 and 005 shall be either 1/2 inch NPT, M 20 or PD 13.5. Conduit entries for models 008-065 shall be either 3/4 inch NPT, M 25 or PG 16.
8. Mechanical Travel Stops:
 - a. Mechanical stainless steel travel stops shall be located outside the actuator for ease of adjustment and contain stainless steel lock nuts with O-ring seals to hold the travel stops in place. The travel stops shall limit the actuator movement to specific degrees of rotation.
9. Manual Override:
 - a. All units shall be equipped with an aluminum manual override handwheel to rotate the valve without electrical power. The override assembly shall ensure positive and fast manual operation without the use of extra tools or levers.
10. Emergency Shut-Off:
 - a. An automatic power cutout switch shall be provided to cut power to the motor when actuator handwheel is engaged for manual operation. This switch shall function as a safety emergency shutdown device.
11. Enclosure:
 - a. The die-cast aluminum enclosure shall be waterproof (NEMA 4X, IP 65) rated and high-quality polyester powder coated for exceptional corrosion, wear, impact and UV resistance. The enclosure cover shall have captive cover bolts therefore preventing time-consuming problems due to lost or misplaced bolts.

12. Valve Status Display:
 - a. The actuator shall have a highly visible clear polycarbonate display prominently labeled and color coded to indicate valve position throughout the full range of travel.
13. Temperature Rating:
 - a. Actuators shall be designed for temperature ranges of -40 degree Fahrenheit (-40 degree Celsius) to 150 degree Fahrenheit (65 degree Celsius).
14. Optional Equipment:
 - a. The actuator shall be designed to include any of the following accessories as an option:
 - 1) Heater:
 - a) With thermostat control to prevent condensation buildup. The heater is pre-wired to the terminal block. Rated output is 15 W at 110 or 240 VAC.
 - 2) Servo:
 - a) For precise modulating control of valve position. A solid-state circuit board compares the input signal with the feedback potentiometer signal and drives the actuator until a balance is reached. The Servo has a specially shaped potentiometer gear which prevents damage due to the over rotation and features voltage spike protection. Adjustments are provided for both open and closed Speed Control of the actuator. Input Signals: 420 mADC in to 250 Ohm, 0-10 VDC, 2-10 VDC and 135 Ohm or greater potentiometer. Adjustments: Zero, Span, Deadband, Open and Close Speed. Internal Feedback: 5 kOhm Potentiometer.

2.09 ECCENTRIC PLUG VALVES

- A. All plug valves shall be eccentric plug valves unless otherwise specified:
 1. Valves shall be of the non-lubricated eccentric type with resilient faced plugs and shall be furnished with end connections as shown on the plans. Flanged valves shall be faced and drilled to the ANSI 125/150 lb. standard.
 2. Bodies shall be of ASTM A 126 Class B cast iron. Bodies in 4 inch (100mm) and larger valves shall be furnished with a 1/8 inch (3mm) welded overlay seat of not less than 90 percent pure nickel. Seat area shall be raised, with raised surface completely covered with weld to insure that the plug face contacts only nickel. Screwed-in seats shall not be acceptable.
 3. Plugs shall be of ASTM A 126 Class B cast iron. The plug shall have a cylindrical seating surface eccentrically offset from the center of the plug shaft. The interference between the plug face and body seat, with the plug in the closed position, shall be externally adjustable in the field with the valve in the line under pressure. Plug facing shall be Buna or suitable elastomer for intended application.
 4. Bearings shall have sleeve type metal bearings and shall be of sintered, oil impregnated permanently lubricated type 316 ASTM A 743 Grade CF8M in 1/2 to 36 inch sizes. In valves larger than 36 inches, the upper and lower plug journals shall be fitted with ASTM A 240 type 316 stainless sleeves with bearings of ASTM B 30, Alloy C95400 aluminum bronze. Non-metallic bearings shall not be acceptable. Valve shall be provided with grit seal below the plug to protect lower bearing journal.

5. Shaft seals shall be of the multiple V-ring type and shall be externally adjustable and repackable without removing the actuator or bonnet from the valve under pressure. Valves utilizing O-ring seals or non-adjustable packing shall not be acceptable.
 6. Pressure ratings shall be 175 psi on sizes 1/2 to 12 inch and 150 psi for 14 to 72 inch. Every valve shall be given a hydrostatic and seat test with test results being certified when required by the specifications.
 7. Manual operator: Manual valves shall have lever or gear actuators and tee wrenches, extension stems, floorstands, etc., as indicated on the plans. All valves 6 inches and larger shall be equipped with gear actuators. All gearing shall be enclosed in a cast iron housing and be suitable for running in a lubricant with seals provided on all shafts to prevent entry of dirt and water into the actuator. The actuator shaft and the quadrant shall be supported on permanently lubricated bronze bearings. Actuators shall clearly indicate valve position and an adjustable stop shall be provided to set closing torque and to provide adjustment to compensate for change in pressure differential or flow direction change. All exposed nuts, bolts and washers shall be zinc plated.
 8. Valves and gear actuators for buried or submerged service shall have seals on all shafts and gaskets on the valve and actuator covers to prevent the entry of water. Actuator mounting brackets for buried or submerged service shall be totally enclosed and shall have gasket seals. All exposed nuts, bolts, springs and washers shall be stainless steel.
- B. Power actuated valves shall be furnished with cylinder actuators:
1. Cylinder actuators shall be rack and gear type. Actuators shall be sealed and shall be suitable for running in a lubricant. The actuator shall clearly indicate valve position and an adjustable stop shall be provided to set closing torque. Cylinder actuators shall be sized to operate with 80 psi cylinder pressure at a maximum valve shutoff pressure of 50 psi. All actuators shall be sized for reverse pressure (pressure against plug face) for sludge service.
 2. All exposed nuts, bolts and washers shall be zinc plated.
 3. Cylinder controls for 2 to 12 inch (50 to 300mm) shall include ASCO Model EF8342G1 solenoid valve 120 Volt, Single Phase, 60 Hz, NEMA 4X with Two 1/4 inch speed control valves to regulate open and close speed of operation.
 4. Cylinder controls for 14 inch to 24 inch (350 to 600mm) shall include ASCO 4-Way solenoid valve, model EF8344G74, 120 Volt, Single Phase, 60 Hz, NEMA 4X with Two 1/2 inch speed control valves to regulate open and close speed of operation.
 5. Cylinder controls for 30 inches and Larger (350 mm) shall include ASCO 4-Way solenoid valve, model EF8344G76, 120 Volt, Single Phase, 60 Hz, NEMA 4X with Two 3/4 inch speed control valves to regulate open and close speed of operation.
 6. All cylinder operated valves shall include 2 single pole double throw mechanical limit switches to indicate full open and closed positions. Limit switches are to be integrated into a die cast epoxy coated aluminum NEMA 4X housing. Housing shall have visual position indication for local indication of valve position. Limit switch setting shall be accomplished by cam adjustment and shall be adjustable infinitely by finger touch or screwdriver.
- C. All valves and actuators shall be as manufactured by DeZURIK Water Controls or approved equal.

2.10 CAST IRON KNIFE GATE VALVES

- A. Valves shall be the bonnetless knife gate type with Wafer style cast monoblock body with raised face flanges and reinforced body ribs in larger diameters for extra body strength. Semi-Lug body shall be drilled to the ANSI 125/150 pound standard. CWP valve rating shall be 150 psi in sizes 2 to 10 inch and a minimum of 60 psi in sizes 12 inch to 24 inch:
- B. Valves shall have internal cast gate wedges and guides. Valve bodies shall be cast iron and be full port design. Valves shall have buna resilient seat. Seat design shall mechanically lock the seat inside the valve body with a stainless steel retainer ring. Valve packing shall be multiple layers of square, tallowed cotton fiber. The packing gland shall be cast iron and shall have equally distributed gland bolts to provide uniform compression of packing.
- C. The gate shall have a beveled knife-edge. Gate sides shall be finish ground. The stem shall be stainless steel. Standard stem protector shall be provided on all handwheel actuators to provide additional protection against dust while the valve is in the open position. The yoke shall be EPOXY coated steel.
- D. Manually actuated valves 2 to 12 inch shall have handwheel actuators. Manual valves 14 to 24 inch shall be supplied with bevel gear actuators.
- E. Power actuated valves shall be furnished with cylinder actuators:
 - 1. Cylinder actuators shall be sized to operate with 80 psi cylinder pressure at a maximum valve shutoff pressure differential of 60 psi. Cylinder bore size from 3 1/4 to 12 inch shall have heavy wall steel tubing with a polished chrome plated interior. Bore size from 14 inch to 20 inch shall be Thermoset fiber reinforced composite, specially designed for cylinder tubing for weight reduction and corrosion resistance. PISTON ROD shall be of High carbon content steel SAE 1045, ground, polished and chrome plated. All cylinders shall be rated for minimum of 150 psig air supply.
 - 2. Cylinder controls for 2 to 14 inch (50 to 355mm) shall include ASCO Model 8342G001 solenoid valve 120 Volt, Single Phase, 60 Hz, NEMA 4X, with 2 Asco 3/8 inch speed control valves to regulate open and close speed of operation.
 - 3. Cylinder controls for 16 inch to 24 inch shall include ASCO 4-Way solenoid valve, model 8344G27, 120 Volt, Single Phase, 60 Hz, NEMA 4X, with 2 Asco 1/2 inch speed control valves to regulate open and close speed of operation.
 - 4. All cylinder operated valves shall include 2 single pole double throw mechanical Honeywell LSXA3K-1A weather-sealed explosion-proof limit switches to indicate full open and closed positions. Limit switches shall be rated at 10 amps at 125 VAC, NEMA 4X. Switches shall be UL listed and CSA certified.
- F. All valves shall be Cast Iron Knife Gate Valves as manufactured by Orbinox Series 10 or approved equal.

2.11 CAST STAINLESS KNIFE GATE VALVES

- A. Valves shall be the bonnetless knife gate type with 1 piece integrally cast stainless steel lug body with raised face flanges and reinforced body ribs in larger diameters

for extra body strength. Lugs 2 to 24 inch shall be drilled to the ANSI 125/150 pound standard. CWP valve rating shall be 150 psi in sizes 2 to 24 inch.

- B. Valves shall have internal cast gate wedges and guides. Valve bodies shall be Type 316 stainless steel and be full port design according to MSS-SP-81. Valves shall have buna resilient seat. Seat design shall mechanically lock the seat inside the valve body with a stainless steel retainer ring. Valve packing shall be multiple layers of square, braided PTFE impregnated fiber. The packing gland shall be stainless steel and shall have equally distributed gland bolts to provide uniform compression of packing.
- C. The gate shall have a beveled knife edge. Gate sides shall be finish ground. The stem shall be stainless steel. Standard stem protector shall be provided on all handwheel actuators to provide additional protection against dust while the valve is in the open position. The yoke shall be epoxy coated steel.
- D. Manually actuated valves 2 to 12 inch shall have handwheel actuators. Manual valves 14 to 24 inch shall be supplied with bevel gear actuators.
- E. Power actuated valves shall be furnished with cylinder actuators:
 - 1. Cylinder actuators shall be sized to operate with 80-psi cylinder pressure at a maximum valve shutoff pressure differential of 150 psi. Cylinder bore size from 3 1/4 to 12 inch shall have heavy wall steel tubing with a polished chrome plated interior. Bore size from 14 inches to 20 inches shall be Thermoset fiber reinforced composite, specially designed for cylinder tubing for weight reduction and corrosion resistance. Piston rod shall be of High carbon content steel SAE 1045, ground, polished and chrome plated. All cylinders shall be rated for minimum of 150 psig (1000 KPA) air supply.
 - 2. Cylinder controls for 2 to 14 inch (50 to 355mm) shall include ASCO Model 8342G001 solenoid valve 120 Volt, Single Phase, 60 Hz, NEMA 4X, with 2 Asco 3/8 inch speed control valves to regulate open and close speed of operation.
 - 3. Cylinder controls for 16 inch to 24 inch shall include ASCO 4-Way solenoid valve, model 8344G27, 120 Volt, Single Phase, 60 Hz, NEMA 4X, with 2 Asco 1/2 inch speed control valves to regulate open and close speed of operation.
 - 4. All cylinder operated valves shall include 2 single pole double throw mechanical Honeywell LSXA3K-1A weather-sealed explosion-proof limit switches to indicate full open and closed positions. Limit switches shall be rated at 10 amps at 125 VAC, NEMA 4X. Switches shall be UL listed and CSA certified.
- F. Valves shall be Series 20 Cast Stainless Steel Knife Gate Valves as manufactured by Orbinox or approved equal.

2.12 PLASTIC BODY DIAPHRAGM VALVES

- A. Type of Service: Use plastic body diaphragm valves in the following services:
 - 1. Sodium Hypochlorite.
 - 2. Citric Acid.
 - 3. Sulfuric Acid (for Siemens system only).
- B. Manufacturers: One of the following or equal:
 - 1. Simtech.

2. Chemtrol.
3. Asahi America (2-1/2 inch and less only for sodium hypochlorite service).

C. Materials:

1. Body: PVC with reinforcing ribs at body and end connections.
2. Diaphragm: Unless otherwise specified below, provide 2 diaphragm layers - Teflon diaphragm with EPDM backing or other material suitable for the intended use:
 - a. For sodium hypochlorite service: 3 diaphragm layers, Teflon (PTFE), PVDF, and ethylene-propylenediene (EPDM) or Viton backing cushion.
3. Bonnet: Reinforced polypropylene with cast iron or silicon bronze drive nut, double lead acme stem threads, acrylic protective cap and visual position indicator:
 - a. Adjustable travel stop: Stainless steel.
 - b. Compressor: PVDF or Cast iron.
4. Handwheel: Polypropylene.
5. Sleeve: Bronze or cast iron.
6. Stem: Stainless steel.
7. Bolt, nut and washer: Stainless steel.
8. Thrust bearing: Teflon disc or carbon steel.
9. End connector: PVC.
10. End connector seal (flange gasket): Suitable for the intended use unless otherwise specified below.
 - a. For sodium hypochlorite and sodium bisulfite solution service: Hypalon 1/8-inch thick gaskets.
11. O-rings: Viton.
12. Position indicator: Carbon steel.

D. Valve Design:

1. End connections: Flanged.
2. Operator handle: Handwheel, with position indicator and adjustable travel stop to prevent overtightening. Provide acrylic stem cap.
3. Diaphragm valves: Weir type.
4. Pressure: 150 psig at 70 degrees Fahrenheit.

E. Electric Actuator:

1. Manufacturers: One of the following or equal:
 - a. Asahi/America.
 - b. Barton/ITT Fluid Technology Corporation.
 - c. Gemu.
2. General:
 - a. Reversing type motor.
 - d. Suitable for 115 volt, 1 phase, 60-hertz power supply.
 - e. Travel stop limit switches with remote valve open and closed status indication.
 - f. Brushless, capacitor-run motors with integral thermal overload protection and auto reset.
 - g. Permanently lubricated gear train.
 - h. Visual position indicator.
 - i. Declutchable manual override.
3. Materials:
 - a. Actuator housing: Fiberglass.

- b. Output shaft: Stainless Steel.
- c. Electrical housing: NEMA 4X.
- d. Enclosure: NEMA 4X.
- e. Thermally bonded epoxy powder coating with stainless steel trim.

2.13 CENTER GUIDE (SILENT) CHECK VALVES

- A. Manufacturers: One of the following or equal:
 - 1. APCO, Model Number 600.
 - 2. Crispin, Series GC.
- B. Valve Design:
 - 1. Center guided, spring-loaded plug.
 - 2. Replaceable seat and plug.
 - 3. Shaft guide bushing.
 - 4. Non-slam, silent shut-off.
 - 5. Flanged body.
- C. Materials:
 - 1. Body: Cast-iron, ASTM A 126 Grade B.
 - 2. Plug and Seat: Bronze, ASTM B 584 C83600.
 - 3. Spring: Stainless steel, ASTM A 276 Type 316.
 - 4. Shaft and Bushing: Bronze, ASTM B 584 C83600.

2.14 CUSHIONED SWING CHECK VALVES

- A. Manufacturers: One of the following or equal:
 - 1. Crispin, Series SWC-AC.
 - 2. APCO, Air Cushioned Swing-Check, Series 6000.
- B. Valve Design:
 - 1. Counter-weighted.
 - 2. Rubber seated and driptight.
 - 3. Totally enclosed pneumatic dampening chambers with adjustment for closing speed.
- C. Materials:
 - 1. Valve Body, Cover, and Disc: Cast-iron, ASTM A 126, Class B.
 - 2. Disc Seat: Buna N.
 - 3. Shaft: Stainless steel.
 - 4. Cushion Cylinder: Corrosion resistant metal.
 - 5. Disc Ring Seat: Bronze.
 - 6. Seat Pins and Lock Screws: Stainless steel.

2.15 FLAPPER TYPE CHECK VALVES FOR AIR SERVICE

- A. Manufacturers: One of the following or equal:
 - 1. Crane Company, Crane Valve Group, Duo Chek Check Valves.
 - 2. Techno Corporation, equivalent product.
- B. Valve Design:
 - 1. Spring-assisted dual valve plates with metal hinge. Springs designed to close valve plates upon flow reversal.

2. Replaceable elastomeric seal secured to valve plates with clamp plates and fasteners.
 3. Valve seats integral with valve body. Eliminate leakage when valve plates are fully closed with elastomeric seal in full contact with valve seat.
 4. Wafer style valve body, unless required otherwise by SUPPLIER's piping connection requirements.
 5. Stops on valve shaft which prevent valve plates from opening more than 90 degrees from closed position.
- C. Valve Design:
1. Dual valve plates with replaceable elastomeric member which acts as both a hinge and a seal.
 2. Elastomeric member secured to valve plates with clamping plates and fasteners.
 3. Full port, seatless design. Eliminate leakage when valve plates are fully closed with elastomeric member in full contact with interior surface of valve port.
 4. Wafer style valve body unless required otherwise by SUPPLIER's piping connection requirements.
- D. Materials:
1. Body: Cast-iron.
 2. Valve Plates: Bronze.
 3. Seal: Buna N.
 4. Trim: Type 316 stainless steel.
 5. Spring: Type 316 stainless steel.

2.16 PLASTIC BALL CHECK VALVES

- A. Manufacturers: One of the following or equal:
1. Chemtrol Division of Nibco.
 2. R. G. Sloane Company, Inc.
- B. Valves: Ball type:
1. Polyvinyl chloride.
 2. Double or single union-type end connections.
 3. Seals: Viton.
- C. Type of Service: Use plastic body diaphragm valves in the following services:
1. Sodium Hypochlorite.
 2. Citric Acid.
 3. Sulfuric Acid (Siemens system only).

PART 3 EXECUTION

3.01 INSPECTION

- A. The SUPPLIER shall inspect and tag all valves prior to equipment assembly on site to ensure that it is free of defects in material and workmanship.

3.02 INSTALLATION

- A. Valves shall be installed in complete accordance with the valve manufacture's instructions and recommendations, and SUPPLIER's instruction for installation by CONTRACTOR.
- B. Where supports are not shown, horizontal runs of piping shall be supplied with sufficient supports to maintain deflection of pipelines in a span at less than 1/4-inch, when filled with water.
- C. Piping shall not interfere with access to valves or equipment, or obstruct removal spaces required for maintenance of equipment.

END OF SECTION

SECTION 15255

STAINLESS STEEL PIPING AND TUBING

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes: Stainless steel piping and tubing.
- B. Related Sections:
 - 1. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the SUPPLIER to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 05120 - Structural Steel.
 - b. Section 09960 - High Performance Coatings.
 - c. Section 15052 - Basic Piping Materials and Methods.

1.02 REFERENCES

- A. American Society of Mechanical Engineers (ASME):
 - 1. B16.3 - Malleable Iron Threaded Fittings.
 - 2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.
 - 3. B16.11 - Forged Fittings, Socket Welded and Threaded.
 - 4. B31.3 - Chemical Plant and Petroleum Refining Piping.
 - 5. B36.19 - Stainless Steel Pipe.
 - 6. Boiler and Pressure Vessel, Section IX.
- B. American Water Works Association (AWWA):
 - 1. C 220 - Stainless Steel Pipe, 4 Inches (100 mm) and Larger.
- C. ASTM International (ASTM):
 - 1. A 182 - Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
 - 2. A 193 - Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature Service.
 - 3. A 194 - Specification for Carbon and Alloy Steel Nuts and Bolts for High Temperature and High Pressure Service.
 - 4. A 240 - Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
 - 5. A 269 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
 - 6. A 276 - Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes.
 - 7. A 312 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes. A 351 - Standard Specification for Castings, Austenitic, Austenitic-Ferritic (Duplex), for Pressure-Containing Parts.
 - 8. A 380 - Standard Specification for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
 - 9. A 743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.

10. A 744 - Standard Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service.
 11. A 774 - Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Services at Low and Moderate Temperatures.
 12. A 778 - Standard Specification for Welded, Unannealed, Austenitic Stainless Steel Tubular Products.
 13. A 790 - Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe.
 14. A 928 - Ferritic/Austenitic (Duplex) Stainless Steel Pipe Electric Fusion Welded with Addition of Filler Metal.
 15. A 967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
 16. B 912 - Passivation of Stainless Steels Using Electropolishing.
 17. F 593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
- D. Compressed Gas Association (CGA):
1. G-4.1 - Cleaning Equipment for Oxygen Service.

1.03 DESIGN REQUIREMENTS

- A. Piping Layout:
1. Piping lay out shall be the responsibility of the SUPPLIER. Fabricate piping systems with piping sections as long as possible, while still allowing shipment, so that joints made up in the field are minimized.
 2. Piping design illustrates piping layout and configuration and does not indicate the location of every field joint and flexible coupling that may be needed to connect piping sections fabricated in the shop.
 3. Add joints and flexible couplings in a manner that achieves intent of maximizing size of individual piping sections.
- B. Shop Fabrication: Fabricate piping sections in the shop and pickle and passivate at point of manufacture.
- C. Field Assembly: Assemble shop-fabricated piping in the field using the joints designed into the piping layout or by using flexible couplings. Field welding is prohibited.

1.04 SUBMITTALS

- A. Layout Drawings: Detailed layout drawings showing dimensions and alignment of pipes; location of valves, fittings, and appurtenances; location of field joints; location of pipe hangers and supports; connections to equipment or structures; location and details of shop welds; and thickness and dimensions of fittings and gaskets:
1. Prepare layout drawings using latest version of AutoCAD.
 2. Submit AutoCAD files after layout drawings have been reviewed and accepted by ENGINEER.
- B. Product Data:
1. Photographs, drawings, and descriptions of pipe, fittings, welding procedures, and pickling and passivating procedures.
 2. Material specifications for pipe, gaskets, fittings, and couplings.

3. Data on joint types and components used in the system including stub ends, backing flanges, flanged joints, grooved joint couplings and screwed joints.
- C. Manufacturing Certifications.
- D. Design pressure de-rating calculations for schedule 40 or schedule 80 pipes that have threaded or grooved connections.

PART 2 PRODUCTS

2.01 STAINLESS STEEL PIPE

- A. General:
1. Pipe sizes shall be determined by SUPPLIER.
- B. Wall Thickness:
1. Piping 3 inches in nominal diameter and greater: Minimum wall thickness corresponding to Schedule 10S.
 2. Piping less than 3 inches in nominal diameter: Minimum wall thickness corresponding the Schedule 40.
 3. Piping with threaded or grooved joints: Minimum wall thickness corresponding the Schedule 40S.
- C. Piping Material and Manufacturing: Comply with the requirements outlined in the following table:

Service	Stainless Steel Grade	Pipe Manufacturing Process
Membrane and Reverse Osmosis Filtration Systems with chloride concentrations less than 6,000 ppm.		
Piping 3 inches in nominal diameter and larger	Type 316L stainless steel conforming to ASTM A 240	In accordance with ASTM A 778
Piping less than 3 inches in nominal diameter	Type 316L stainless steel conforming to ASTM A 240	In accordance with ASTM A 312
Brackish water Membrane and Reverse Osmosis Membrane Filtration Systems with chloride concentrations between 6,000 and 10,000 ppm.		
Piping 6 inches in nominal diameter and larger	High grade stainless steel with PREN greater than 33	In accordance with ASTM A 312, ASTM A 790, or ASTM A 928
Piping less than 6 inches in nominal diameter	High grade stainless steel with PREN greater than 33	In accordance with ASTM A 312 or ASMT A 790
All Other Service Applications		
Piping 3 inches in nominal diameter and larger	Type 304L stainless steel conforming to ASTM A 240	In accordance with ASTM A 778
Piping less than 3 inches in nominal diameter	Type 304L stainless steel conforming to ASTM A 240	In accordance with ASTM A 312
PREN: Pitting Resistance Equivalency Number PREN = Cr% + (3.3 x Mo%) + (16 x N%)		

- D. Fittings for Piping 3 Inches in Nominal Diameter and Greater:
 - 1. Material: ASTM A 240 stainless steel, grade to match the pipe.
 - 2. Manufacturing Standard: ASTM A 774.
 - 3. Wall Thickness of Fitting: In accordance with ASME B 36.19 for the schedule of pipe specified.
 - 4. End Configuration: As needed to comply with specified type of joint.
 - 5. Dimensional Standards:
 - a. Fittings with Weld Ends: In accordance with ASME B 16.9.
 - b. Fittings with Flanged Ends: In accordance with ASME B16.5, Class 150.
- E. Fittings for Piping Less than 3 Inches in Diameter:
 - 1. Material: ASTM A 240 stainless steel, grade to match the pipe.
 - 2. Manufacturing Standard: ASTM A 403, Class WP.
 - 3. Wall Thickness and Dimensions of Fitting: In accordance with ASME B16.3 or ASME B16.9 as appropriate and as required for the schedule of pipe specified.
 - 4. End Configuration: As needed to comply with specified type of joint.
 - 5. Forgings conforming to ASTM A182, Grade F304 or Grade F316; or barstock conforming to ASTM A276, Type 304 or Type 316. Forging or barstock material shall match the piping materials.
- F. Piping Joints:
 - 1. Joint Types, Piping Greater than 2 Inches in Diameter, General:
 - a. Joints at Valves and Pipe Appurtenances: Provide flanged valves and flanged pipe appurtenances in stainless steel piping systems with flanged ends. Design and fabricate piping sections to make connections with flanged valves and pipe appurtenances using piping stub ends with backing flanges, flanged coupling adapters or flanged joints:
 - 1) Flexible Couplings and Flanged Coupling Adapters: Provide stainless steel construction with materials matching the piping system, and conforming to requirements of Section 15121.
 - 2. Joints in Piping 2 Inches in Diameter and Smaller: Flanged or screwed with Teflon tape thread lubricant, as scheduled per Section 15052.
 - 3. Welded Joints:
 - a. Pipe 12 Inches and Larger in Diameter: Automatically weld joints using gas tungsten-arc procedures.
 - b. Piping 4 Inches Through 12 Inches in Diameter: Double butt welded joints
 - c. Piping less than 4 Inches in Diameter: Single butt-welded joints.
 - d. Each weld shall be marked with a symbol that identifies the welder.
 - 4. Flanged Joints: Conforming to the requirements of ASME B16.5, Class 150.
 - 5. Piping Stub Ends and Backing Flanges for Pipe 3 inches and Larger:
 - a. Piping Stub Ends: Cast Type 304L or 316L stainless steel to match the pipe material with machined gasket and wetted surfaces of stub ends free of crevices, pits, cracks and protrusions. Manufacturers: Alaskan Copper Works, Figure SK-38 or equal.
 - b. Backing Flanges: Cast or forged Type 304 stainless steel with drilled bolt patterns conforming to ASME B16.1, Class 125 or ASME B16.5, Class 150. Manufacturers: Alaskan Copper Works, Figure SK-39 or equal.
 - 6. Flanges for Schedule 40s and Schedule 80S Pipe:
 - a. Provide forged Type 316L stainless steel welding neck flanges or slip-on flanges conforming to ASME B16.5 Class 150.
 - b. Material shall conform to ASTM A182.

7. Grooved Joints:
 - a. Pipe size less than 2 inch:
 - 1) Pressure less than 250 psi:
 - a) Schedule 5 and Schedule 10 stainless steel shall be rolled grooves.
 - 2) Pressure greater than 250 psi and less than 500 psi:
 - a) Grooves shall be cut from Schedule 40 or Schedule 80 stainless steel.
 - b. Pipe size equal to or greater than 2 inch:
 - 1) Pressure less than 150:
 - a) Schedule 5 and Schedule 10 stainless steel shall be rolled grooves.
 - 2) Pressure greater than 150 psi and less than 500 psi:
 - a) Grooves shall be cut from Schedule 40 or Schedule 80 stainless steel.
 - c. Pipe and fittings roll grooved to conform with AWWA C 220.
 - d. Pipe and fittings with cut grooves must submit pipe strength calculations, as per Article 1.04 F.
 - e. Grooving may be accomplished in factory or in field.
 - f. Couplings:
 - 1) Rigid type, cast from ductile iron, Victaulic Style 07 or equal. High performance coating as scheduled in Section 09960.

G. Gaskets:

1. Aeration Air Service: In accordance with Section 15052.
2. All Other Service Applications: EPDM, nitrile, or other materials compatible with the process fluid.

H. Bolts for Flanges and Stub End/Backing Flanges: In compliance with ASTM A193 heavy hex head. Length such that after installation, end of bolt projects 1/8-inch to 3/8-inch beyond outer face of nut. Nuts shall comply with ASTM A194 heavy hex patter:

1. Bolts and nuts shall be Type 316 stainless steel.

I. Fabrication of Pipe Sections:

- a. Welding: Weld in accordance with Section 05120.
2. Weld Seams:
 - a. Full penetration welds, free of oxidation, crevices, pits and cracks and without undercuts.
 - b. Provide weld crowns of 1/16 inch with tolerance of plus 1/16 inch and minus 1/32 inch.
 - c. Where internal weld seams are not accessible, use gas tungsten-arc procedures with internal gas purge.
 - d. Where internal weld seams are accessible, weld seams inside and outside using manual shielded metal-arc procedures.

J. Cleaning (pickling) and Passivation:

1. Following shop fabrication of pipe sections, straight spools, fittings and other piping components, pickle and passivate fabricated pieces.
2. Passivate in accordance with ASTM A 380 or A 967.
 - a. If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible. However,

- these treatments must be followed by inorganic cleaners such as nitric acid/hydrofluoric acid.
- b. Passivation treatments with citric acid are not allowed.
- 3. Finish Requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.

2.02 STAINLESS STEEL TUBING

- A. Stainless Steel Tubing:
 - 1. Seamless tubing made of Type 316L stainless steel and conforming to ASTM A 269, wall thickness not less than 0.035 inch.
- B. Fittings: Swage ferrule design:
 - 1. Components made of:
 - a. Type 316 stainless steel.
 - 2. Double acting ferrule design, providing both a primary seal and a secondary bearing force.
 - 3. Flare type fittings are not acceptable.
 - 4. Manufacturers: One of the following or equal:
 - a. Crawford Fitting Company, Swagelok.
 - b. Hoke, Gyrolok.
 - c. Parker, CPI.
- C. Valves for Use with Stainless Steel Tubing:
 - 1. Ball type valves with swage ends to match tubing diameter.
 - 2. Constructed from:
 - a. Type 316 stainless steel with TFE seats.
 - 3. Manufacturers: Nupro or equal.

PART 3 EXECUTION

3.01 FIELD ASSEMBLY OF SHOP-FABRICATED PIPING SECTIONS

- A. Join shop-fabricated piping sections together using backing flanges, flexible couplings, flanged coupling adapters, grooved couplings or flanges.
- B. Slope horizontal lines so that they can be drained completely.
- C. Provide valve drains at low points in piping systems.
- D. Install eccentric reducers where necessary to facilitate draining of piping system.
- E. Provide access for inspection and flushing of piping systems to remove sediment, deposits, and debris.

3.02 FIELD QUALITY CONTROL

- A. Test Piping to Pressure and by Method Specified in Piping Schedule:
 - 1. If pressure testing is accomplished with water, only potable quality water shall be used.
 - 2. If pressure testing is accomplished with water, piping shall be thoroughly drained and dried.

- B. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.

3.03 PROTECTION

- A. Preserve appearance and finish of stainless steel piping by providing suitable protection during handling and installation and until final acceptance of the Work:
 - 1. Handling methods and equipment used shall prevent damage to the coating and shall include the use of wide canvas slings and wide padded skids.
 - 2. Bare cables, chains, hooks, metal bars, or narrow skids shall not be used.
 - 3. Store stainless steel piping and fittings away from any other piping or metals. Storage in contact with ground or outside without protection from bad weather is prohibited.
 - 4. Protect stainless steel piping and fittings from carbon steel projections (when grinding carbon steel assemblies in proximity) and carbon steel contamination (do not contact stainless steel with carbon steel wire brush or other carbon steel tool).

3.04 INSTALLATION

- A. Stainless steel piping and tubing shall be installed by CONTRACTOR.

END OF SECTION

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SECTION 15958

MECHANICAL EQUIPMENT TESTING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes: Testing of mechanical equipment and systems.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01756 - Testing, Training, and Facility Start-Up.
 - b. Section 16222 - Low Voltage Motors up to 500 Horsepower.
 - c. Section 17950 - Testing, Calibration, and Commissioning.

1.02 REFERENCES

- A. American National Standards Institute (ANSI):
 - 1. S1.4 Specification for Sound Level Meters.
- B. Hydraulic Institute (HI):
 - 1. 1.1-1.5 Standard for Centrifugal Pumps for Nomenclature, Definitions, Application and Operation.
 - 2. 1.6 Standard for Centrifugal Pump Tests.
 - 3. 2.1-2.5 Standard for Vertical Pumps for Nomenclature, Definitions, Application and Operation.
 - 4. 2.6 Standard for Vertical Pump Tests.
 - 5. 3.1-3.5 Standard for Rotary Pumps for Nomenclature, Definitions, Application and Operation.
 - 6. 3.6 Standard for Rotary Pump Tests.
 - 7. 4.1-4.6 Standard for Sealless Rotary Pumps for Nomenclature, Definitions, Application, Operation and Test.
 - 8. 5.1-5.6 Standard for Sealless Centrifugal Pumps for Nomenclature, Definitions, Application, Operation and Test.
 - 9. 6.1-6.5 Standard for Reciprocating Power Pumps for Nomenclature, Definitions, Application and Operation.
 - 10. 6.6 Standard for Reciprocating Pump Tests.
 - 11. 7.1-7.5 Standard for Controlled Volume Pumps for Nomenclature, Definitions, Application and Operation.
 - 12. 8.1-8.5 Standard for Direct Acting for Steam Pumps for Nomenclature, Definitions, Application and Operation.

13. 9.1-9.5 Standard for Pumps – General Guidelines for Types, Definitions, Application and Sound Measurement.

1.03 SUBMITTALS

- A. Schedule of factory tests and field tests as specified in Section 01756 and this Section.
- B. Test instrumentation calibration data.
- C. Start-up plan as specified in Section 01756.
- D. Test plan specified in this Section.
- E. Test result reports.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 QUALITY CONTROL TESTING AND REPORTING

- A. Scheduling and notification:
 - 1. Witnessed source quality control tests: Schedule test date and notify Engineer at least 30 days prior to start of test.
 - 2. Field quality control tests: Schedule test date and notify Engineer at least 7 days prior to start of test.
- B. Testing levels:
 - 1. Test equipment based on test levels specified in the equipment section of this Project.
 - 2. Requirements for Test Levels 1 to 4 are defined below.
 - 3. Test levels apply for both Source (Factory) Quality Control Tests and Field Quality Control Tests as specified in the equipment sections of this Project.
 - 4. If testing is not specified in the equipment section, provide Level 1 testing.
 - 5. Requirements of Section 01756 apply to Test Levels.
- C. Witnessing: Source Quality Control Tests not witnessed unless specified otherwise in the equipment section or Section 01756; Field Quality Control Tests shall be witnessed.
- D. Instrumentation: Provide necessary test instrumentation which has been calibrated within 1 year from date of test to recognized test standards traceable to the National Institute of Standards and Technology, Washington, D.C. or approved source. Properly calibrated field instrumentation permanently installed as a part of the Work may be utilized for Field Quality Control Tests.
- E. Temporary facilities and labor: Provide necessary fluids, utilities, temporary piping, temporary supports, temporary access platforms or access means and other

temporary facilities and labor necessary to safely operate the equipment and accomplish the specified testing. With Owner's permission, some utilities may be provided by fully tested permanently installed utilities that are part of the Work.

- F. Test fluids:
 - 1. Factory tests: Use water or air as appropriate at ambient conditions unless specified otherwise in the equipment section.
 - 2. Field tests: Use specified process fluid at available conditions.
- G. Pressure testing: Hydrostatically pressure test pressure containing parts in the factory at the appropriate standard or code required level above the equipment component specified design pressure or operating pressure, whichever is higher. Submit pressure test reports before shipping.
- H. Test measurement and result accuracy:
 - 1. Use test instruments with accuracies as recommended in the appropriate referenced standards. When no accuracy is recommended in the referenced standard, use 1 percent or better accuracy test instruments. Improved (lower error tolerance) accuracies specified elsewhere prevail over this general requirement.
 - 2. Do not adjust results of tests for instrumentation accuracy. Measured values and values directly calculated from measured values shall be the basis for comparing actual equipment performance to specified requirements.
- I. Field testing:
 - 1. Submit test plan as specified in Section 01756 and this Section. Indicate test start time and duration, equipment to be tested, other equipment involved or required; temporary facilities required, number and skill or trade of personnel involved; safety issues and planned safety contingencies; anticipated effect on Owner's existing equipment and other information relevant to the test. Provide locations of all instruments to be used for testing. Provide calibration records for all instrumentation.
 - 2. Perform general start-up and testing procedures as specified in Section 01756.
 - 3. Prior to testing, verify equipment protective devices and safety devices have been installed, calibrated, and tested.
- J. Reports: Submit reports for source and field-testing. Submit Source Quality Control Test result reports before shipping equipment to the field. Report features:
 - 1. Report results in a bound document in generally accepted engineering format with title page, written summary of results compared to specified requirements, and appropriate curves or plots of significant variables in English units.
 - 2. Include appendix with a copy of raw, unmodified test data sheets indicating test value, date and time of reading, and initials of person taking the data.
 - 3. Include appendix with sample calculations for adjustments to raw test data and for calculated results.
 - 4. Include appendix with the make, model, and last calibration date of instrumentation used for test measurements.
 - 5. Include in body of report a drawing or sketch of the test system layout showing location and orientation of the test instruments relative to the tested equipment features.

3.02 EQUIPMENT TESTING, GENERAL

- A. Tests for pumps, all levels of testing:
 - 1. Test in accordance with applicable HI Standards in addition to the requirements in this and other Sections.
 - 2. Test tolerances: In accordance with appropriate HI Standards, except the following modified tolerances apply:
 - a. From 0 to plus 5 percent of head at the rated design point flow.
 - b. From 0 to plus 5 percent of flow at the rated design point head.
 - c. No negative tolerance for the efficiency at the rated design point.
 - d. No positive tolerance for vibration limits. Vibration limits and test methods in HI Standards do not apply, use limits and methods specified in this or other Sections of the Specifications.
- B. Tests for drivers: Test motors as specified in Section 16222. Test other drivers as specified in the driver equipment section.

3.03 REQUIREMENTS FOR VIBRATION TESTING

- A. Definitions:
 - 1. Peak-to-peak displacement: The root mean squared average of the peak-to-peak displacement multiplied by the square root of 2.
 - 2. Peak velocity: The root mean squared average of the peak velocity multiplied by the square root of 2.
 - 3. Peak acceleration: The root mean squared average of the peak acceleration multiplied by the square root of 2.
 - 4. High frequency enveloping: A process to extract very low amplitude time domain signals associated with impact or impulse events such as bearing or gear tooth defects and display them in a frequency spectrum of acceleration versus frequency.
 - a. Manufacturers: One of the following or equal:
 - 1) Rockwell Automation, Entek Group, "Spike Energy" analysis.
 - 2) CSI, "PeakVue."
 - 5. Low speed equipment: Equipment or components of equipment rotating at less than 600 revolutions per minute.
 - 6. High speed equipment: Equipment and equipment components operating at or above 600 revolutions per minute.
- B. Vibration instrumentation requirements:
 - 1. Analyzers: Use digital type analyzers or data collectors with anti-aliasing filter, 12 bit A/D converter, fast fourier transform circuitry, phase measurement capability, time wave form data storage, high frequency enveloping capabilities, 35 frequency ranges from 21 to 1,500,000 cycles per minute, adjustable fast fourier transform resolution from 400 to 6,400 lines, storage for up to one hundred 3,200 line frequency spectra, RS232C data output port, circuitry for integration of acceleration data to velocity or double integration to displacement.
 - a. Manufacturers: One of the following or equal:
 - 1) Entek-IRD, Division of Rockwell Automation, Enpac 1200 with applicable data analysis software or Entek Model 838 analyzer with built in printer.

- 2) Computational Systems Inc., (CSI) Division of Emerson Electric, Model 2120A, Data Collector/analyzer with applicable analysis software.
2. Analyzer settings:
 - a. Units: English, inches/second, mils, and gravitational forces.
 - b. Fast fourier transform lines: Most equipment 1,600 minimum; for motors, enough lines as required to distinguish motor current frequencies from rotational frequencies, use 3,200 lines for motors with a nominal speed of 3,600 revolutions per minute; 3,200 lines minimum for High Frequency Enveloping; 1,600 lines minimum for low speed equipment.
 - c. Sample averages: 4 minimum
 - d. Maximum frequency (Fmax): 40 times rotational frequency for rolling element bearings, 10 times rotational frequency for sleeve bearings.
 - e. Amplitude range: Auto select but full scale not more than twice the acceptance criteria or the highest peak, whichever is lower.
 - f. Fast fourier transform windowing: Hanning Window.
 - g. High pass filter: Minus 3 dB at 120 cycles per minute for high speed equipment. Minus 3 dB at 21 cycles per minute for low speed equipment.
3. Accelerometers:
 - a. For low speed equipment: Low frequency, shear mode accelerometer, 500 millivolts per gravitational force sensitivity, 10 gravitational force range, plus/minus 5 percent frequency response from 0.5 hertz to 850 hertz, magnetic mount.
 - 1) Manufacturers: One of the following or equal:
 - a) Wilcoxon Research, Model 797L.
 - b) PCB, Model 393C.
 - b. For high speed equipment: General purpose accelerometer, 100 millivolts per gravitational force sensitivity, 50 gravitational force range, plus/minus 3dB frequency response range from 2 hertz to 12,000 hertz when stud mounted, with magnetic mount holder.
 - 1) Manufacturers: One of the following or equal:
 - a) Wilcoxon Research, Model 793.
 - b) Entek-IRD Model 943.
- C. Accelerometer mounting:
 1. Use magnetic mounting or stud mounting.
 2. Mount on bearing housing in location with best available direct path to bearing and shaft vibration.
 3. Remove paint and mount transducer on flat metal surface or epoxy mount for High Frequency Enveloping measurements.
- D. Vibration testing results presentation:
 1. Provide equipment drawing with location and orientation of measurement points indicated.
 2. For each vibration measurement take and include appropriate data on equipment operating conditions at the time vibration data is taken; for pumps, compressors, and blowers record suction pressure, discharge pressure, and flow.
 3. When Vibration Spectra Data required:
 - a. Plot peak vibration velocity versus frequency in cycles per minute.
 - b. Label plots showing actual shaft or part rotation frequency, bearing inner and outer race ball pass frequencies, gear mesh frequencies and relevant

- equipment excitation frequencies on the plot; label probable cause of vibration peaks whether in excess of specification limits or not.
- c. Label plots with equipment identification and operating conditions such as tag number, capacity, pressure, driver horsepower, and point of vibration measurement.
- d. Plot motor spectra on a log amplitude scale versus frequency.
- 4. For low speed equipment, plot peak vibration displacement versus frequency as well as velocity versus frequency.
- 5. Provide name of manufacturer and model number of the vibration instrumentation used, including analyzer and accelerometer used together with mounting type.

3.04 TESTING LEVELS

- A. Level 1 Quality Control Tests:
 - 1. Level 1 General Equipment Performance Test:
 - a. For equipment, operate, rotate, or otherwise functionally test for 15 minutes minimum after components reach normal operating temperatures.
 - b. Operate at rated design load conditions.
 - c. Confirm that equipment is properly assembled, equipment moves or rotates in the proper direction, shafting, drive elements and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
 - 2. Level 1 Pump Performance Test:
 - a. Measure flow and head while operating at or near the rated condition; for factory testing, testing may be at reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
 - b. Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222 or the applicable equipment section. Use actual driver for field tests.
 - c. Record measured flow, suction pressure, discharge pressure, and make observations on bearing temperatures and noise levels.
 - 3. Level 1 Vibration Test:
 - a. Test requirement:
 - 1) Measure filtered vibration spectra versus frequency in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component.
 - 2) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.
 - b. Equipment operating condition: Test at specified maximum speed.
 - 4. Level 1 Noise Test:
 - a. Measure unfiltered overall A-weighted sound pressure level in dBA at 3 feet horizontally from the surface of the equipment and at a mid-point of the equipment height.

B. Level 2 Quality Control Tests:

1. Level 2 General Performance Test:

- a. For equipment, operate, rotate, or otherwise functionally test for at least 2 hours after components reach normal operating temperatures.
- b. Operate at rated design load conditions.
- c. Confirm that equipment is properly assembled, equipment moves or rotates in the proper direction, shafting, drive elements and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.

2. Level 2 Pump Performance Test:

- a. Test 2 hours minimum for flow and head at the rated condition; for factory testing, testing may be at a reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
- b. Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222. Use actual driver for field tests.
- c. Test for flow and head at 2 additional conditions; 1 at 25 percent below the rated flow and 1 at 10 percent above the rated flow.
- d. Record measured flow, suction pressure, discharge pressure, and observations on bearing temperatures and noise levels at each condition.

3. Level 2 Vibration Test:

- a. Test requirement:
 - 1) Measure filtered vibration spectra versus frequency and measure vibration phase in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component; measure actual rotational speeds for each vibration spectra measured using photometric or other tachometer input connected directly to the vibration data collector.
 - 2) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.
- b. Equipment operating condition: Repeat test requirements at design specified maximum speed and at minimum speed for variable speed equipment.
- c. Natural frequency test of field installed equipment:
 - 1) Excite the installed equipment and support system in 3 perpendicular planes, use same planes as operating vibration measurement planes, and determine the as-installed natural resonant frequency of the driven equipment, the driver, gears and supports.
 - 2) Perform test at each bearing housing, at each support pedestal, and for pumps on the suction and discharge piping.
 - 3) Perform with equipment and attached piping full of intended service or process fluid.

4. Level 2 Noise Test:

- a. Measure filtered A-weighted overall sound pressure level in dBA for each of 8 octave band mid-points beginning at 63 hertz measured at 3 feet horizontally from the surface of the equipment at mid-point height of the noise source.

C. Level 3 Quality Control Tests:

1. Level 3 General Equipment Performance Tests:

- a. For equipment, operate, rotate, or otherwise functionally test for at least 4 hours after components reach normal operating temperatures.
- b. Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
- c. Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration or temperatures are observed.
- d. Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
- e. Bearing temperatures: During maximum speed or capacity performance testing, measure and record the exterior surface temperature of each bearing versus time.

2. Level 3 Pump Performance Test:

- a. Test 4 hours minimum for flow and head at or near the rated condition; for factory testing, testing may be at a reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
- b. Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222. Use actual driver for field tests.
- c. Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 15 minutes; for factory testing, test at other speeds may be omitted if test driver at reduced speeds is used for rated condition testing.
- d. Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices are not required by the equipment section) and record observations on noise levels.

3. Level 3 Vibration Test:

- a. Requirements: Same as Level 2 vibration test except data taken at each operating condition tested and with additional requirements below.
- b. Perform High Frequency Enveloping Analysis for gears and bearings.
 - 1) Measure bearing element vibration directly on each bearing cap in a location close as possible to the bearing load zone that provides a smooth surface and direct path to the bearing to detect bearing defects.
 - 2) Report results in units of acceleration versus frequency in cycles per minute.
- c. Perform Time Wave Form analysis for gears, low speed equipment and reciprocating equipment; plot true peak amplitude velocity and displacement versus time and label the period between peaks with the likely cause of the periodic peaks (relate the period to a cause).

- d. Plot vibration spectra on 3 different plots; peak displacement versus frequency, peak acceleration versus frequency and peak velocity versus frequency.
- 4. Level 3 Noise Test: Measure filtered, un-weighted overall sound pressure level in dB at 3 feet horizontally from the surface of the equipment at mid-point height and at 4 locations approximately 90 degrees apart in plan view; report results for each of 8 octave band mid-points beginning at 63 hertz.

D. Level 4 Quality Control Tests:

- 1. Level 4 General Equipment Performance Test:
 - a. For equipment, operate, rotate, or otherwise functionally test for at least 8 hours after components reach normal operating temperatures.
 - b. Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
 - c. Confirm that equipment is properly assembled, equipment rotates in the proper direction, shafting and bearings are installed and lubricated in accordance with proper tolerances, and that no unusual noise, vibration or temperatures are observed.
 - d. Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
 - e. Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
- 2. Level 4 Pump Performance Test:
 - a. Test 8 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field-testing, test with furnished motor at full speed.
 - b. Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 20 minutes or longer as necessary to measure required performance, vibration and noise data at each test condition.
 - c. Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices not required by the equipment section) and record observations on noise levels.
 - d. Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.
 - e. Perform efficiency and/or Net Positive Suction Head Required (NPSHr) and/or priming time tests when specified in the equipment section in accordance with the appropriate HI standard and as follows:
 - 1) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.
 - 2) Perform efficiency testing with test fluids at maximum rated speed.
 - 3) Perform priming time testing with test fluids at maximum rated speed.
- 3. Level 4 Vibration Test: Same as Level 3 vibration test.

4. Level 4 Noise Test: Same as Level 3 Noise Test except with data taken at each operating condition tested.

3.05 SOURCE QUALITY CONTROL

- A. Test equipment as specified for each type of test at the test levels specified in equipment sections. Prepare and submit test reports as specified.
- B. Inspection and balancing:
 1. Statically and dynamically balance each of the individual rotating parts as required to achieve the required field vibration limits. Statically and dynamically balance the completed equipment rotating assembly and drive shaft components.
 2. Furnish copies of material and component inspection reports including balancing reports for equipment system components and for the completed rotating assembly.
- C. Critical speed of rotating equipment: Satisfy the following:
 1. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered rigid such as horizontal pumps, all non-clog pumps, blowers, air compressors, and engines shall be at least 25 percent above the equipment's maximum operating speed.
 2. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered flexible or flexibly mounted such as vertical pumps (vertical in-line and vertical non-clog pumps excluded) and fans shall at least 25 percent below the equipment's lowest operating speed.
 3. The second lateral and torsional critical speed of all constant, variable, and 2-speed equipment that is considered flexible or flexibly mounted shall be at least 25 percent above the maximum operating speed.

3.06 FIELD QUALITY CONTROL

- A. Test equipment as specified for each type of test at the test levels specified in equipment sections. Prepare and submit test reports as specified. Comply with latest version of applicable standards.
- B. For variable speed equipment, conduct test to establish performance over the entire speed range and at the average operating condition. Establish performance curves for:
 1. The speed corresponding to the rated maximum capacity.
 2. The speed corresponding to the minimum capacity.
 3. The speed corresponding to the average operating conditions.

3.07 VIBRATION ACCEPTANCE CRITERIA

- A. Testing of rotating mechanical equipment: Tests are to be performed by an experienced, factory trained, and independent authorized vibration analysis expert.
- B. Vibration displacement limits: Unless otherwise specified, equipment operating at speeds 600 revolutions per minute or less is not to exhibit unfiltered readings in excess of following:

Operating Speed (revolutions per minute)	Unfiltered (Overall) Peak-to-Peak Amplitude (mils)
	All Rotating Equipment
0 - 300	6.5
301 - 600	4.5
Note: For all equipment, axial shaft displacements not to exceed 50 percent of the maximum radial shaft displacements shown in the table relative to the casing.	

- C. Vibration velocity limits: Unless otherwise specified, equipment operating at speeds greater than 600 revolutions per minute is not to exceed the following peak velocity limits:

Item	Unfiltered Overall Limit (inches per second)	Any Filtered Peak Limit (inches per second)
Non-Clog Solids Handling Centrifugal Pumps	0.35	0.25
Horizontal and Vertical In-Line Centrifugal Pumps (other than Non-Clog type)	0.18 (Input BHP 25 or less)	0.14 (Input BHP 25 or less)
	0.22 (Input BHP more than 25 but less than 100)	0.18 (Input BHP more than 25 but less than 100)
	0.25 (Input BHP 100 or more)	0.20 (Input BHP 100 or more)
Vertical Turbine, Mixed Flow, and Propeller Pumps	0.31 (Input BHP 100 or less)	0.22
	0.35 (Input BHP 125 or more)	0.25
Vertical Turbine, Mixed Flow, and Propeller Short Set Pumps	0.28 (Input BHP 100 or less)	0.21
	0.33 (Input BHP 125 or more)	0.24
Motors	See Applicable Motor Specification	
Gear Reducers, Radial	Not to exceed AGMA 6000-A88 limits	
Other Reducers, Axial	0.10	0.10
Centrifugal Fans and Blowers	0.15	0.10
Other Equipment, Radial	0.16	0.10
Other Equipment, Axial	0.10	0.10

- D. Equipment operation: Measurements are to be obtained with equipment installed and operating within capacity ranges specified and without duplicate equipment running.
- E. Additional criteria:
 - 1. No narrow band spectral vibration amplitude components, whether sub-rotational, higher harmonic, or synchronous multiple of running speed, are to exceed 40 percent of synchronous vibration amplitude component without manufacturer's detailed verification of origin and ultimate effect of such excitation.
 - 2. The presence of discernable vibration amplitude peaks in Test Level 2 or 3 vibration spectra at bearing inner or outer race frequencies shall be cause for rejection of the equipment.
 - 3. For motors, the following shall be cause for rejection:
 - a. Stator eccentricity evidenced by a spectral peak at 2 times electrical line frequency that are more than 40 percent of the peak at rotational frequency.
 - b. Rotor eccentricity evidenced by a spectral peak at 2 times electrical line frequency with spectra side bands at the pole pass frequency around the 2 times line frequency peak.
 - c. Other rotor problems evidenced by pole pass frequency side bands around operating speed harmonic peaks or 2 times line frequency side bands around rotor bar pass frequency or around 2 times the rotor bar pass frequency.
 - d. Phasing problems evidenced by 1/3 line frequency side band spectral peaks around the 2 times electrical line frequency peak.
 - 4. The presence of peaks in a High Frequency Enveloping spectra plot corresponding to bearing, gear or motor rotor bar frequencies or harmonics of these frequencies shall be cause for rejection of the equipment; since inadequate lubrication of some equipment may be a cause of these peaks, lubrication shall be checked, corrected as necessary and the high frequency envelope analysis repeated.

3.08 NOISE REQUIREMENTS AND CONTROL

- A. Make measurements in relation to reference pressure of 0.0002 microbar.
- B. Make measurements of emitted noise levels on sound level meter meeting or exceeding ANSI S1.4, Type II.
- C. Set sound level meter to slow response.
- D. Unless otherwise specified, maximum free field noise level not to exceed 85 dBA measured as sound pressure level at 3 feet from the equipment.

3.09 FUNCTIONAL AND OPERATIONAL TESTING OF EQUIPMENT

- A. Functional testing as specified in Section 01756 and this Section.

- B. General checkout: Prior to operating equipment, inspect, test, and check supporting systems, including but not limited to power systems, control systems, piping systems, lubrication systems, and safety systems.
 - 1. Test and calibrate instrumentation and electrical devices as specified in Sections 16950 and 17950.
 - 2. Test and prepare piping as specified in Section 15956.
 - 3. As a minimum for control systems associated with the equipment, perform the following:
 - a. Individual Loop Tests: Test from field device to intermediate terminations to controller and back to controlled element.
 - b. End-to-end test: Simulate input at field device and observe control system response at the final field control element.
 - 4. Prior to testing, provide signed and dated certificates of calibration for test instrumentation and equipment.
- C. Operation of related existing equipment: Owner will operate related existing equipment or facilities necessary to accomplish the testing.
- D. Acceptable tests: Demonstrate the equipment performance meets the requirements of this Section and the equipment section; when the equipment fails to meet the specified requirements, perform additional more detailed testing to determine the cause, correct, repair, or replace the causative components and repeat the testing that revealed the deficiency.
- E. Operational testing: As specified in Section 01756.

END OF SECTION

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SECTION 16050

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. General requirements applicable to all Electrical Work.
 - 2. General requirements for electrical submittals.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the responsibility of the supplier and its subcontractors to review all sections to ensure a complete and coordinated package.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Document 00701 — Procurement General Conditions.
 - b. Section 01330 - Submittal Procedures - Procurement.
 - c. Section 01410 - Regulatory Requirements.
 - d. Section 01610 - Project Design Criteria.
 - e. Section 01612 - Seismic Design Criteria.
 - f. Section 01782 - Operation and Maintenance Data.
 - g. Section 16222 - Low Voltage Motors up to 500 Horsepower.
 - h. Section 16075 - Electrical Identification.
- C. Interfaces to equipment, instruments, and other components:
 - 1. The drawings, specifications, and overall design are based on preliminary information furnished by various equipment manufacturers which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
 - 2. Submit all such changes and additions to the Engineer for acceptance as specified in Document 00701.
 - 3. Review the complete set of drawings and specifications in order to ensure that all items related to the electrical power and control systems are completely accounted for. Include any such items that appear on the drawings or in the Specifications from another discipline in the scope of work:
 - a. If a conflict between drawings and specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.

- D. All electrical equipment and systems for the entire Project must comply with the requirements of the electrical specifications, whether referenced in the individual equipment specifications or not:
 - 1. The requirements of the electrical specifications apply to all electrical work specified in other sections, including packaged mechanical systems, LCPs, VCPs, etc.
 - 2. Inform all vendors supplying electrical equipment or systems of the requirements of the electrical specifications.
 - 3. The Owner is not responsible for any additional costs due to the failure of the Supplier to notify all vendors of the electrical specifications requirements.
- E. Contract Documents:
 - 1. General:
 - a. The drawings and specifications are complementary and are to be used together in order to fully describe the Work.
 - 2. Specifications:
 - a. The General and Supplementary Conditions of the Contract Documents govern the Work.
 - b. These requirements are in addition to all General Requirements.
- F. Alternates/Alternatives:
 - 1. Coordinate with Document 00701 for substitute item provisions.
- G. Changes and change orders:
 - 1. As specified in Document 00701.

1.02 REFERENCES

- A. Code compliance:
 - 1. As specified in Section 01410.
 - 2. The publications are referred to in the text by the basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of the bid governs.
 - 3. The standards listed are hereby incorporated into this Section.
 - a. American National Standards Institute (ANSI).
 - b. American Society of Civil Engineers (ASCE):
 - 1) Minimum Design Loads for Buildings and Other Structures.
 - c. ASTM International (ASTM).
 - d. Illuminating Engineering Society (IES). Institute of Electrical and Electronics Engineers (IEEE).
 - e. Insulated Cable Engineers Association (ICEA).
 - f. International Code Council (ICC).
 - 1) International Code Council Evaluation Service (ICC-ES).
 - a) AC 156 – Acceptance Criteria for Seismic Certification by Shake Table Testing of Non-Structural Components (ICC-ES AC 156).
 - g. International Society of Automation (ISA).
 - h. National Electrical Manufacturers Association (NEMA):
 - 1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
 - i. National Fire Protection Association (NFPA):
 - 1) 70 - National Electric Code (NEC).
 - j. National Institute of Standards and Technology (NIST).
 - k. Underwriters' Laboratories, Inc. (UL).

- B. Compliance with laws and regulations:
 - 1. As specified in Document 00701.

1.03 DEFINITIONS

- A. Definitions of terms and other electrical and instrumentation considerations as set forth by:
 - 1. IEEE.
 - 2. NETA.
 - 3. IES.
 - 4. ISA.
 - 5. NEC.
 - 6. NEMA.
 - 7. NFPA.
 - 8. NIST.
- B. Specific definitions:
 - 1. FAT: Factory acceptance test.
 - 2. ICSC: Instrumentation and controls subcontractor.
 - 3. Local control panel (LCP): Operator interface panel that may contain an human machine interface (HMI), pilot type control devices, operator interface devices, control relays, etc. and does not contain a local control panel (PLC) or remote input/output (RIO).
 - 4. PCM: Process control module: An enclosure containing any of the following devices: PLC, remote terminal unit (RTU), or RIO.
 - 5. PCIS: Process control and instrumentation system.
 - 6. RTU: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
 - 7. Space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment, i.e., provide all standoffs, bus, and hardware, as part of the space.
 - 8. Spare: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that physically contains a device with no load connections to be made.
 - 9. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.
 - 10. Unequipped space: That portion of the switchgear, motor control center, panelboard, switchboard or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.

1.04 SYSTEM DESCRIPTION

- A. General requirements:
 - 1. The Work includes everything necessary for and incidental to executing and completing the Electrical Work described on the Drawings and specified in the Specifications and reasonably inferable there from.
 - 2. Defective work:
 - a. As specified in Document 00701.

- B. New system:
 - 1. Contractor will provide all power feeds required for a complete and operating system.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Section 01330 and this Section.
- B. General:
 - 1. Adhere to the wiring numbering scheme specified in Section 16075 throughout the Project:
 - a. Uniquely number each wire.
 - b. Wire numbers must appear on all Equipment Drawings.
 - 2. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.
- C. Seismic requirements:
 - 1. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in Section 01612.
 - 2. For equipment installed in structures designated as seismic design category C, D, E or F, prepare and submit the following:
 - a. Statement of seismic qualification, and special seismic certification:
 - 1) "Statement of seismic qualification:" Provide manufacturer's statement that the equipment satisfies the seismic design requirements of the building code indicated in Section 01410, including the requirements of ASCE 7, Chapter 13.
 - 2) "Special seismic certification:" Provide manufacturer's certification that the equipment, when subjected to shake table testing in accordance with ICC-ES AC 156, meets the "Post-Test Functional Compliance Verification" requirements of ICC-ES AC 156 for "Components with $I_p = 1.5$." Compliance shall include both operability and containment of hazardous materials as appropriate to the unit being tested.
 - b. Substantiating test data: With seismic qualification and special seismic certification statements, submit results of testing in accordance with ICC-ES AC 156.
 - c. Anchoring design calculations and details:
 - 1) Submit project-specific drawings and supporting calculations, prepared and sealed by a professional engineer licensed in the state where the Project is being constructed, and showing details for anchoring electrical equipment to its supports and for anchoring supports provided with the equipment to the structure. Prepare calculations in accordance with the requirements of Section 01612.
 - 3. Exemptions: A "statement of seismic qualification" and a "special seismic certification" are not required for the following equipment:
 - a. Temporary or moveable equipment.
 - b. Equipment anchored to the structure and having a total weight of 20 pounds or less.
 - c. Distribution equipment anchored to the structure and having a total unit weight of 5 pounds per linear foot, or less.

D. Submittal organization:

1. First page:
 - a. Specification section reference.
 - b. Name and telephone number of individual who reviewed submittal before delivery to Engineer.
 - c. Name and telephone number of individual who is primarily responsible for the development of the submittal.
 - d. Place for Contractor's review stamp and comments.
2. Next pages:
 - a. Provide confirmation of specification compliance in a tabular form that individually lists each specification section, paragraph, and sub-paragraphs and unequivocally states compliance with said requirement or takes exception to the requirement and lists the reason for said exception and offers alternative means for compliance.
 - b. Include a response in writing to each of the Engineer's comments or questions for submittal packages which are re-submitted:
 - 1) In the order that the comments or questions were presented throughout the submittal.
 - 2) Referenced by index section and page number on which the comment appeared.
 - 3) Acceptable responses to Engineer's comments are either:
 - a) Engineer's comment or change is accepted and appropriate changes are made.
 - b) Explain why comment is not accepted or requested change is not made.
 - c) Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.
 - 4) Any re-submittal, which does not contain responses to the Engineer's previous comments shall be returned for Revision and Re-submittal.
 - 5) No further review by the Engineer will be performed until a response for previous comments has been received.
3. Remaining pages:
 - a. Actual submittal data:
 - 1) Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the specification section. For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is intended to be used.

E. Submittal requirements:

1. Furnish submittals that are fully indexed with a tabbed divider for every component.
2. Sequentially number pages within the tabbed sections. Submittals and operation and maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.
3. Edit all submittals and operation and maintenance manuals so that the submittal specifically applies to only the equipment furnished.
 - a. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.

4. Submit copies of shop drawings, and product data:
 - a. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
5. Where submittals are required, provide a separate submittal for each specification section. In order to expedite construction, the Supplier may make more than 1 submittal per specification section, but a single submittal may not cover more than 1 specification section:
 - a. The only exception to this requirement is when 1 specification section covers the requirements for a component of equipment specified in another section. (For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section.)
6. Exceptions to Specifications and Drawings:
 - a. Include a list of proposed exceptions to the Specifications and Drawings along with a detailed explanation of each.
 - b. If there is insufficient explanation for the exception or deviation, the submittal will be returned requiring revision and re-submittal.
 - c. Acceptance of any exception is at the sole discretion of the Engineer.
 - 1) Furnish all items (materials, features, functions, performance, etc.) required by the Contract Documents that are not accepted as exceptions.
 - d. Replace all items that do not meet the requirements of the Contract Documents, which were not previously accepted as exceptions, even if the submittals contained information indicating the failure to meet the requirements.
7. Specific submittal requirements:
 - a. Shop drawings:
 - 1) Required for materials and equipment listed in this and other sections.
 - 2) Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
 - 3) Shop drawings requirements:
 - a) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
 - b) Locations of conduit entrances and access plates.
 - c) Component layout and identification.
 - d) Schematic and wiring diagrams with wire numbers and terminal identification.
 - e) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
 - f) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.
 - g) Weight.
 - h) Finish.
 - i) Nameplates:
 - (1) As specified in Section 16075.
 - j) Temperature limitations, as applicable.
 - b. Product data:
 - 1) Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.

- 2) Include:
 - a) Catalog cuts.
 - b) Bulletins.
 - c) Brochures.
 - d) Quality photocopies of applicable pages from these documents.
 - e) Identify on the data sheets the Project name, applicable specification section, and paragraph.
 - f) Identify model number and options for the actual equipment being furnished.
 - g) Neatly cross out options that do not apply or equipment not intended to be supplied.
 - c. Detailed sequence of operation for all equipment or systems.
 - d. Completed Motor Data Sheet, as specified in Section 16222, for every motor furnished:
 - 1) Submit one copy of the Motor Data Sheet to the Engineer for review as part of the associated equipment submittal.
- F. Operation and maintenance manuals:
 - 1. As specified in Section 01782.
 - 2. Furnish the Engineer with a complete set of written operation and maintenance manuals.
- G. Material and equipment schedules:
 - 1. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
 - a. Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.
- H. Test reports:
 - 1. Include the following:
 - a. A description of the test.
 - b. List of equipment used.
 - c. Name of the person conducting the test.
 - d. Date and time the test was conducted.
 - e. All raw data collected.
 - f. Calculated results.
 - g. Each report signed by the person responsible for the test.
- I. Calculations:
 - 1. Where required by specific Electrical Specifications:
 - a. Because these calculations are being provided by a registered professional engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.
- J. Factory acceptance test:
 - 1. As specified in Section 01330.
 - 2. Include complete test procedure and all forms to be used during test.

1.06 QUALITY ASSURANCE

- A. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

1.07 DELIVERY, STORAGE, AND PROTECTION

- A. Shipping precautions:
 - 1. After completion of shop assembly and successful factory testing, pack all equipment in protective crates, and enclose in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.
 - 2. Place dehumidifiers, when required, inside the polyethylene coverings.
 - 3. Skid-mount the equipment for final transport.
 - 4. Provide lifting rings for moving without removing protective covering.
 - 5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.
- B. Delivery and inspection:
 - 1. Deliver products in undamaged condition, in manufacturer's original container or packaging with identifying labels intact and legible. Include date of manufacture on label.
- C. Special instructions:
 - 1. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.

1.08 PROJECT OR SITE CONDITIONS

- A. Site conditions:
 - 1. Provide an electrical, instrumentation and control system, including all equipment, raceways and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
 - 2. Seismic load resistance:
 - a. Provide electrical equipment with construction and anchorage to supporting structures designed to resist site seismic loads as specified in Section 01612.
 - 3. Altitude, temperature and humidity:
 - a. As specified in Section 01610.
 - b. Provide all electrical components and equipment fully rated for continuous operation at this altitude, with no additional derating factors applied.
 - c. Provide additional temperature conditioning equipment to maintain all equipment in non-conditioned spaces subject to these ambient temperatures, with a band of 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature, as determined by the equipment manufacturer's guidelines.
- B. Provide enclosures for electrical, instrumentation and control equipment, regardless of supplier or subcontractor furnishing the equipment, that meet the requirements outlined in NEMA Standard 250 for the following types of enclosures:
 - 1. NEMA Type 1: Intended for indoor use, primarily to provide a degree of protection from accidental contact with energized parts or equipment.
 - 2. NEMA Type 4: Intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing.

3. NEMA Type 4X: Made from corrosion resistant materials (fiberglass reinforced plastic, 316 stainless steel or equal) and are intended for indoor or outdoor use, primarily to protect equipment from exposure to windblown dust and rain, splashing or hose directed water, ice formation and freezing, and corrosion.
4. NEMA Type 12: Intended for indoor use, primarily to provide a degree of protection from dust, falling dirt and dripping non-corrosive liquids.
5. NEMA Type 6: Rated for submergence.
6. NEMA Type 6P: Rated for prolonged submergence.

C. Plant area Electrical Work requirements:

1. Provide all Electrical Work in accordance with the following table:

PLANT AREA	NEMA ENCLOSURE TYPE	EXPOSED CONDUIT TYPE	ENVIRONMENT W = WET D = DAMP C = CLEAN/DRY X = CORROSIVE H = HAZARDOUS	SUPPORT MATERIALS
Membrane Basins	NEMA 4X	PCS	X	Stainless Steel

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

A. Factory acceptance testing:

1. Where factory acceptance testing is required for equipment covered by these Specifications, notify the Engineer in writing when the equipment is completed and ready for factory inspection and testing:
 - a. Indicate the desired dates for inspection and testing.
 - b. Schedule the FAT after approval of the FAT procedures submittal:
 - 1) Submit a copy of the test procedures including all forms at least 21 days before any scheduled test date.
 - 2) Notify the Engineer of the scheduled tests a minimum of 15 days before the date of the test.

1.11 WARRANTY

A. Warrant the Electrical Work as specified in Document 00701:

1. Provide additional warranty as specified in the individual Electrical Specifications.

1.12 SYSTEM START-UP

- A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:
 - 1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

- A. Before Functional Testing, perform all maintenance activities required by any sections of the Specifications including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.
- B. Furnish all spare parts as required by other sections of the Specifications.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Provide similar items of same manufacturer throughout the electrical and instrumentation portion of the Project.
- B. Allowable manufacturers are specified in individual Electrical Specifications.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

- A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products and that bear all approvals and labels as required by the Specifications.
- B. Provide materials complying with the applicable industrial standard as specified in Document 00701.
- C. Stainless steel:
 - 1. Where stainless steel is indicated or used for any portion of the Electrical Work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.
 - 2. Provide exposed screws of the same alloys.
 - 3. Provide finished material free of any burrs or sharp edges.
 - 4. Use only stainless steel hardware, when chemically compatible, in all areas that are or could be in contact with corrosive chemicals.

5. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA Type 4X construction.
6. Do not use stainless steel in any area containing chlorine, gas or solution, chlorine products or ferric chloride.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products.
- B. Arrange with all manufacturers of the electrical equipment, to allow the Owner and Engineer to inspect and witness the testing of the equipment at the site of fabrication:
 1. Testing includes the cabinets, special control systems, power equipment, and other pertinent systems and devices.
- C. Factory testing is specified in the individual sections of the Electrical Specifications.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Labeling:
 1. Provide all nameplates and labels as specified in Sections 16075.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. Inspection:
 - 1. Provide any assistance necessary to support inspection activities.
 - 2. Engineer inspections may include, but are not limited to, the following:
 - a. Inspect equipment and materials for physical damage.
 - b. Inspect equipment nameplate data to verify compliance with design requirements.
 - c. Inspect cable terminations.
- B. Field testing:
 - 1. Notify the Engineer when the Electrical Work is ready for field acceptance testing.
 - 2. Record results of the required tests along with the date of test.
- C. Workmanship:
 - 1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
 - a. Neatly coil and label spare wiring lengths.
 - b. Shorten, re-terminate, and re-label excessive used as well as spare wire and cable lengths, as determined by the Engineer.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

- A. Furnish all personnel and equipment necessary to conduct the demonstration and training requirements as specified in the individual sections.

3.11 PROTECTION

- A. Protect all Work from damage or degradation until Substantial Completion.
- B. Maintain all surfaces to be painted in a clean and smooth condition.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16075

ELECTRICAL IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Identifying electrical, instrumentation, and process equipment and components.
 - 2. Material, manufacturing and installation requirements for identification devices.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the responsibility of the supplier and its subcontractors to review all sections to ensure a complete and coordinated package.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures - Procurement.
 - b. Section 16050 - Common Work Results for Electrical.

1.02 REFERENCES

- A. As specified in Section 16050.
- B. Occupational Safety and Health Administration (OSHA).

1.03 DEFINITIONS

- A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

- A. Nameplates:
 - 1. Provide a nameplate for each piece of electrical equipment and devices, control panel and control panel components.
 - 2. Provide all nameplates of identical style, color, and material throughout the facility.
 - 3. Device nameplates information:
 - a. Designations as indicated on the Drawings and identified on the Process and Instrumentation Drawings.
- B. Wire numbers:
 - 1. Coordinate the wire numbering system with all vendors of equipment so that every field wire has a unique number associated with it for the entire system:
 - a. Internal panel wires on a common terminal shall have the same wire number.

2. Provide the following wiring numbering schemes throughout the project for field wires between process control module, (PCM), vendor control panels, (VCP), etc.

(ORIGIN LOC.)-(ORIGIN TERM.)/(DEST. LOC.)-(DEST. TERM.)

OR

Where:

	(ORIGIN LOC.)-(ORIGIN TERM.)
ORIGIN LOC.	= Designation for originating panel or device
ORIGIN TERM.	= Terminal designation at originating panel or device
DEST. LOC.	= Designation for destination panel or device
DEST. TERM.	= Terminal designation at destination panel or device or PLC I/O address at destination panel

- a. Identify equipment and field instruments as the origin.
 - b. PCMs are always identified as the destination.
 - c. Location is the panel designation for VCP, LCP, or PCM. For connections to MCCs, location is the specific starter tag and loop number. Location is the tag and loop number for motor starters, field instruments and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.
 - d. Terminal designation is the actual number on the terminal block where the conductor terminates at field devices and vendor control panels. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.
 - e. Terminal designations at motor leads shall be the motor manufacturer's standard terminal designation (e.g. T1, T2, T3, etc.).
 - f. Terminal designations at PCMs where the field conductor connects to field terminal blocks for a PLC input or output shall be the PLC address (Note: the following PLC I/O numbering scheme is typical for Allen-Bradley, the numbering scheme should be modified to match that of the actual PLC manufacturer used for the project):
 - 1) Discrete Point: W:X:Y/Z
 - Analog Point: W:X:Y.Z
 - Where:
 - W = I for input, O for output
 - X = PLC number (1, 2, 3...)
 - Y = Slot number (01, 02, 03...)
 - Z = Terminal number (00, 01, 02...) for a discrete point or a word number for an analog point (1, 2, 3...)
 - g. Terminal designations at PCMs where the conductor does not connect to a PLC I/O point shall be the terminal number with a "C" prefix (e.g., C0010). For common power after a fuse or neutrals after a switch, the subsequent points shall have and capital letter suffix starting with "A" (e.g., C0010A).
3. **Case 1:** Vendor control panel (VCP) to process control module (PCM):
 Field wire number/label: A-B/C-D
 A = Vendor control panel number without hyphen (VCP#)

- B = Terminal number within VCP (manufacturer's or vendor's standard terminal number)
- C = Process control module number without hyphen (PCM#)
- D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

Examples: VCP#-10/PCM#-I:1:01/01
VCP#-10/PCM#-O:1:10/07
VCP#-10/PCM#-C0100

- 4. **Case 2:** Field instrument to process control module (PCM):
Field wire number/label: E-F/C-D
C = Process control module number without hyphen (PCM#)
D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)
E = Field mounted instrument tag and loop numbers without hyphen (EDV#)
F = Manufacturer's standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma

Examples: TIT#-2,3/PCM#-I:1:01.1
TSH#-1/PCM#-I:2:01/00

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 16050.
- B. Product data:
 - 1. Nameplates:
 - a. Color.
 - b. Size:
 - 1) Outside dimensions.
 - 2) Lettering.
 - c. Material.
 - d. Mounting means.
 - 2. Nameplate schedule:
 - a. Show exact wording for each nameplate.
 - b. Include nameplate and letter sizes.
 - 3. Wire numbers:
 - a. Manufacturer's catalog data for wire labels and label printer.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050.

1.08 PROJECT SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050.

1.12 SYSTEM START-UP

- A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Nameplates and signs:
 - 1. One of the following or equal:
 - a. Brady.
 - b. Seton.
- B. Conductor and cable markers:
 - 1. Heat-shrinkable tubing:
 - a. One of the following or equal:
 - 1) Raychem.
 - 2) Brady.
 - 3) Thomas & Betts.
 - 4) Kroy.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

- A. Nameplates:
 - 1. Fabricated from white-center and red face or black-center, white face laminated plastic engraving stock:
 - a. 3/32-inch thick material.
 - b. Two-ply.
 - c. With chamfered edges.
 - d. Block style engraved characters of adequate size to be read easily from a distance of 6 feet:
 - 1) No characters smaller than 1/8-inch in height.
- B. Signs:
 - 1. Automatic equipment and high voltage signs:
 - a. Suitable for exterior use.
 - b. In accordance with OSHA regulations.
- C. Conductor and cable markers:
 - 1. Machine printed black characters on white tubing.

2. Ten point type or larger.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Nameplates:

1. Provide all nameplates for control panel operator devices (e.g. pushbuttons, selector switches, pilot lights, etc.):
 - a. Same material and same color and appearance as the device nameplates, in order to achieve an aesthetically consistent and coordinated system.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. As specified in Section 16050.

B. Nameplates:

1. Attach nameplates to equipment with rivets, bolts or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.
2. On NEMA Type 4, NEMA Type 4X, or NEMA Type 7 enclosures, use epoxy-based cement to attach nameplates.
3. Nameplates shall be aligned and level or plumb to within 1/64 inch over the entire length:
 - a. Misaligned or crooked nameplates shall be remounted, or provide new enclosures at the discretion of the Engineer.

C. Conductor and cable markers:

1. Apply all conductor and cable markers before termination.
2. Heat-shrinkable tubing:
 - a. Tubing shall be shrunk using a heat gun that produces low temperature heated air.
 - b. Tubing shall be tight on the wire after it has been heated.

- c. Characters shall face the open panel and shall read from left to right or top to bottom.
 - d. Marker shall start within 1/32 inch of the end of the stripped insulation point.
- D. Signs and labeling:
 - 1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
 - a. Fasten warning signs with round head stainless steel screws or bolts.
 - b. Locate and mount in a manner to be clearly legible to operations personnel.
 - 2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, etc where the voltage exceeds 600 volts.
 - 3. Furnish and install warning signs on equipment that has more than one source of power.
 - a. Warning signs to identify every panel and circuit number of the disconnecting means of all external power sources.
 - 4. Place warning signs on equipment that has 120 VAC control voltage source used for interlocking.
 - a. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. Replace any nameplates, signs, conductor markers, cable markers or raceway labels that in the sole opinion of the Engineer do not meet the Engineer's aesthetic requirements.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16123

600 VOLT OR LESS WIRES AND CABLES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. 600 volt class wire and cable.
 - 2. Instrumentation class wire and cable.
 - 3. Network cable.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the responsibility of the supplier and its subcontractors to review all sections to ensure a complete and coordinated package.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 16050 - Common Work Results for Electrical.
 - c. Section 16075 - Electrical Identification.

1.02 REFERENCES

- A. As specified in Section 16050.
- B. ASTM International (ASTM):
 - 1. B 3 - Standard Specification for Soft or Annealed Copper Wire.
 - 2. B 8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- C. CSA International (CSA).
- D. Insulated Cable Engineers Association (ICEA):
 - 1. NEMA WC 70/ICEA S-95-658-1999 - Standard for Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
 - 2. NEMA WC 57/ICEA S-73-532 - Standard for Control, Thermocouple Extension, and Instrumentation Cables.
- E. National Electrical Manufacturers Association (NEMA):
 - 1. 250 – Enclosures for Electrical Equipment (1000 V Maximum).
- F. National Fire Protection Association (NFPA):
 - 1. 70 - National Electrical Code (NEC).
 - 2. 72 - National Fire Alarm and Signaling Code.
 - 3. 101 - Life Safety Code.

- G. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
 - 1. 568-C.2 - Balanced Twisted-Pair Telecommunication Cabling and Components Standard.
- H. Underwriter's Laboratories Inc., (UL):
 - 1. 44 - Thermoset-Insulated Wires and Cables.
 - 2. 1424 - Standard for Cables for Power-Limited Fire-Alarm Circuits.
 - 3. 1569 - Standard for Metal-Clad Cables.
 - 4. 2196 - Standard for Tests for Fire Resistive Cables.
 - 5. 2225 - Standard for Cables and Cable-Fittings For Use in Hazardous (Classified) Locations.

1.03 DEFINITIONS

- A. As specified in Section 16050.
- B. Definitions of terms and other electrical considerations as set forth in the:
 - 1. ASTM.
 - 2. ICEA.
- C. NEMA:
 - 1. Type 4 enclosure in accordance with NEMA 250.
 - 2. Type 4X enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION

- A. Furnish and install the complete wire and cable system.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 16050.
- B. Product data:
 - 1. Manufacturer of wire and cable.
 - 2. Insulation:
 - a. Type.
 - b. Voltage class.
 - 3. American wire gauge (AWG) size.
 - 4. Conductor material.
 - 5. Pulling compounds.
- C. Shop drawings:
 - 1. Show splice locations.
- D. Test reports:
 - 1. Submit test reports for meg-ohm tests.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050.
- B. All wires and cables shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050.

1.12 SYSTEM START-UP

- A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. 600 volt class wire and cable:
 - a. General Cable.
 - b. Okonite Company.
 - c. Southwire Company.
 - 2. Instrumentation class wire and cable:
 - a. Alpha Wire Company.
 - b. Belden CDT.
 - c. General Cable BICC Brand.
 - d. Okonite Company.
 - e. Rockbestos Surprenant Cable Corporation.
 - 3. Network cables:
 - a. Belden CDT.
 - b. General Cable.
 - c. CommScope.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

- A. Conductors:
 - 1. Copper in accordance with ASTM B 3.

2.04 MANUFACTURED UNITS

- A. General:
 - 1. Provide new wires and cables manufactured within 1 year of the date of delivery to the Site.
 - 2. Permanently mark each wire and cable with the following at 24-inch intervals:
 - a. AWG size.
 - b. Voltage rating.
 - c. Insulation type.
 - d. UL symbol.
 - e. Month and year of manufacture.
 - f. Manufacturer's name.
 - 3. Identify and mark wire and cable as specified in Section 16075:
 - a. Use integral color insulation for Number 2 AWG and smaller wire.
 - b. Wrap colored tape around cable larger than Number 2 AWG.
- B. 600 volt class wire and cable:
 - 1. Provide AWG or kcmil sizes as required:
 - a. Size wire as follows:
 - 1) In accordance with the NEC:
 - a) Use 75 degree Celsius ampacity ratings.
 - b) Ampacity rating after all derating factors, equal to or greater than rating of the overcurrent device.
 - 2) Provide Number 12 AWG minimum for power conductors.
 - 3) Provide Number 14 AWG minimum for control conductors.
 - 2. Provide Class B stranding in accordance with ASTM B 8:
 - a. Provide Class C stranding where extra flexibility is required.
 - 3. Insulation:
 - a. XHHW-2.
 - b. 90 degrees Celsius rating.
 - 4. Multiconductor cables:
 - a. Number and size of conductors as required.
 - b. Individual conductors with XHHW-2 insulation.
 - c. Overall PVC jacket.
 - d. Color-coding for control wire in accordance with ICEA Method 1, E-2 in accordance with NEMA WC 57/ICEA S-73-532.
 - e. Ground conductor: Insulated, green:
 - 1) Sized in accordance with NEC.
- C. Instrumentation class cable:
 - 1. Suitable for use in wet locations.
 - 2. Voltage rating: 600 volts.
 - 3. Temperature rating:
 - a. 90 degrees Celsius rating in dry locations.
 - b. 75 degrees Celsius rating in wet locations.
 - 4. Conductors:
 - a. Insulation:
 - 1) Flame-retardant PVC, 15 mils nominal thickness, with nylon jacket 4 mils nominal thickness.
 - b. Number 16 AWG stranded and tinned.
 - c. Color code:
 - 1) Pair: Black and white.

- 2) Triad: Black, white and red.
 - 3) Multiple pairs or triads:
 - a) Color-coded and numbered.
 - 5. Drain wire:
 - a. 18 AWG.
 - b. Stranded, tinned.
 - 6. Jacket:
 - a. Flame retardant, moisture and sunlight resistant PVC.
 - b. Ripcord laid longitudinally under jacket to facilitate removal.
 - 7. Shielding:
 - a. Individual pair/triad:
 - 1) Minimum 1.35-mil double-faced aluminum foil/polyester tape overlapped to provide 100 percent coverage.
 - b. Multiple pair or triad shielding:
 - 1) Group shield: Minimum 1.35-mil double-faced aluminum foil/polyester tape overlapped to provide 100 percent coverage.
 - 2) Completely isolate group shields from each other.
 - 3) Cable shield: 2.35 mils double-faced aluminum and synthetic polymer backed tape overlapped to provide 100 percent coverage.
 - c. All shielding to be in contact with the drain wire.
- D. Network cables:
- 1. Category 5e:
 - a. Conductors:
 - 1) 24 AWG solid bare annealed copper.
 - b. Insulation:
 - 1) Polyolefin.
 - 2) 4 twisted pairs.
 - c. Color code:
 - 1) Pair 1: Blue-blue/white.
 - 2) Pair 2: Orange-orange/white.
 - 3) Pair 3: Green-green/white.
 - 4) Pair 4: Brown-brown/white.
 - d. Outer jacket:
 - 1) PVC with ripcord.
 - e. Electrical characteristics:
 - 1) Frequency range: 1-100 MHz.
 - 2) Attenuation: 24 dB.
 - 3) Near-end crosstalk (NEXT): 30.1 dB.
 - 4) Power sum NEXT: 27.1 dB.
 - 5) Attenuation to crosstalk ratio (ACR): 6.1 dB.
 - 6) Equal level far-end crosstalk (ELFEXT): 17.4 dB.
 - 7) Power sum ELFEXT: 14.4 dB.
 - 8) Return loss: 10 dB.
 - 9) Propagation delay: 548 nanoseconds.
 - 10) Delay skew: 50 nanoseconds.
 - 2. RS-485 cable:
 - a. Two-wire:
 - 1) Shielded twisted pair.
 - 2) Tinned, copper conductors minimum with 7 by 30 stranding.
 - 3) AWG #22.

- 4) Insulation:
 - a) FHDPE: Foam high-density polyethylene.
 - b) 300-volt insulation level.
- 5) Outer shield:
 - a) 100 percent coverage.
 - b) Tape/braid.
 - c) Aluminum foil-polyester tape.
 - d) Tinned copper braid.
- 6) Outer shield drain wire:
 - a) Tinned, copper conductor minimum with 7 by 30 stranding.
 - b) AWG #22.
- 7) Outer jacket PVC:
 - a) Sunlight resistant.
- 8) UL/CSA flame tested.
- 9) Minimum bending radius 2.5 inches.
- 10) Nominal OD 0.284 inch.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

- A. Wire ties:
 - 1. One of the following or equal:
 - a. T&B "Ty-Rap" cable ties.
 - b. Panduit cable ties.
- B. Wire markers:
 - 1. As specified in Section 16075.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Assembly and testing of cable shall comply with the applicable requirements of ICEA S-95-658-1999.
- B. Test Type XHHW-2 in accordance with the requirements of UL 44.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050.
- B. Color-coding:
 - 1. Color-coding shall be consistent throughout the facility.
 - 2. The following color code shall be followed for all 240/120 volt and 208/120 volt systems:
 - a. Phase A - Black.
 - b. Phase B - Red.
 - c. Phase C - Blue.
 - d. Single phase system - Black for one hot leg, red for the other.
 - e. Neutral - White.
 - f. High phase or wild leg - Orange.
 - g. Equipment ground - Green.
 - 3. The following color code shall be followed for all 480/277 volt systems:
 - a. Phase A - Brown.
 - b. Phase B - Orange.
 - c. Phase C - Yellow.
 - d. Neutral - Gray.
 - e. Equipment ground - Green.
 - 4. The following color code shall be followed for all 120 VAC control wiring:
 - a. Power - Red.
 - b. Neutral - White.
 - 5. The following color code shall be followed for all general purpose DC control circuits:
 - a. Grounded conductors - White with blue stripe.
 - b. Ungrounded conductors - Blue.
 - 6. Wires in intrinsically safe circuits shall be light blue.
 - 7. Wire colors shall be implemented in the following methods:
 - a. Wires manufactured of the desired color.
 - b. Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape:
 - 1) Colored tape shall be wrapped to overlap 1/2 of the width of the tape.
- C. Install and terminate all wire in accordance with manufacturer's recommendations.
- D. Neatly arrange and lace conductors in all switchboards, panelboards, pull boxes, and terminal cabinets by means of wire ties:
 - 1. Do not lace wires in gutter or panel channel.
 - 2. Install all wire ties with a flush cutting wire tie installation tool:
 - a. Use a tool with an adjustable tension setting.
 - 3. Do not leave sharp edges on wire ties.
- E. Terminate solid conductors at equipment terminal screws with the conductor tightly wound around the screw so that it does not protrude beyond the screw head:
 - 1. Wrap the conductor clockwise so that the wire loop is closed as the loop is tightened.
 - 2. Do not use crimp lugs on solid wire.

- F. Terminate stranded conductors on equipment box lugs such that all conductor strands are confined within the lug:
 - 1. Use ring type lugs if box lugs are not available on the equipment.
- G. Apply wire markers to all wires at each end after being installed in the conduit and before meg-ohm testing and termination.
- H. Instrumentation class cable:
 - 1. Install instrumentation class cables in separate raceway systems from power cables:
 - 2. Do not make intermediate terminations.
 - 3. Grounding:
 - a. Shielded instrumentation cable shall have its shield grounded at one end only unless shop drawings indicate otherwise:
 - 1) The grounding point shall be at the control panel or at the power source end of the signal carried by the cable.
 - b. Terminate the shield drain wire on a dedicated terminal block.
 - c. Use manufacturer's terminal block jumpers to interconnect ground terminals.
 - d. Connection to the panel main ground bus shall be via a green No. 12 conductor to the main ground bus for the panel.
- I. Multi-conductor cable:
 - 1. Use one conductor in the cable as a ground conductor:
 - a) Use an internal ground conductor, if it meets NEC requirements for equipment ground conductor size.
 - b) Where 2 parallel cables are used, and the internal ground conductor in each cable does not meet NEC requirements for the combined circuit, use 4-conductor cable, with one of the full-sized conductors serving as ground.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

- A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16150

LOW VOLTAGE WIRE CONNECTIONS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Wire connecting devices.
 - 2. Terminations.
 - 3. Splices.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the responsibility of the supplier and its subcontractors to review all sections to ensure a complete and coordinated package.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures - Procurement.
 - b. Section 16050 - Common Work Results for Electrical.
 - c. Section 16123 - 600 Volt or Less Wires and Cables.

1.02 REFERENCES

- A. As specified in Section 16050.
- B. ASTM International (ASTM):
 - 1. D 3005 – Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.
- C. CSA International (CSA):
 - 1. C22.2 - No.197-M1983 (R2208) - PVC Insulating Tape.
- D. Underwriters Laboratories, Inc. (UL):
 - 1. 510 - Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.

1.03 DEFINITIONS

- A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

- A. Provide a complete system of wiring connectors, terminators, fittings, etc. for a complete wiring system suitable for the cables and conductors used.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 16050.
- B. Product data:
 - 1. Catalog cut sheets.
 - 2. Installation instructions.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050.
- B. All materials shall be UL listed.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050.

1.12 SYSTEM START-UP

- A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers for each type of technology are specified with the equipment in this Section.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

- A. Control connections:
 - 1. Use insulated ring type wire terminators for connections to all screw terminals:
 - a. With chamfered/funneled terminal barrel entry.
 - b. Deep internal serrations.
 - c. Long barrel design to reduce electrical resistance and increased insulator-barrel surface area to ensure that the insulator remains in contact with the barrel.
 - d. Electroplated-tin copper conductor.
 - e. Manufacturer: One of the following or equal:
 - 1) Thomas and Betts, Stakon.
 - 2) Engineer knows of no equal.
 - 2. For process equipment connections work from manufacturer's drawings.
- B. Joints, splices, taps, and connections:
 - 1. 600-volt conductors:
 - a. Splices are not allowed.
 - b. Use solderless connectors.
 - c. Use only plated copper alloy connectors or lugs:
 - 1) Aluminum connectors or lugs are not acceptable for copper conductors.
 - d. For wire Number 10 AWG and smaller use compression splice caps, with insulating caps:
 - 1) Manufacturer: One of the following or equal:
 - a) Buchanan 2006S or 2011S, with 2007 or 2014 insulating caps.
 - b) Engineer knows of no equal.
 - e. For wire Number 8 AWG and larger, use heavy duty copper compression connectors:
 - 1) Manufacturer: One of the following or equal:
 - a) Burndy.
 - b) Thomas and Betts.
 - f. Heat shrink tubing:
 - 1) Suitable for indoors, outdoors, overhead, direct burial or submerged applications.
 - 2) Minimum shrink ratio: 4 to 1.
 - 3) Continuous operating temperature: -55 degrees Celsius to 110 degrees Celsius.
 - 4) Internally applied adhesive sealant.
 - 5) Cross-linked polyolefin:
 - a) Manufacturers, one of the following or equal:
 - (1) 3M ITCSN.
 - (2) Thomas & Betts Shrink-Kon.
 - 2. Instrumentation class cable splices:
 - a. Splices are not allowed.
- C. Insulating tape:
 - 1. General purpose insulating tape:
 - a. Minimum 7 mil vinyl tape.
 - b. Suitable for application in an ambient of -18 degrees Celsius (0 degrees Fahrenheit).
 - c. Operating range up to 105 degrees Celsius (220 degrees Fahrenheit).

- d. Flame retardant, hot- and cold- weather resistant, UV resistant.
 - e. For use as a primary insulation for wire cable splices up to 600 VAC.
 - f. Meeting and complying with:
 - 1) ASTM D 3005 Type I.
 - 2) UL 510.
 - 3) CSA C22.2.
 - g. Manufacturer: One of the following or equal:
 - 1) 3M - Scotch Number Super 33+.
 - 2) Engineer knows of no equal.
2. General-purpose color-coding tape:
- a. Minimum 7 mil vinyl tape.
 - b. Suitable for application on PVC and polyethylene jacketed cables.
 - c. For use indoors and outdoors in weather protected enclosures.
 - d. Available with the following colors:
 - 1) Red.
 - 2) Yellow.
 - 3) Blue.
 - 4) Brown.
 - 5) Gray.
 - 6) White.
 - 7) Green.
 - 8) Orange.
 - 9) Violet.
 - e. For use as phase identification, marking, insulating, and harnessing.
 - f. Meeting and complying with:
 - 1) UL 510.
 - 2) CSA C22.2.
 - g. Manufacturer: One of the following or equal:
 - 1) 3M - Scotch Number 35.
 - 2) Engineer knows of no equal.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050.
- B. Load connections:
 - 1. Connect loads to the circuits as indicated. Color-code all branch circuits as specified in Section 16123.
- C. Zero to 600-volt systems:
 - 1. Make all connections with the proper tool and die as specified by the device manufacturer.
 - 2. Use only tooling and dies manufactured by the device manufacturer.
 - 3. Insulate all connections and splices with Scotch 33+ tape and Scotchfill, or pre-molded plastic covers, or heat shrink tubing and caps.
 - 4. Number all power and control wires before termination.
- D. Motor connections (600 volts and below):
 - 1. Terminate wires with compression type ring lugs at motors.
 - 2. Connection at both the motor leads and the machine wires shall have ring type compression lugs.
 - 3. Cover bolted connectors with a heat shrinkable, cross-linked polyolefin material formed as a single opening boot:
 - a. In damp and wet locations, use a complete kit containing mastic that shall seal out moisture and contamination.
 - b. Shrink cap with low heat as recommended by manufacturer.
 - 4. Wire markers shall be readable after boot installation.
 - 5. Manufacturer: One of the following or equal:
 - a. Raychem MCK.
 - b. Engineer knows of no equal.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

- A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

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SECTION 16222

LOW VOLTAGE MOTORS UP TO 500 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Low voltage motors up to 500 horsepower:
 - a. Furnished separately.
 - b. Part of driven equipment specified in other sections.
 - c. Other electric motors required for a complete installation.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the responsibility of the supplier and its subcontractors to review all sections to ensure a complete and coordinated package.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 16050 - Common Work Results for Electrical.

1.02 REFERENCES

- A. As specified in Section 16050.
- B. American Bearing Manufacturers Association (ABMA):
 - 1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
 - 2. 11 - Load Ratings and Fatigue Life for Roller Bearings.
- C. American Petroleum Institute (API):
 - 1. 670 - Vibration, Axial Position, and Bearing Temperature Monitoring Systems.
- D. ASTM International (ASTM).
 - 1. B-117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.
- E. Institute of Electrical and Electronic Engineers (IEEE):
 - 1. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
 - 2. 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators.
 - 3. 114 - Standard Test Procedure for Single-Phase Induction Motors.
 - 4. 303 - Recommended Practice for Auxiliary Devices for Rotating Electrical Machines in Class 1, Division 2 and Zone 2 Locations.
 - 5. 841 - Standard for Petroleum and Chemical Industry-Premium-Efficiency, Severe Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 370 kW (500 hp).

6. 1349 - Guide for Application of Electric Motors in Class I, Division 2 Hazardous (Classified) Locations.
- F. National Electrical Manufacturers' Association (NEMA):
 1. MG-1 - Motors and Generators.
 2. MG-2 - Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators.
- G. Underwriters Laboratories Inc. (UL):
 1. 674 - Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.

1.03 DEFINITIONS

- A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

- A. Furnish and install electric motors and accessories as specified in this Section and the Sections specifying driven equipment to provide a complete and operable installation.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 16050.
- B. Submit completed motor data sheets for each motor supplied:
 1. Conform to data sheet in the appendix of this Section.
 2. Manufacturer's or other data sheets are not acceptable.
- C. Product data:
 1. Descriptive bulletins.
 2. Machine tag and loop number as identified in the P&IDs and in the specification section number of the driven machine.
 3. Complete electrical data.
 4. Torque, current, and power factor vs. speed curves:
 - a. At 100 percent rated voltage for all full voltage started and VFD driven motors.
 - b. For motors on reduced voltage start at 70, 80, 90 and 100 percent rated voltage.
 5. Accessories data:
 - a. Power factor correction capacitors:
 - 1) Size in KVAR, for all motors not connected to variable frequency drives.
 - b. Motor winding heaters:
 - 1) Voltage.
 - 2) Watts.
 - c. Winding temperature detectors:
 - 1) Type.
 - 2) Rating.
 - d. Moisture detectors.
 6. Mechanical data:
 - a. Bearing design and bearing life calculations.

- b. Resonant frequencies for all VFD-driven motors 50 horsepower or greater.
- D. Shop drawings:
 - 1. Motor weight.
 - 2. Frame size.
 - 3. Conduit box(es), size(s), and location(s).
 - 4. Outline drawings with dimensions.
 - 5. Installation details for the project seismic criteria.
- E. Test reports:
 - 1. Factory test reports with test reference standard identified.
- F. Certification:
 - 1. When motors are driven by variable speed drive systems, submit certification that selected motor:
 - a. Is capable of satisfactory performance under the intended load.
 - b. Meets the requirements of the latest edition of NEMA MG-1 Part 31.
 - c. Is matched to the type of variable frequency drive specified.
- G. Calculations:
 - 1. Where site conditions specified in Section 16050 exceed manufacturer's ratings, provide derating calculations for each motor.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050.
- B. Motors 200 hp and larger:
 - 1. Rotate shaft 90 degrees once per month.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050.

1.12 SYSTEM START-UP

- A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTION (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:

1. US Motors.
2. General Electric.
3. Reliance.
4. Toshiba.
5. Baldor.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. 3-phase induction motors - general:

1. Voltage:
 - a. All motors 1/2 hp and larger shall be rated 460 V, 3 phase.
 - b. Dual voltage motors rated 230/460 V, 3 phase are acceptable provided all leads are brought to the conduit box.
2. Motors driving identical machines shall be identical.
3. All motors greater than 1 hp and up to 500 hp shall meet the "NEMA Premium Efficiency" percent listed in NEMA MG-1.
4. Horsepower as required by the driven equipment specification:
 - a. Horsepower ratings indicated on the Drawings are based on vendor's estimates. Provide motors sized for the load of the actual equipment furnished without operating in the service factor.
5. Service factor:
 - a. 1.15 service factor on sine wave power.
 - b. 1.0 when driven by VFD.
6. Torque:
 - a. Provide motors that develop sufficient torque for acceleration to full speed at voltage 10 percent less than motor nameplate rating.
 - b. When started using reduced voltage starters:
 - 1) Provide motors that develop sufficient torque for acceleration to full speed.
 - c. NEMA Design B except where driven load characteristics require other than normal starting torque:
 - 1) In no case shall starting torque or breakdown torque be less than the values specified in NEMA MG-1.
7. Enclosures:
 - a. As specified in the individual equipment Specifications or in this Section.
 - b. Totally enclosed fan cooled:
 - 1) Cast iron conduit box.

- 2) Tapped drain holes with Type 316 stainless steel plugs for frames 286T and smaller, and automatic breather and drain devices for frames 324T and larger.
- c. Lifting devices: All motors weighing 265 pounds (120 kilograms) or more shall have suitable lifting devices for installation and removal.
- 8. Manufactured with cast iron frames in accordance with NEMA MG-1 or manufacturer's standard material for the specified rating.
- 9. Nameplates:
 - a. Provide all motors with a permanent, stainless steel nameplate indelibly stamped or engraved with:
 - 1) NEMA standard motor data.
 - a) Indicate compliance with NEMA MG-1 Part 31 for inverter duty motors.
 - 2) AFBMA bearing numbers and lubrication instructions.
- 10. Hardware:
 - a. Type 316 stainless steel.
- 11. Conduit boxes:
 - a. Cast iron or stamped steel.
 - b. Split from top to bottom.
 - c. Provide gaskets at the following interfaces:
 - 1) Frames and conduit boxes.
 - 2) Conduit boxes and box covers.
 - d. Rotatable through 360 degrees in 90-degree increments.
 - 1) Where available based on the size of the conduit box.
 - e. Exceeding the dimensions defined in NEMA MG-1.
 - f. Provide grounding lugs inside conduit boxes for motor frame grounding.
- 12. Motor bearings:
 - a. Antifriction.
 - b. Regreasable and initially filled with grease for horizontal motors, vertical motors per manufacturer's standard design.
 - c. Bearings and lubrication suitable for ambient temperature and temperature rise.
 - d. Suitable for intended application and have ABMA L-10 rating life of 60,000 hours or more.
 - e. Fit bearings with easily accessible grease supply, flush, drain, and relief fittings using extension tubes where necessary.
 - f. Where specified in the equipment Specifications, provide split-sleeve type hydrodynamic radial bearings. Provide a bearing isolator to protect bearings from contaminants.
- 13. Insulation systems:
 - a. Motors installed in ambient temperatures 40 degrees Celsius or less:
 - 1) Provide Class F insulation.
 - 2) Design temperature rise consistent with Class B insulation.
 - 3) Rated to operate at an ambient temperature of 40 degrees Celsius at the altitude where the motor will be installed.
 - b. Motors installed in ambient temperatures between 40 degrees Celsius and 50 degrees Celsius:
 - 1) Provide Class F insulation.
 - 2) Design temperature rise consistent with Class B insulation.
 - 3) Rated to operate at an ambient temperature of 50 degrees Celsius at the altitude where the motor will be installed.

- c. Motors installed in ambient temperatures between 50 degrees Celsius and 65 degrees Celsius:
 - 1) Provide Class H insulation.
 - 2) Design temperature rise consistent with Class F insulation.
 - 3) Rated to operate at an ambient temperature of 65 degrees Celsius at the altitude where the motors will be installed.
- 14. Motor leads:
 - a. Insulated leads with non-wicking, non-hydroscopic material. Class F insulation.
- 15. Noise:
 - a. Maximum operating noise level in accordance with NEMA MG-1.
- B. Motors driven by variable frequency drives:
 - 1. Compatible with the variable frequency drives specified.
 - 2. Inverter duty rated and labeled.
 - 3. Meet the requirements of NEMA MG-1 Part 31.
 - 4. Winding insulation meets the requirements of NEMA MG-1 Part 31.4.4.2.
 - 5. Capable of running continuously at 1/10th of full speed, with no harmful effects or overheating.
 - 6. Shaft grounding ring:
 - a. Provide a shaft grounding ring for each VFD driven motor.
 - b. Aluminum frame and internal components.
 - c. Conductive microfiber brushes.
 - d. Maintenance free design.
 - e. Aegis Bearing Protection ring as manufactured by Electro Static Technology or equal.
- C. Motors installed in corrosive environments:
 - 1. Stator double dipped in varnish and baked.
 - 2. Stator and rotor coated with corrosion resistant epoxy.
 - 3. Frame, brackets, fan guard and conduit box coated with minimum of 2 coats of epoxy paint.
 - 4. Withstand salt spray tests in accordance with ASTM B-117.
 - 5. Suitable for hose down areas.
- D. Single phase motors:
 - 1. Capacitor start type rated for operation at 115 volts, 60 hertz, unless otherwise specified.
 - 2. Totally enclosed fan cooled (TEFC) motors manufactured in accordance with NEMA MG 1.
 - 3. Ball bearings: Sealed.
 - 4. 1/2 horsepower or less fan motors:
 - a. Split-phase or shaded pole type when standard for the equipment.
 - b. Open type when suitably protected from moisture, dripping water, and lint accumulation.
 - 5. Wound rotor or commutator type single-phase motors only when their specific characteristics are necessary for application and their use is acceptable to the Engineer.
 - 6. Integral overload protection.
- E. Direct current motors:
 - 1. Voltage as indicated on the Drawings.

2. Provide with controller that accepts DC voltage as required by the driven equipment manufacturer.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

- A. Motor winding heaters:
 1. Provide all 3 phase motors with belted or cartridge space heaters mounted within the motor enclosure.
 2. Space heater rating shall be 120 volts, single-phase, unless otherwise shown.
 3. Power leads for heaters wired into conduit box.
 4. Installed within motor enclosure adjacent to core iron.
- B. Winding temperature detectors:
 1. Provide factory installed winding temperature detector with leads terminating in the conduit box:
 - a. Where required by the driven equipment Specification or as indicated on the Drawings.
 2. Temperature switches with normally closed contacts as indicated on the Drawings.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Factory testing:
 1. Motors less than 250 horsepower:
 - a. Perform manufacturer's standard production tests including but not limited to:
 - 1) No load current.
 - 2) High potential test.
 - 3) Winding resistance.
 - b. Furnish copies of standard test reports on prototype or identical units.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050.
- B. Install motors in accordance with manufacturer's instructions.

- C. Install shaft grounding ring on VFD driven motors in accordance with the manufacturer's instructions.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. As specified in Section 16050.
- B. Before start-up, perform insulation resistance test on each motor furnished or installed on this project:
 - 1. Windings energized to 1,000 volts DC for 1 minute.
 - 2. Resistance measured at the end of the test, recorded, and submitted to the Engineer for review.
 - 3. Inform the Engineer of any unusual or unacceptable test results.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

- A. As specified in Section 16050.

END OF SECTION

MOTOR DATA SHEET			
MOTOR/ EQUIPMENT TAG _____		MOTOR NUMBER _____	
SPECIFICATION NUMBER OF DRIVEN MACHINE _____			
MOTOR NAMEPLATE DATA			
MANUFACTURER _____	MODEL/SERIES _____	MODEL NO. _____	
FRAME _____	ENCLOSURE _____	NEMA DESIGN _____	
HP _____	SERVICE FACTOR _____	RPM _____	
INSULATION CLASS _____	VOLTS _____	FULL LOAD AMPS _____	
AMBIENT TEMP _____	PHASE _____	NO LOAD AMPS _____	
DESIGN TEMP RISE _____	HERTZ _____	LOCK ROTOR AMPS _____	
INRUSH CODE LETTER _____			
		100% LOAD	75% LOAD
		50% LOAD	
GUARANTEED MINIMUM EFFICIENCIES:		_____	_____
GUARANTEED MINIMUM POWER FACTOR:		_____	_____
MAXIMUM SIZE OF POWER FACTOR CORRECTION CAPACITOR:		_____ KVAR	
ACCESSORIES			
MOTOR WINDING HEATER _____		VOLTS _____	WATTS _____
WINDING THERMAL PROTECTION _____			
WINDING TEMP SWITCHES (YES/NO) _____			
RTD:			
TYPE _____	QUANTITY PER PHASE _____	# OF WIRES _____	
NOMINAL RESISTANCE _____	NOMINAL TEMP _____	COEFFICIENT _____	
RECOMMENDED ALARM _____	DEGREES CELSIUS _____	RECOMMENDED TRIP _____	DEGREES CELSIUS _____
SPECIAL APPLICATIONS			
INVERTER DUTY* (YES/NO) _____		PART WINDING (YES/NO) _____	
WYE - DELTA (YES/NO) _____			
2 SPEED, 1 WINDING (YES/NO) _____		2 SPEED, 2 WINDING (YES/NO) _____	
AREA CLASSIFICATION:			
CLASS _____	DIVISION _____	GROUP _____	TEMP CODE _____
* Conforms to NEMA MG-1 Part 31.			

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SECTION 16262

VARIABLE FREQUENCY DRIVES 0.50-50 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Variable frequency drives (VFD) 0.5 to 50 horsepower for control of NEMA Design B squirrel cage induction motors installed in:
 - a. Vendor furnished equipment.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the responsibility of the supplier and its subcontractors to review all sections to ensure a complete and coordinated package.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures - Procurement.
 - b. Section 16050 - Common Work Results for Electrical.

1.02 REFERENCES

- A. As specified in Section 16050.
- B. International Organization for Standardization (ISO):
 - 1. 9001 - Quality Management Systems - Requirements.
- C. Underwriters' Laboratories (UL):
 - 1. 508C - Power Conversion Equipment.

1.03 DEFINITIONS

- A. As specified in Section 16050.
- B. Specific definitions:
 - 1. Point of common coupling: the point of common coupling for all harmonic calculation and field measurements for both voltage and current distortions is defined as the closest directly connected panelboard or motor control center bus supplying power to the VFD.

1.04 SYSTEM DESCRIPTION

- A. Design requirements:
 - 1. Each VFD system consists of all components required to meet the performance, protection, safety, testing, and certification criteria of this Section.

2. The VFD system:
 - a. Is a fully integrated package.
 - b. Includes all material necessary to interconnect all VFD system elements, even if shipped separately.
- B. Any modifications to a standard product necessary to meet this Section shall be made only by the VFD manufacturer:
 1. Each VFD shall be completely factory pre-wired, assembled, and then tested as a complete system by the VFD manufacturer to ensure a properly coordinated, fully integrated drive system.
 2. The VFD shall be capable of operating standard NEMA Design B motors. It is the responsibility of the VFD manufacturer to ensure that the drive will not damage motor insulation due to high carrier frequency, reflected wave, dv/dt or other drive electrical characteristics based upon the installed conditions:
 - a. Provide equipment necessary to mitigate potential damage to motor insulation.
- C. Performance:
 1. Operating envelope:
 - a. Speed and torque requirements:
 - 1) Provide a variable torque or constant torque VFD as required by the driven load.
 - 2) The VFD shall be capable of producing a variable alternating voltage/frequency output to provide continuous operation over the 40 to 200 percent (25 to 120 hertz) speed range.
 - b. Current requirements:
 - 1) Full rated current output on a continuous basis.
 - 2) Variable torque VFD:
 - a) Minimum 110 percent current overload for 1 minute.
 - 3) Constant torque VFD:
 - a) Minimum 150 percent current overload for 1 minute.
 2. Minimum VFD system efficiency:
 - a. Ninety-six percent.
 - b. VFD system efficiency shall be calculated as follows:

$$\text{Efficiency } (\%) = \frac{\text{Power (Load)}}{\text{Power (Supply)}} \times 100$$

Power (Load) is the total power measured at the output terminals of the drive system, including VFD, output filters or transformers. Power (Supply) is the total power measured at the input terminals of the VFD including input filters, line reactors, isolation transformers, harmonic distortion attenuation equipment and auxiliary equipment (e.g., controls, fans) for complete system operation.
 3. Total power factor:
 - a. Minimum of 0.96 lagging across the entire speed range.
 - b. At no speed shall the VFD have a leading power factor.
 4. Frequency accuracy:
 - a. Minimum of within 0.01 percent.
 5. Speed regulation:
 - a. Minimum of within 0.5 percent across the entire speed range.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 16050:
 - 1. Custom prepared by the VFD manufacturer and specific for the equipment furnished.
- B. Product data:
 - 1. Manufacturer of the VFD.
 - 2. Manufacturer of all components of the VFD.
 - 3. Dimensions:
 - a. Height.
 - b. Width.
 - c. Depth.
 - d. Weight.
 - 4. Nameplate schedule.
 - 5. Bill of material.
 - 6. Ratings:
 - a. Voltage.
 - b. Phase.
 - c. Input current.
 - d. Output current.
 - e. Interrupting rating.
 - f. Momentary current rating.
 - 7. List of recommended spare parts.
 - 8. Catalog cut sheets for major components.
 - 9. Design data:
 - a. Efficiency and power factor values.
 - b. Certification that the drive is sized for the full nameplate motor horsepower and current of the driven load at the installed altitude and ambient temperature.
 - c. Certification that based upon VFD design, cable length to motor, and motor dielectric insulation level that the VFD will not damage motor insulation due to carrier frequency, reflected wave, dv/dt, or other VFD produced characteristics.
 - d. Certification that all electronic circuits and printed circuit boards are conformally coated.
 - 10. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 16050:
 - a. Manufacturer's statement of seismic qualification with substantiating test data.
 - b. Manufacturer's special seismic certification with substantiating test data.
- C. Shop drawings:
 - 1. Complete plan and elevation drawings showing:
 - a. All dimensions.
 - b. Panel, sub-panel and component layout indexed to the bill of material.
 - c. Conduit connections.
 - 2. Block diagram showing the basic control and protection systems specifying the protection, control, trip and alarm functions, the reference signals and commands and the auxiliary devices.

3. Complete schematic, wiring and interconnection diagrams showing connections to both internal and external devices:
 - a. Include terminal number and wire numbers.
 4. Complete single-line and 3-line diagrams including, but not limited to, circuit breakers, motor circuit protectors, contactors, instrument transformers, meters, relays, timers, control devices, and other equipment comprising the complete system:
 - a. Clearly indicate device electrical ratings on the drawings.
- D. Installation instructions:
1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
 2. For equipment installed in structures designated as seismic design category A or B:
 - a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.
 3. For equipment installed in structures designated as seismic design category C, D, E, or F:
 - a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 16050.
 - b. Submit anchoring drawings with supporting calculations.
 - c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.
- E. Operation and maintenance manuals:
1. Spare parts list with supplier names and part numbers.
 2. Startup and commissioning instructions and data.
 3. Operating manuals:
 - a. Submit operating instructions and a maintenance manual presenting full details for care and maintenance of each model of VFD provided under this Contract.
 4. Operating instructions:
 - a. Written descriptions detailing the operational functions of all controls on the front panel.
 5. Maintenance manual:
 - a. Furnish maintenance manuals with instructions covering all details pertaining to care and maintenance of all equipment as well as identifying all parts.
 - b. Manuals shall include, but are not limited to the following:
 - 1) Adjustment and test instructions covering the steps involved in the initial test, adjustment and start-up procedures.
 - 2) Detailed control instructions which outline the purpose and operation of every control device used in normal operation.
 - 3) All schematic wiring and external diagrams:
 - a) Furnish drawings in a reduced 11-inch by 17-inch format that are fully legible at that size.
- F. Test reports.

- G. Manufacturer's field reports:
 - 1. Certification letter from the VFD manufacturer that the VFD(s) has been inspected and installed in accordance with the manufacturer's requirements.
 - 2. Report listing the setting of all VFD adjustable parameters and their values after start-up.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050.
- B. Qualifications:
 - 1. Any third party certification, safety or protection requirements shall be applied to the VFD system as a whole. Certification or protection of system elements or individual components by themselves is not acceptable.
 - 2. VFD systems shall be UL 508C listed and labeled.
 - 3. Variable frequency drives shall be manufactured by the VFD manufacturer at its own facility which shall have a quality assurance program that is certified in conformance with ISO 9001.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050.
- B. Ship the VFDs and associated equipment to the job site on a dedicated air ride vehicle that will allow the Contractor to utilize on site off loading equipment:
 - 1. VFDs shall be delivered to the site preassembled and wired.
 - 2. Furnish temporary equipment heaters within the VFD to prevent condensation from forming.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050.

1.09 SEQUENCING

- A. Submit equipment for review.
- B. Following approved submittal, conduct internal factory test to ensure that all systems and equipment are functional and submit certified test results for Engineer's review.
- C. Conduct factory acceptance test.
- D. Ship equipment to project site after successful completion of factory acceptance test.
- E. Submit manufacturer's certification that all equipment has been properly installed and is fully functional for Engineer's review.
- F. Conduct field acceptance test and submit results for Engineer's review.
- G. Conduct Owner's training sessions.

H. Formally energize, start-up and commission equipment.

1.10 SCHEDULING

A. As specified in Section 16050.

1.11 WARRANTY

A. As specified in Section 16050.

1.12 SYSTEM START-UP

A. As specified in Section 16050.

B. The VFD manufacturer shall be responsible for start up of the VFDs in the presence of the equipment suppliers, Contractor, Engineer and Owner.

1.13 OWNERS INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING

A. After startup and training has been completed, the VFDs shall be commissioned by the VFD manufacturer:

1. The VFDs shall operate the driven load without failure under normal operating conditions for a period of 30 days.
2. Any failures shall be repaired by the VFD manufacturer.
3. Following repair, the commissioning period shall be restarted. Commissioning shall only be complete once an uninterrupted 30-day period has been completed.

1.15 MAINTENANCE

A. Spare parts:

1. The following spare parts shall be furnished:
 - a. One set of all power and control fuses for each VFD.
 - b. One complete main control key pad for each type and rated size of VFD.
 - c. One spare fan for each VFD unit.
 - d. Two sets of ventilation filters for each VFD unit (if applicable in VFD cabinet louvers).
 - e. Any special dedicated tools for emergency service and troubleshooting.
 - f. One set of thyristors or power electronics for each type and rated size of VFD.
 - g. All hardware and software required for configuration, maintenance, troubleshooting and inquiry of all drive parameters.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:

1. Eaton/Cutler-Hammer.
2. Allen-Bradley.

3. Siemens-Robicon.
4. Schneider Electric/Square D.
5. General Electric.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

A. General:

1. Sinusoidal pulse width modulated (PWM) type drive.
 - a. Six-pulse insulated gate bipolar transistor (IGBT) power section.
 - b. Microprocessor based controls.
 - c. Line and load reactors.

B. Ratings:

1. Voltage:
 - a. Input voltage: 480 volts within 10 percent, 3-phase, 60 hertz.

C. Operational features:

1. Protective features:
 - a. Provide the following minimum protective features:
 - 1) Motor overload protection.
 - 2) Instantaneous overcurrent.
 - 3) Instantaneous overvoltage.
 - 4) Undervoltage.
 - 5) Power unit overtemperature.
 - 6) Phase loss.
 - 7) VFD output short circuit.
2. Control mode:
 - a. Operation in either a constant volts/hertz or sensorless vector mode:
 - 1) The control mode selectable using the programming keypad.
3. Frequency control:
 - a. Minimum of 3 selectable skip frequencies with adjustable bandwidths.
 - b. Programmable minimum frequency.
 - c. Programmable maximum frequency.
4. Acceleration/deceleration:
 - a. Separately adjustable acceleration and deceleration rates:
 - 1) Each rate adjustable from 0.01 to 3,600 seconds.
5. Spinning load:
 - a. The VFD shall be capable of determining the speed and direction of a spinning load, "catch" the load and accelerate or decelerate it without damage to the load.
6. Programmable loss of signal:
 - a. Upon loss of speed reference the VFD shall be programmable to either:
 - 1) Stop.
 - 2) Maintain current speed.
 - 3) Default to pre-selected speed.

7. Power interrupt ride-through:
 - a. The VFD shall be capable of continuous operation in the event of a power loss of 5 cycles or less.
8. Inputs/Outputs:
 - a. Manufacturer's standard number the following:
 - 1) Analog inputs:
 - a) Configurable as either 0 to 10 volts or 4 to 20 milliamperes.
 - 2) Analog outputs:
 - a) Programmable 4 to 20 milliamperes isolated.
 - 3) Discrete inputs:
 - a) Programmable.
 - 4) Discrete outputs:
 - a) Programmable.
 - b) Form C relay contacts.
 - 5) Potentiometer 3-wire input.
 - b. Provide additional inputs/outputs as required to meet the control functions specified.
9. Diagnostics:
 - a. Store a minimum of 4 fault conditions in non-volatile memory on a first in-first out basis.
 - b. Operational parameters stored at the time of a the fault:
 - 1) Operating frequency.
 - 2) Drive status.
 - 3) Power mode.
 - c. Fault memory accessible via RS-232, RS-422 or RS-485.
10. Automatic restart:
 - a. User selectable automatic restart feature allowing the VFD to restart following a momentary power failure or other VFD fault:
 - 1) Programmable for up to 9 restart attempts.
 - 2) Adjustable time delay between restart attempts.

2.06 COMPONENTS

- A. Enclosure:
 1. Vendor control panel.
 2. Provide cooling devices required to maintain the VFD within the manufacturer's specified temperature limits for the Project conditions:
 - a. Provide cooling device failure alarm.
- B. Power disconnect:
 1. Flange mounted thermal magnetic circuit breaker.
 2. Lockable in the OFF position.
- C. Reactors:
 1. Line reactors: 3 percent input and 3 percent output.
- D. Keypad:
 1. Provide each VFD with a keypad for programming and control.
 2. Keypad requirements:
 - a. Password security to protect drive parameters.
 - b. Mounted on the door of the VFD.

- c. Back-lit LCD:
 - 1) Minimum of 2 lines with a minimum of 16 characters per line.
- d. Programming and display features language: English.
- e. Capable of displaying the following parameters:
 - 1) Speed (percent).
 - 2) Output current (amperes).
 - 3) Output frequency (hertz).
 - 4) Input voltage.
 - 5) Output voltage.
 - 6) Total 3-phase kilowatt.
 - 7) Kilowatt-hour meter.
 - 8) Elapsed run time meter.
 - 9) Revolutions per minute.
 - 10) Direct current bus voltage.
- 3. In addition to all keys required for programming, provide the following controls on the keypad:
 - a. Auto/manual selector.
 - b. Start pushbutton.
 - c. Stop pushbutton.
 - d. Jog pushbutton.
 - e. Speed increment.
 - f. Speed decrement.
 - g. Forward/reverse selector.
 - h. Run LED indicator.
 - i. Program LED indicator.
 - j. Fault LED indicator.
- 4. Provide the VFD with the hardwired controls as specified.
- E. Control power transformer:
 - 1. Furnish a control power transformer mounted and wired inside the VFD enclosure.
 - 2. With primary and secondary fusing.
 - 3. Sized to power all VFD controls and options as well as any external devices indicated on the Drawings including the motor winding heater.

2.07 ACCESSORIES

- A. Metal oxide varistors:
 - 1. Provide protection for the VFD against:
 - a. Line transients: 5,000 volt peak minimum.
 - b. Line to ground transients: 7,000 peak minimum.
- B. Conformal coating:
 - 1. Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as a protection against moisture, dust, temperature extremes, and chemicals such as H₂S and chlorine.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

- A. Enclosure finish shall be manufacturer's standard gray.

2.11 SOURCE QUALITY CONTROL

- A. VFDs, factory testing:
 - 1. General:
 - a. Incoming inspection of components and raw materials based on strategic supplier base and experience.
 - b. All VFDs furnished under this Section shall be tested and inspected as specified below. Testing of VFDs based on sampling plans is not allowed.
 - c. The testing procedures specified are the minimum acceptable requirements. The manufacturer may perform additional tests at its discretion.
 - 2. Failure of any component during testing requires repair of the faulted component and complete retest.
 - 3. Testing sequence:
 - a. Submit a detailed test procedure for the VFD factory test:
 - 1) A minimum of 8 weeks in advance of the proposed testing date.
 - 2) No tests shall be performed until the test procedure is reviewed and accepted by the Engineer.
 - 4. Component tests:
 - a. Preliminary inspection:
 - 1) Verify that all components are correct.
 - 2) Verify that all connections are properly torqued.
 - b. Printed circuit boards:
 - 1) Test for correct component placement and value and complete board functional test to ensure proper performance with specified tolerances.
 - 2) Heat cycle test for 48 hours at 60 degrees Celsius.
 - 3) Apply control power to microprocessors, printed circuit boards, diagnostic boards, and similar devices including software to test for proper operation, sequencing, logic, and diagnostics.
 - 4) Test operation of all analog and discrete inputs and outputs.
 - c. Wiring:
 - 1) Control and power wiring continuity verified point-to-point.
 - 2) Hi-pot power and control wiring at manufacturer's recommended levels.
 - 3) Verify ground bond resistance.
 - d. Load testing:
 - 1) No load testing in accordance with the manufacturer's standard factory test procedure.
 - 2) Full load testing:
 - a) Test each VFD and a representative motor with the system logic and a dynamometer load to simulate field operation conditions at 25 percent, 50 percent, and 100 percent full load current.
 - b) Load test each VFD at a minimum ambient temperature of 40 degrees Celsius.
 - (1) Monitor and record temperature rise.

- (2) Once temperature rise stops continue to operate the VFD for a minimum of 2 hours.
- (a) If operating temperature exceeds the rated value, repair or replace the VFD and retest.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
- C. General:
 - 1. Furnish components and equipment as required to complete the installation.
 - 2. Bundle circuits together and terminate in each unit:
 - a. Tie with nylon wire ties.
 - b. Label all wires at each end with wire numbers shown on the approved control drawings.
 - c. All connections to and from the VFD (free-standing or within motor control center) enclosure must be made via terminal blocks.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. As specified in Section 16050.
- B. Provide the services of a VFD manufacturer representative for startup assistance and training:
 - 1. Inspection and field adjustment:
 - a. Supervise the following and submit written certification that the equipment and controls have been properly installed, aligned, adjusted, and readied for operation.
 - 2. Startup field testing:
 - a. Provide technical direction for testing, checkout, and startup of the VFD equipment in the field.
 - b. Under no circumstances are any portions of the drive system to be energized without authorization from the manufacturer's representative.

3.08 ADJUSTING

- A. Make all adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.
- B. Provide the services of a VFD manufacturer factory technician to make all drive parameters and protective device settings:
 - 1. Protective device settings provided by the VFD manufacturer in accordance with the manufacturer of the driven equipment requirements.
 - 2. Provide documentation of VFD settings included but not limited to:
 - a. Minimum speed.
 - b. Maximum speed.
 - c. Skip speeds.
 - d. Current limit.
 - e. Acceleration time.
 - f. Deceleration time.

3.09 CLEANING

- A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING

- A. As specified in Section 16050.
- B. Demonstrate the operation of each VFD to the Engineer's and Owner's satisfaction.
- C. Training:
 - 1. Provide instruction of the Owner's operation and maintenance staff on the operation and maintenance of the VFD.
 - 2. Separate classes are required for the operations staff and maintenance staff:
 - a. Operations staff training shall consist of two identical training sessions, each consisting of 1 session per day for two days, with each session lasting 4 hours for a total class time of 8 hours:
 - 1) The sessions shall be scheduled with the Owner to ensure all operators have the opportunity to attend.
 - b. Maintenance staff training shall consist of 1 session per day for one day with each session lasting for 8 hours, for a total class time of 8 hours.
 - c. Instruction shall occur at the Owner's facility and shall utilize the actual VFDs installed at the site.

3.11 PROTECTION

- A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16272

DRY TYPE TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Enclosed dry-type transformers:
 - a. Rated 1 to 1,000 kilovolt-amperes, single and 3-phase.
 - b. Primary voltage 600 volts and below.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the responsibility of the supplier and its subcontractors to review all sections to ensure a complete and coordinated package.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures - Procurement.
 - b. Section 16050 – Common Work Results for Electrical.

1.02 REFERENCES

- A. As specified in Section 16050.
- B. American National Standards Institute (ANSI):
 - 1. C57.96 – Distribution and Power Transformers, Guide for Loading Dry-Type.
 - 2. 389 - IEEE Recommended Practice for Testing Electronics Transformers and Inductors.
- C. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. C57.12.01 - Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and/or Resin Encapsulated Windings.
- D. National Electrical Manufacturers Association (NEMA):
 - 1. TP-1 - 2002 - Guide for Determining Energy Efficiency for Distribution Transformers.
 - 2. TP-2 - Standard Test Method for Measuring the Energy Consumption of Distribution Transformers.
- E. Underwriters Laboratory (UL):
 - 1. 1561 - Standard for Dry-Type General Purpose and Power Transformers.

1.03 DEFINITIONS

- A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTIONS

- A. Provide 3-phase or 1-phase, 60 hertz dry-type with voltage ratings, kilovolt-ampere capacities, and connections as required:
 - 1. Transformers shall provide full capacity at the Project elevation and environmental conditions as specified in Section 16050 after all derating factors have been applied.
 - 2. Suitable for continuous operation at full rating with normal life expectancy in accordance with ANSI C57.96.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 16050.
- B. Product data:
 - 1. Catalog cut sheets.
 - 2. Nameplate data.
 - 3. Dimensions:
 - a. Height.
 - b. Width.
 - c. Depth.
 - 4. Inrush current.
 - 5. Insulation system and temperature constraints.
 - 6. Number and rating of taps.
 - 7. Sound levels.
 - 8. Connection diagrams:
 - a. Primary.
 - b. Secondary.
 - 9. BIL rating.
 - 10. Required clearances.
 - 11. Percent impedance.
 - 12. Efficiency.
 - 13. Certification of full capacity capability at the Project elevation and ambient conditions.
 - 14. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 16050:
 - a. Manufacturer's statement of seismic qualification with substantiating test data.
 - b. Manufacturer's special seismic certification with substantiating test data.
- C. Installation instructions:
 - 1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
 - 2. For equipment installed in structures designated as seismic design category A or B:
 - a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.
 - 3. For equipment installed in structures designated as seismic design category C, D, E, or F:
 - a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 16050.

- b. Submit anchoring drawings with supporting calculations.
- c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050.

1.12 SYSTEM START-UP

- A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. General Electric.
 - 2. Jefferson.
 - 3. Schneider Electric/Square D.
 - 4. Eaton/Cutler-Hammer.
 - 5. ABB.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

- A. Cores:
 - 1. Non-aging, grain-oriented silicon steel.
 - 2. Magnetic flux densities below the saturation point.

- B. Windings:
 - 1. High-grade magnet wire.
 - 2. Impregnated assembly with non-hydroscopic, thermo-setting varnish:
 - a. Cured to reduce hot-spots and seal out moisture.
 - 3. Material electrical grade:
 - a. Copper.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT

- A. General:
 - 1. 10 kilovolts BIL for 600-volt class windings.
 - 2. Sound levels, in accordance with ANSI 389 test conditions, not to exceed:

Kilovolt-Amperes Range	Audible Sound Level (db)
1-9	40
10-50	45
51-150	50
151-300	55
301-500	60
501-700	62
701-1000	64

- 3. Taps:
 - a. 15 kilovolt-amperes and less:
 - 1) Two 5 percent full capacity primary taps below rated voltage.
 - b. 25 kilovolt-amperes and larger:
 - 1) Four 2.5 percent full capacity primary taps below rated voltage.
 - 2) Two 2.5 percent full capacity primary taps above rated voltage.
 - c. Operated by a tap changer handle or tap jumpers accessible through a panel.
 - 4. Terminals:
 - a. UL listed for either copper or aluminum conductors.
 - b. Rated for 75 degrees Celsius.
 - 5. Daily overload capacities, at rated voltage and without reduction in life, in accordance with ANSI C57.96.
- B. Transformers less than 15 kilovolt-amperes:
 - 1. Insulation class: 185 degrees Celsius.
 - 2. Temperature rise: 115 degrees Celsius.
- C. Energy efficient transformers 15 kilovolt-amperes and larger:
 - 1. Insulation class: 220 degrees Celsius.
 - 2. Temperature rise: 80 degrees Celsius, except as noted below:
 - a. 150-degree Celsius rise for dry-type transformers located in motor control centers.
 - 3. Efficiency:
 - a. In accordance with NEMA TP-1.
 - b. Measured in accordance with NEMA TP-2.

- D. Enclosures:
 - 1. Heavy gauge steel:
 - a. Outdoor: Moisture and water resistant with rodent screens over all openings and in a weather-protected enclosure, NEMA Type 3R.
 - b. Indoor: NEMA Type 2.
 - 2. Louvers to limit coil temperature rise to the value stated above, and case temperature rise to 50 degrees Celsius.
 - 3. Built-in vibration dampeners to isolate the core and coils from the enclosure:
 - a. Neoprene vibration pads and sleeves.

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

- A. Nameplates:
 - 1. Non-corrosive metal or UL listed non-metallic:
 - a. Stamped, engraved or printed with the following information:
 - 1) Phases.
 - 2) Frequency.
 - 3) Kilovolt-ampere rating.
 - 4) Voltage ratings.
 - 5) Temperature rise.
 - 6) Impedance.
 - 7) Insulation class.
 - 8) BIL rating.
 - 9) Connection diagram.
 - 10) Weight.
 - 11) Manufacturer.
 - 12) The identification "transformer".
 - 13) Classes of cooling.
 - 14) Tap voltage(s).
 - 15) Vector diagram.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

- A. Finish to consist of de-greasing, phosphate cleaning, and an electrodeposited manufacturer's standard gray enamel rust-inhibiting paint.

2.11 SOURCE QUALITY CONTROL

- A. Factory tests:
 - 1. Applied voltage test to each winding and from each winding to the core:
 - a. 600-volt class winding 4.5 kilovolt.
 - 2. Induced voltage test at 2 times normal voltage and 400 hertz for 1,080 cycles.
 - 3. Voltage ratio and polarity.
 - 4. Sound level, performed in a test room with ambient sound level not exceeding 24 db.
 - 5. Perform all tests in accordance with UL 1561.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATIONS, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16412

LOW VOLTAGE MOLDED CASE CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Low voltage molded case circuit breakers as specified.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the responsibility of the supplier and its subcontractors to review all sections to ensure a complete and coordinated package.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 16050 - Common Work Results for Electrical.

1.02 REFERENCES

- A. As specified in Section 16050.
- B. National Electrical Manufacturers Association (NEMA):
 - 1. AB 3. - Molded Case Circuit Breakers and Their Application.
- C. Underwriter's Laboratories (UL):
 - 1. 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
 - 2. 943 - Ground Fault Circuit Interrupters.

1.03 DEFINITIONS

- A. As specified in Section 16050.
- B. In accordance with UL 489.

1.04 SYSTEM DESCRIPTION

- A. Molded case thermal magnetic or motor circuit protector type circuit breakers as required and connected to form a completed system.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 16050.

- B. Product data:
 - 1. Catalog cut sheets.
 - 2. Manufacturer's time-current curves for all molded case circuit breakers furnished.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050.
- B. Low voltage molded case circuit breakers shall be UL listed and labeled.

1.07 DELIVERY, STORAGE AND HANDLING

- A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050.

1.12 SYSTEM START-UP

- A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Eaton/Cutler-Hammer.
 - 2. General Electric Company.
 - 3. Schneider Electric/Square D Company.
 - 4. ABB.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

- A. General:
 - 1. Conforming to UL 489.
 - 2. Operating mechanism:
 - a. Quick-make, quick-break, non-welding silver alloy contacts.
 - b. Common Trip, Open and Close for multi-pole breakers such that all poles open and close simultaneously.
 - c. Mechanically trip free from the handle.
 - d. Trip indicating handle - automatically assumes a position midway between the manual ON and OFF positions to clearly indicate the circuit breaker has tripped.
 - e. Lockable in the "OFF" position.
 - 3. Arc extinction:
 - a. In arc chutes.
 - 4. Voltage and current ratings:
 - a. Minimum ratings as required.
 - b. Minimum frame size 100A.
 - 5. Interrupting ratings:
 - a. Minimum ratings as required.
 - b. Not less than the rating of the assembly (panelboard, switchboard, motor control center, etc.)
- B. Motor circuit protectors:
 - 1. Instantaneous only circuit breaker as part of a listed combination motor controller.
 - 2. Each pole continuously adjustable in a linear scale with 'LO' and 'HI' settings factory calibrated.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

- A. Terminals:
 - 1. Line and load terminals suitable for the conductor type, size, and number of conductors in accordance with UL 489.
- B. Case:
 - 1. Molded polyester glass reinforced.
 - 2. Ratings clearly marked.
- C. Trip units:
 - 1. Provide thermal magnetic trip.
 - 2. Thermal magnetic:
 - a. Instantaneous short circuit protection.
 - b. Inverse time delay overload.
 - c. Ambient or enclosure compensated by means of a bimetallic element.

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Test breakers in accordance with:
 - 1. UL 489.
 - 2. Manufacturer's standard testing procedures.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Install breakers to correspond to the accepted shop drawings.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. As specified in Section 16050.

3.08 ADJUSTING

- A. Adjust motor circuit protectors in accordance with NEC and the manufacturer's recommendation based on the nameplate values of the installed motor.

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

- A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16422

MOTOR STARTERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Motor starters and contactors.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the responsibility of the supplier and its subcontractors to review all sections to ensure a complete and coordinated package.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures - Procurement.
 - b. Section 01756 - Testing, Training, and Facility Start-Up.
 - c. Section 16050 - Common Work Results for Electrical.
 - d. Section 16075 - Electrical Identification.
 - e. Section 16123 – 600 Volt or Less Wires and Cables.
 - f. Section 16412 - Low Voltage Molded Case Circuit Breakers.
 - g. Section 17710 - Control Systems - Panels, Enclosures, and Panel Components.

1.02 REFERENCES

- A. As specified in Section 16050.
- B. International Electrotechnical Commission (IEC):
 - 1. 60 947-4 - Low-Voltage Switchgear and Control Gear.
 - 2. 801-1 - Electromagnetic Compatibility for Industrial-Process Measurement and Control Equipment - Part 1: General Information.
- C. National Electrical Manufacturer's Association (NEMA):
 - 1. ICS 2 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 V.
- D. Underwriters Laboratories (UL):
 - 1. 508 - Standard for Industrial Control Equipment.
 - 2. 508A - Standard for Industrial Control Panels.

1.03 DEFINITIONS

- A. As specified in Section 16050.

- B. Specific definitions and abbreviations:
1. FVNR: Full voltage non-reversing.
 2. FVR: Full voltage reversing.
 3. TS1W: 2 speed 1 winding (consequent pole).
 4. TS2W: 2 speed 2 winding.
 5. PWS: Part winding start.
 6. RVAT: Reduced voltage auto transformer.
 7. RVSS: Reduced voltage solid state.
 8. Overload relay class: A classification of an overload relay time current characteristic by means of a number which designates the maximum time in seconds at which it will operate when carrying a current equal to 600 percent of its current rating.

1.04 SYSTEM DESCRIPTION

- A. General requirements:
1. Starters for control panels.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 16050:
1. Submit motor starter data with equipment submittal.
- B. Product data:
1. Manufacturer.
 2. Catalog cut sheets.
 3. Technical information.
 4. Complete nameplate schedule.
 5. Complete bill of material.
 6. List of recommended spare parts.
 7. Confirmation that the overload relay class for each starter meets the requirements of the equipment and motor supplier.
 8. Electrical ratings:
 - a. Phase.
 - b. Wire.
 - c. Voltage.
 - d. Ampacity.
 - e. Horsepower.
 9. Furnish circuit breaker submittals as specified in Section 16412.
- C. Shop drawings:
1. Elementary and schematic diagrams:
 - a. Provide 1 diagram for every starter and contactor.
 - b. Indicate wire numbers for all control wires on the diagrams:
 - 1) Wire numbering as specified in Section 16075.
 - c. Indicate interfaces with other equipment on the drawings.
- D. Operation and maintenance manuals:
1. Submit complete operating and maintenance instructions presenting full details for care and maintenance of equipment furnished or installed under this Section. Including but not limited to:
 - a. Electrical ratings:
 - 1) Phase.

- 2) Wire.
 - 3) Voltage.
 - 4) Ampacity.
 - b. Complete bill of material.
 - c. Manufacturer's operating and maintenance instructions starter and/or contactor component parts, including:
 - 1) Protective devices (fuses, breakers, overload relays, heater elements, etc.).
 - 2) Pilot devices.
 - d. Complete renewal parts list.
 - e. As-built drawings:
 - 1) Furnish as-built drawings for each starter and contactor indicating final:
 - a) Wire numbers.
 - b) Interfaces with other equipment.
 - 2) 11-inch by 17-inch format.
- E. Certifications:
- 1. Provide manufacturer's certification that all electronic circuits and printed circuit boards are conformally coated.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050.
- B. Regulatory requirements:
 - 1. All starters and components shall be UL listed and labeled:
 - a. UL 508 - Industrial Control Equipment.
 - b. UL 508A - Industrial Control Panels.
 - 2. NEMA ICS 2 - Industrial Control and System Controllers; Contactors and Overload Relays Rated: 600 Volts.
 - 3. Combination starters shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050.

1.12 SYSTEM START-UP

- A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

- A. Spare parts:
 - 1. Provide the following spare parts, suitably packaged and labeled with the corresponding equipment number:
 - a. One spare fuse of each size and type per starter.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. NEMA starters and contactors:
 - a. Allen-Bradley.
 - b. Schneider Electric/Square D.
 - c. General Electric.
 - d. Eaton/Cutler-Hammer.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

- A. General:
 - 1. Provide combination type starters with motor circuit protector or thermal-magnetic circuit breaker and control power transformer with ratings as required.
 - 2. NEMA size, design, and rated:
 - a. NEMA Size 1 minimum.
 - 3. Coordinate motor circuit protector, thermal magnetic circuit breaker, or fusible disconnect, and overload trip ratings with nameplate horsepower and current ratings of the installed motor:
 - a. If motors provided are different in horsepower rating than those specified, provide starters coordinated to the actual motors furnished.
 - 4. Provide starters NEMA Size 2 and larger with arc quenchers on load breaking contacts.
 - 5. Mount extended overload reset buttons to be accessible for operation without opening starter enclosure door.
- B. Full voltage starters (FVNR, FVR, TS1W, TS2W):
 - 1. Across-the-line full voltage magnetic starters.
 - 2. Rated for 600 volts.
 - 3. Electrical characteristics as specified.
 - 4. Provide positive, quick-make, quick-break mechanisms, pad lockable enclosure doors.
 - 5. Furnish starter with bi-metallic overload relays.
 - 6. Double-break silver alloy contacts.

7. Reversing starters provided with both mechanical and electrical interlocks to prevent line shorts and energizing both contactors simultaneously.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

- A. Molded case circuit breakers:
 1. Circuit breaker type and ratings as required.
 2. Provide as specified in Section 16412.
- B. Contactors:
 1. NEMA size as required.
 2. Electrically held:
 - a. For lighting loads designed to withstand the initial inrush currents of ballast and lamp loads.
 3. Factory adjusted and chatter free.
 4. Auxiliary contacts:
 - a. Contact ratings as per NEMA A 600 rating:
 - 1) Auxiliary contacts rated 10 amps at 600 volts.
 - b. Provide all contacts necessary for proper operation.
 - c. Provide at least 1 normally open and 1 normally closed spare auxiliary contact.
 5. Constructed in accordance with the following standards:
 - a. UL 508.
 - b. IEC 947-4.
 - 1) Type 1 coordination when protected by a circuit breaker.
 - 2) Type 2 coordination when protected by a suitable UL listed fuse.
 - c. IEC 801-1 parts 2 through 6.
- C. Overloads:
 1. Bi-metallic overload relay:
 - a. Class 20 protection.
 - b. Ambient compensated.
 - c. Interchangeable heater pack:
 - 1) One heater per phase.
 - 2) Coordinate with installed motor full load amps and service factor.
 - d. Visible trip indicator.
 - e. Push-to-trip test.
 - f. Isolated normally open alarm contact.
 - g. Normally closed trip contacts.
 - h. Manual reset.
- D. Control power transformer:
 1. Furnish integral control power transformer capacity to power:
 - a. All motor controls.
 - b. Motor winding heaters, through a normally closed auxiliary contact on the starter.
 - c. Cabinet heater.
 2. Primary and secondary fusing:
 - a. Fusing sized by the manufacturer for the rating of the transformer furnished.

3. Control power transformer secondary voltage:
 - a. 120 VAC.

2.07 ACCESSORIES

- A. Lugs and terminals:
 1. For all external connections of No. 6 AWG and larger.
 2. UL listed for either copper or aluminum conductors.
- B. Surge protective devices:
 1. Furnish surge protection devices across the coil of each starter, contactor, and relay.
- C. Pilot devices:
 1. Provide pilot lights, switches, elapsed time meters, and other devices as specified.
 2. As specified in Section 17710.
- D. Nameplates and wire markers:
 1. As specified in Section 16075.
- E. Conformal coating:
 1. Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as protection against moisture, dust, temperature extremes, and chemicals such as H₂S and chlorine.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050.
- B. Starters in control panels:
 1. Install as specified in Section 17710.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

- A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING

- A. As specified in Section 16050.
- B. Demonstrate operation of equipment as specified in Section 01756:
 - 1. Demonstrate the operation of every motor starter to the Engineer's and Owner's satisfaction.
- C. Training:
 - 1. Provide the services of the manufacturer's technical representative for training purposes.

3.11 PROTECTION

- A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

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SECTION 16445

PANELBOARDS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Panelboards serving utilization equipment at the voltage levels and configurations required by equipment specs.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the responsibility of the supplier and its subcontractors to review all sections to ensure a complete and coordinated package.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures - Procurement.
 - b. Section 16050 - Common Work Results for Electrical.
 - c. Section 16075 - Electrical Identification.
 - d. Section 16285 - Surge Protective Devices.
 - e. Section 16412 - Low Voltage Molded Case Circuit Breakers.

1.02 REFERENCES

- A. As specified in Section 16050.
- B. Underwriter's Laboratories, Inc. (UL):
 - 1. 67 - Standard for Panelboards.

1.03 DEFINITIONS

- A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

- A. Circuit breaker panelboards as required by packaged equipment specifications:
 - 1. Service voltage and configuration as required.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 16050.
- B. Product data:
 - 1. Manufacturer of panelboard.
 - 2. Bill of material.

3. Assembly ratings including:
 - a. Voltage.
 - b. Phase.
 - c. Continuous current.
 - d. Short circuit interrupting rating.
 4. NEMA enclosure type.
 5. Cable terminal sizes based upon actual feeder and sub-feeder conductors used.
 6. Furnish circuit breaker submittals as specified in Section 16412.
 7. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in Section 16050:
 - a. Manufacturer's statement of seismic qualification with substantiating test data.
 - b. Manufacturer's special seismic certification with substantiating test data.
- C. Shop drawings:
1. Drawings to contain:
 - a. Overall panelboard dimensions, interior panel dimensions, and wiring gutter dimensions:
 - 1) Height.
 - 2) Length.
 - 3) Width.
 - b. Weight.
 - c. Anchoring locations.
 - d. Breaker layout drawing with dimensions:
 - 1) Location of the main, branches, solid neutral, and ground.
 - e. Conduit entry/exit locations.
 - 1) Identify all conduit entry/exit locations and restrictions.
 - f. Individual panel schedules identifying breaker locations, ratings, and nameplate designations within the panelboard, for every panelboard.
- D. Installation instructions:
1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
 2. For equipment installed in structures designated as seismic design category A or B:
 - a. Provide manufacturer's installation instructions and anchoring details for connecting equipment to supports and structures.
 3. For equipment installed in structures designated as seismic design category C, D, E, or F:
 - a. Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section 16050.
 - b. Submit anchoring drawings with supporting calculations.
 - c. Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.
- E. Operations and maintenance manual:
1. Provide a complete manual for the operation and maintenance of the panelboard, circuit breakers, devices, and accessories:
 - a. Including but not limited to:
 - 1) Instruction narratives and bulletins.

- 2) Renewal parts lists.
- 3) Time-current curves for all devices.

F. Calculations:

1. Detailed calculations or details of the actual physical testing performed on the panelboard to prove the panelboard is suitable for the seismic requirements at the Project Site.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050.
- B. Panelboards shall be UL listed and labeled.
- C. Provide SPD units that are designed, manufactured, tested and installed in compliance with the following codes and standards:
 1. Institute of Electrical and Electronics Engineers (IEEE C62.41, C62.45, C62.62).
 2. Federal Information Processing Standards Publication 94 (FIPS PUB 94).
 3. National Electrical Manufacturer Association.
 4. National Fire Protection Association (NFPA 20, 75 and 780).
 5. National Electric Code (NFPA 70).
 6. Underwriters Laboratories (UL 1449 3rd Edition and UL 1283).
 7. International Electrotechnical Commission (IEC 801).

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050.

1.12 SYSTEM START-UP

- A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Panelboards: One of the following or equal:
 - 1. Eaton/Cutler-Hammer.
 - 2. General Electric Company.
 - 3. Schneider Electric/Square D Company.
- B. Circuit breakers:
 - 1. Same manufacturer as the panelboard.
- C. Surge Protective Devices: One of the following or equal:
 - 1. Liebert.
 - 2. Eaton/Cutler-Hammer.
 - 3. Schneider Electric/Square D.
 - 4. General Electric.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS]

- A. Provide Type 1 or Type 2 SPD units as required for the locations installed.
- B. Electrical requirements:
 - 1. SPD ratings are to be consistent with the nominal system operating voltage, phase, and configuration.
 - 2. MCOV:
 - a. For the SPD and all components in the suppression path (including all MOVs, SADs, and selenium cells): Greater than 115 percent of the nominal system operating voltage.
 - 3. Operating frequency:
 - a. 47 to 63 hertz.
 - 4. SCCR:
 - a. 65 kAIC minimum, but not less than the equipment it is connected to.
 - b. The SCCR shall be marked on the SPD in accordance with UL 1449 and the NEC.
 - 5. Nominal discharge current I_n :
 - a. 20 kA.
 - 6. Maximum VPR:

Modes	<u>240/120</u>	<u>208Y/120</u>	480Y/277
L-N, L-G, N-G	900	900	1,500
L-L	1,200	1,200	2000
 - 7. Peak surge current:
 - a. Branch locations:
 - 1) 120 kA per phase, minimum.
 - 2) 60 kA per mode minimum.

- C. Protection modes:
 - 1. Provide SPD protection modes as follows:
 - a. Line to Neutral (L-N) where applicable.
 - b. Line to Ground (L-G).
 - c. Neutral to Ground (N-G), where applicable.
- D. Environmental requirements:
 - 1. Storage temperature:
 - a. -40 degrees to +50 degrees Celsius.
 - 2. Operating temperature:
 - a. -0 degrees to +60 Celsius.
 - 3. Relative humidity:
 - a. 5 percent to 95 percent.
 - 4. Audible noise:
 - a. Less than 45 dBA at 5 feet (1.5 m).
 - 5. Operating altitude:
 - a. Zero to 12,000 feet above sea level.
- E. Provide surge protective devices that are suitable for application in IEEE C62.41 Category A, B and C3 environments, as tested to IEEE C62.45.

2.05 EQUIPMENT

- A. Provide panelboards with:
 - 1. Molded-case circuit breakers.
 - 2. Spares and spaces for any future circuit breakers required.
- B. Short circuit rating:
 - 1. Provide panelboards with the following minimum short-circuit ratings:
 - a. 120/208 VAC or 120/240 VAC: 18 KAIC.
 - b. 480 VAC or 277/480 VAC: 65 KAIC.
 - 2. Testing method in accordance with UL 67.
 - 3. Mark each panelboard with its maximum short circuit rating at the supply voltage.
 - 4. Panelboards shall be fully rated.

2.06 COMPONENTS

- A. Enclosure:
 - 1. NEMA enclosure type:
 - a. As specified in Section 16050 for the installed location.
 - 2. Minimum width: 20 inches.
 - 3. Gutter space in accordance with the NEC:
 - a. Minimum of 4 inches of gutter space.
 - 4. Dead-front, no live parts when the panelboard is in service.
 - 5. Enclose entire panelboard bus assembly in a corrosion resistant galvanized steel cabinet.
 - 6. 4-piece front to provide ease of wiring access.
 - 7. Lockable, hinged door over the protective devices with a flush, cylinder tumbler-type lock with catch and door pull.
 - a. Minimum 2 keys per panelboard.
 - b. Key all panelboard locks alike.

8. Circuit directory frame and card on the inside of the door.
 9. Interior design such that replacement of circuit breakers does not require disturbing adjacent units or removal of the main bus connectors.
 10. Provide NEMA Type 4X enclosures with a NEMA Type 4X stainless steel outer enclosure (with a hinged door) and a NEMA Type 1 interior panelboard.
- B. Bus:
1. General:
 - a. Tin-plated copper.
 2. Phase bus:
 - a. Full size and height without reduction.
 - b. Sized in accordance with UL standards to limit temperature rise on any current carrying part to a maximum of 50 degrees Celsius:
 - 1) Limit current density to less than 1,000 amps per square inch.
 - c. Insulate all current carrying parts from ground and phase-to-phase with a high dielectric strength insulator.
 3. Ground bus:
 - a. Copper, solidly bonded.
 4. Neutral bus:
 - a. Provide where required.
 - b. 200 percent rated.
 - c. Provide lugs for each outgoing feeder requiring a neutral connection.
 5. Provide insulation barriers over the vertical bus behind the dead front shield to provide increased safety during field service.
- C. Lugs:
1. UL listed for copper and aluminum wire:
 - a. Provide lugs rated for 75-degree Celsius terminations.
 - b. Provide bolted or compression main lug terminations as required for the incoming cable size.
- D. Circuit breakers: As specified in Section 16412:
1. Provide all circuit breakers with bolt-on connections:
 - a. Plug-in circuit breakers are not allowed.
- E. SPD Internal connections:
1. Provide low impedance copper plates for intra-unit connections:
 - a. Attach surge modules using bolted connections to the plates for low impedance connections.
 2. Size all connections, conductors, and terminals for the specified surge current capacity.
- F. SPD Surge diversion modules:
1. MOV:
 - a. Where multiple MOVs are used in parallel, utilize computer matched MOVs to within 1 volt variance and tested for manufacturer's defects.
- G. SPD Overcurrent protection:
1. Individually fuse all components, including suppression, filtering, and monitoring components:
 - a. Rated to allow maximum specified nominal discharge current capacity.

- b. Overcurrent protection that limits specified surge currents is not acceptable.

H. Connections:

- 1. Provide terminals to accommodate wire sizes up to #2 AWG.

2.07 ACCESSORIES

A. Surge protective devices:

- 1. Furnish panelboards with surge protective devices.
- 2. Unit status indicators:
 - a. Provide red and green solid-state indicators, with printed labels, on the front cover to redundantly indicate on-line unit status:
 - 1) The absence of the green light and the presence of the red light indicate that surge protection is reduced and service is needed to restore full operation.
 - 2) Indicates the status of protection on each mode or phase.
- 3. Provide an audible alarm which activates under any fault condition.
 - a. Provide an alarm On/Off switch to silence the alarm.
 - b. A visible LED will confirm whether alarm is On or Disabled.
 - c. Locate both switches and the audible alarm on the unit's front cover.

B. Nameplates:

- 1. As specified in Section 16075.
- 2. Install on outside of door.
- 3. Indicating:
 - a. Panel designation.
 - b. Voltage.
 - c. Number of phases and configuration.

C. Circuit identification labels:

- 1. Provide index cards behind heavy clear plastic in cardholders on the inside of the doors.
- 2. Type all information on the cards using equipment tag designations.
- 3. Laminated on both sides.

D. Pad locking mechanism:

- 1. Provide a pad locking attachment to allow circuit breakers to be locked in the off position.
- 2. At a minimum, provide 1 mechanism per panelboard:
 - a. Provide multiple mechanisms if required to accommodate all circuit breaker frame sizes in the panelboard.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES

- A. Finish stand-alone panelboards with a primer, rust-resistant phosphate undercoat, and 2 coats of oven-baked enamel with manufacturer's standard gray.

- B. Finish panelboards mounted in motor control centers to match the motor control center finish and color.

2.11 SOURCE QUALITY CONTROL

- A. Perform standard factory tests on the panelboards:
 - 1. Test in accordance with the latest version of NEMA and UL standards.
- B. Permanently affix surge rating to the SPD.
- C. Perform manufacturer's standard factory test for SPDs.
 - 1. Perform testing in accordance with UL 1449.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050.
- B. Install the equipment in accordance with the accepted installation instructions and anchorage details to meet the seismic and wind load requirements at the Project site.
- C. General:
 - 1. Surface, flush or MCC mounted as required.
 - 2. Mount rigidly to structural members with exposed surfaces plumb and level to within 1/32 inch.
 - 3. Perform work in accordance with the manufacturer's instructions and shop drawings.
 - 4. Provide all brackets, hangers, supports, and hardware for mounting as required.
 - 5. In all NEMA Type 4 and NEMA Type 4X locations, mount panelboards on 7/8-inch deep stainless steel preformed channel, with channel running vertically from top to bottom of panelboard:
 - a. Use only stainless steel mounting hardware.
 - 6. Mount panelboard so that top operating handle is not more than 6 feet-7 inches above the operating floor.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 16050.

3.12 SCHEDULES

A. Provide typewritten schedule in each panelboard.

END OF SECTION

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SECTION 16494
LOW VOLTAGE FUSES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Fuses: 600 volt class and lower.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the responsibility of the supplier and its subcontractors to review all sections to ensure a complete and coordinated package.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures - Procurement.
 - b. Section 16050 - Common Work Results for Electrical.

1.02 REFERENCES

- A. As specified in Section 16050.

1.03 DEFINITIONS

- A. As specified in Section 16050.

1.04 SYSTEM DESCRIPTION

- A. Fuses for overcurrent protection and/or current limiting applications as required.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 16050.
- B. Product data:
 - 1. Catalog cut sheets.
 - 2. Complete fuse schedule.
 - 3. Manufacturer original 11-inch by 17-inch, time current curves for all fuses furnished.
- C. Shop drawings:
 - 1. Include drawings of spare fuse cabinets.

1.06 QUALITY ASSURANCE

- A. As specified in Section 16050.

- B. All low voltage fuses shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 16050.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 16050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 16050.

1.12 SYSTEM START-UP

- A. As specified in Section 16050.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

- A. Spare parts:
 - 1. Provide 3 spare fuses for each size and type used or supplied under any Section of the Contract Documents.
 - 2. Provide spare fuse cabinet(s):
 - a. Metal cabinet with hinged door and shelves or fuse holders.
 - b. Gray enamel finish.
 - c. Mount near equipment and label "Spare Fuses" on face of cabinet.
 - d. Suitable pocket inside door of each cabinet with typewritten spare fuse inventory in clear plastic protective insert.
 - e. Provide as many cabinets as required to hold entire spare fuse inventory.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Ferraz Shawmut.
 - 2. Littelfuse.
 - 3. Bussmann.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

A. General:

1. Provide durable, readily visible label inside each fuse enclosure, clearly indicating the correct type, size, and ratings of replacement fuse:
 - a. Label shall not cover or interfere with equipment manufacturer's instructions.
2. Affix a label indicating recommended torque for fuse mounting bolts or studs to the inside of fuse access doors.
3. To ensure selective coordination of protective devices:
 - a. Provide fuses for new facilities by the same manufacturer.
 - b. Provide fuses for renovations of the same manufacturer as existing fuses.
4. Provide fuses rated for the voltage and available short circuit current at which they are applied.

B. Fusing of control circuits:

1. Provide:
 - a. Time-delay Class CC fuses installed in UL listed Class CC fuse blocks as specified in the Contract Documents.
2. Provide minimum protection for control circuits in accordance with the latest revision of UL Standard 508 for Industrial Control.
3. Fuse both the primary and secondary circuit of control power transformers:
 - a. Fuse ratings shall be in accordance with NEC requirements.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 16050.

- B. General:
 - 1. Install fuses properly aligned, electrically and mechanically secure.
 - 2. Evenly torque mounting bolts and nuts to ASTM recommendations for type and diameter of mounting bolts or studs provided.
 - 3. Paralleling of fuses is not permitted.
 - 4. Install fuses so that the fuse nameplate and rating are easily readable in the equipment.
- C. Replace fuses, on all phases, for any fuses that opened during start-up and testing.
- D. After completion of testing, deliver spare fuses in quantities specified:
 - 1. Fuses shall be new, in manufacturer's original packaging, and stored in a clean, dry location.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. As specified in Section 16050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

- A. As specified in Section 16050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

- A. As specified in Section 16050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17050

COMMON WORK RESULTS FOR PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. General requirements applicable to all Process Control and Instrumentation Work.
 - 2. General requirements for process control and instrumentation submittals.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - a. Items involving electrical, control, and instrumentation construction may be indicated on the Drawings or specified in the Specifications that do not apply specifically to electrical, control and instrumentation systems.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Document 00700 - General Conditions.
 - b. Document 00800 - Supplementary Conditions.
 - c. Section 01140 - Work Restrictions.
 - d. Section 01292 - Schedule of Values.
 - e. Section 01312 - Project Meetings.
 - f. Section 01324A - Progress Schedules and Reports.
 - g. Section 01324B - Progress Schedules and Reports.
 - h. Section 01324C - Progress Schedules and Reports.
 - i. Section 01329 - Safety Plan.
 - j. Section 01330 - Submittal Procedures.
 - k. Section 01410 - Regulatory Requirements.
 - l. Section 01450 - Quality Control.
 - m. Section 01610 - Project Design Criteria.
 - n. Section 01612 - Seismic Design Criteria.
 - o. Section 01614 - Wind Design Criteria.
 - p. Section 01756 - Testing, Training, and Facility Start-Up.
 - q. Section 01770 - Closeout Procedures.
 - r. Section 01782 - Operation and Maintenance Data.
 - s. Section 16050 - Common Work Results for Electrical.
 - t. Section 16075 - Electrical Identification.
 - u. Section 16222 - Low Voltage Motors up to 500 Horsepower.
 - v. Section 16950 - Field Electrical Acceptance Tests.
 - w. Section 17100 - Control Strategies.

- x. Section 17101 - Specific Control Strategies.
 - y. Section 17761 - PLC Programming Software.
 - z. Section 17950 - Testing, Calibration, and Commissioning.
- C. Interfaces to equipment, instruments, and other components:
- 1. The Drawings, Specifications, and overall design are based on preliminary information furnished by various equipment manufacturers, which identify a minimum scope of supply from the manufacturers. This information pertains to, but is not limited to, instruments, control devices, electrical equipment, packaged mechanical systems, and control equipment provided with mechanical systems.
 - 2. Provide all material and labor needed to install the actual equipment furnished, include all costs to add any additional instruments, wiring, control system inputs/outputs, controls, interlocks, electrical hardware etc., which may be necessary to make a complete, functional installation based on the actual equipment furnished:
 - a. Make all changes necessary to meet the manufacturer's wiring requirements.
 - 3. Submit all such changes and additions to the Engineer for acceptance as specified in Document 00700.
 - 4. Review the complete set of Drawings and Specifications in order to ensure that all items related to the instrumentation and control systems are completely accounted for. Include any items that appear on Drawings or in Specifications from another discipline in the scope of Work:
 - a. If a conflict between Drawings and Specifications is discovered, refer conflict to the Engineer as soon as possible for resolution.
 - 5. Loop drawings:
 - a. Provide complete loop drawings for all systems, including packaged equipment furnished as part of a vendor furnished package, and for all pre-purchased equipment.
 - b. The form, minimum level of detail, and format for the loop drawings must match that of the sample loop drawings included in the Contract Documents.
- D. All instrumentation, and control equipment and systems for the entire project to comply with the requirements specified in the Instrumentation and Control Specifications, whether referenced in the individual Equipment Specifications or not:
- 1. The requirements of the Instrumentation and Control Specifications apply to all Instrumentation and Control Work specified in other Specifications, including HVAC controls, packaged mechanical systems, LCPs, VCPs, etc.
 - 2. Inform all vendors supplying instrumentation, control systems, panels, and/or equipment of the requirements of the Instrumentation and Control Specifications.
 - 3. The Owner is not responsible for any additional costs due to the failure of the Contractor to notify all subcontractors and suppliers of the Instrumentation and Control Specifications' requirements.
- E. Contract Documents:
- 1. General:
 - a. The Drawings and Specifications are complementary and are to be used together in order to fully describe the Work.

2. Specifications:
 - a. Documents 00700 and 00800 of the Contract Documents govern the Work.
 - b. These requirements are in addition to all General Requirements.
3. Contract Drawings:
 - a. The Instrumentation and Control Drawings show in a diagrammatic manner, the desired locations, and arrangements of the components of the Instrumentation Work. Follow the Drawings as closely as possible, use professional judgment and coordinate with the other trades to secure the best possible installation, use the entire Drawing set for construction purposes.
 - b. Locations of equipment, control devices, instruments, boxes, panels, etc. are approximate only, exercise professional judgment in executing the Work to ensure the best possible installation:
 - 1) The equipment locations and dimensions indicated on the Drawings and elevations are approximate. Use the shop drawings to determine the proper layout, foundation, and pad requirements, etc. for final installation. Coordinate with all subcontractors to ensure that all instrumentation and control equipment is compatible with other equipment and space requirements. Make changes required to accommodate differences in equipment dimensions.
 - 2) The Contractor has the freedom to select any of the named manufacturers as identified in the individual Specifications; however, the Engineer has designed the spatial equipment layout based upon a single manufacturer and has not confirmed that every named manufacturer's equipment fits in the allotted space. It is the Contractor's responsibility to ensure that the equipment being furnished fits within the defined space.
 - c. Installation details:
 - 1) The Contract Drawings include installation details showing means and methods for installing instrumentation and control equipment. For cases where typical details are not provided or compatible with an installed location, develop installation details that are necessary for completing the Work, and submit these details for review by the Engineer.
 - d. Schematic diagrams:
 - 1) All controls are shown de-energized.
 - 2) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.
 - 3) Add slave relays, where required, to provide all necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
 - 4) Mount all devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted or indicated.
 - 5) Control schematics are to be used as a guide in conjunction with the descriptive operating sequences indicated on the Drawings or in the Specifications. Combine all information and furnish a coordinated and fully functional control system.

- F. Alternates/Alternatives:
 - 1. Substitute item provisions as specified in Document 00700.
- G. Changes and change orders:
 - 1. As specified in Document 00700.

1.02 REFERENCES

- A. Code compliance:
 - 1. As specified in Section 01410:
 - a. The publications are referred to in the text by basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of Bid governs.
 - 2. The following codes and standards are hereby incorporated into this Section:
 - a. American National Standards Institute (ANSI).
 - b. American Petroleum Institute (API):
 - 1) RP 550 – Manual on Installation of Refinery Instruments and Control Systems; Part II-Process Stream Analyzers; Section 5-Oxygen Analyzers.
 - 2) RP 551 - Process Measurement Instrumentation.
 - c. International Organization for Standardization (ISO):
 - 1) 9001 - Quality Management Systems - Requirements.
 - d. International Society of Automation (ISA):
 - 1) 5.1 - Instrumentation Symbols and Identification.
 - 2) 5.4 - Instrument Loop Diagrams.
 - 3) 20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.
 - e. National Electrical Manufacturers Association (NEMA):
 - 1) 250 - Enclosures for Electrical Equipment (1000 V Maximum).
 - f. National Fire Protection Association (NFPA):
 - 1) 70 - National Electrical Code (NEC).
 - g. Underwriters Laboratories, Inc. (UL):
 - 1) 508 – Standard of Safety for Industrial Control Equipment.
 - 2) 508A – Standard of Safety for Industrial Control Panels.
- B. Compliance with Laws and Regulations:
 - 1. As specified in Document 00700.

1.03 DEFINITIONS

- A. Definitions of terms and other electrical and instrumentation considerations in accordance with:
 - 1. Factory Mutual (FM).
 - 2. International Electrotechnical Commission (IEC).
 - 3. Institute of Electrical and Electronics Engineers (IEEE).
 - 4. International Society of Automation (ISA).
 - 5. International Organization for Standardization (ISO).
 - 6. National Electrical Code (NEC).
 - 7. National Electrical Manufacturers Association (NEMA).
 - 8. InterNational Electrical Testing Association (NETA).
 - 9. National Fire Protection Association (NFPA).
 - 10. National Institute of Standards and Technology (NIST).

11. Underwriters Laboratories (UL).

B. Specific definitions:

1. Control circuit: Any circuit operating at 120 volts alternating current (VAC) or direct current (VDC) or less, whose principal purpose is the conveyance of information (including performing logic) and not the conveyance of energy for the operation of an electrically powered device.
2. Panel: An instrument support system that may be a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems. Unless otherwise specified or clearly indicated by the context, the term "panel" in these Contract Documents is interpreted as a general term, which includes flat surfaces, enclosures, cabinets and consoles.
3. Power circuit: Any circuit operating at 90 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.
4. Signal circuit: Any circuit operating at less than 50 VAC or VDC, which conveys analog information or digital communications information.
5. Digital bus: A communication network, such as Profibus, Foundation Fieldbus, or DeviceNet, allowing instruments and devices to transmit data, control functions and diagnostic information.
6. 2-Wire transmitter (loop powered): A transmitter that derives its operating power supply from the signal transmission circuit and requires no separate power supply connections. As used in this Section, two-wire transmitter refers to a transmitter that provides 4 to 20 milliamperes current regulation of a signal in a series circuit with an external 24 VDC driving potential:
 - a. Fieldbus communications signal or both.
7. Powered transmitters: A transmitter that requires a separate power source (120 VAC, 240 VAC, etc.) in order for the transmitter to develop its signal. As used in this Section, the produced signal may be a 4 to 20 milliampere current signal, a digital bus communications signal or both.
8. System supplier - As specified in ICSC Qualifications in the Quality Assurance article of this Section.

C. Acronym definitions:

1. CCS: The SCADA central computer system (CCS) consisting of personal computers and software. The personal computer-based hardware and software system that includes the operator interface, data storage, data retrieval, archiving, alarming, historian, reports, trending, and other higher level control system software and functions.
2. DPDT: Double-pole, double-throw.
3. ES: Enterprise system: Computer based communications or data sharing system utilized for non-process control functions such as E-mail, sharing files, creating documents, etc.
4. FAT: Factory acceptance test.
5. HART: Highway addressable remote transducer.
6. HOA: Hand-Off-Auto control function that is totally PLC based. In the Hand mode, equipment is started or stopped, valves are opened or closed through operator direction under the control of the PLC software. In the Auto mode, equipment is started or stopped and valves are opened or closed through a control algorithm within the

- PLC software. In the Off mode, the equipment is prohibited from responding from the PLC control.
7. HMI: Human machine interface: PLC based operator interface device consisting of an alphanumeric or graphic display with operator input functionality. The HMI is typically a flat panel type of display mounted on the front of a PLC enclosure with either a touch screen or tactile button interface.
 8. ICSC: Instrumentation and control system contractor: Subcontractor who specializes in the design, construction, fabrication, software development, installation, testing, and commissioning of industrial instrumentation and control systems.
 9. IJB: Instrument junction boxes: A panel designed with cord sets to easily remove, replace or relocate instrument signals.
 10. I/O: Input/Output.
 11. IP: Internet protocol or ingress protection.
 12. LCP: Local control panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
 13. LAN: Local area network: A control or communications network that is limited to the physical boundaries of the facility.
 14. LOR: Local-Off-Remote control function. In the Remote mode, equipment is started or stopped, and valves are opened or closed through the PLC based upon the selection of the HOA. In the Local mode, equipment is started or stopped, valves are opened or closed based upon hardwired control circuits completely independent of the PLC with minimum interlocks and permissive conditions. In the Off mode, the equipment is prohibited from responding to any control commands.
 15. NJB: Network junction box. An enclosure that contains multiple access points to various networks within the facility. Networks could be Ethernet, Ethernet/IP, Fieldbus, RIO etc.
 16. OIT: Operator interface terminal: PC-based interface device used for operator interface with the SCADA system.
 17. P&ID: Process and instrumentation diagram.
 18. PC: Personal computer.
 19. PCIS: Process control and instrumentation system: Includes the entire instrumentation system, the entire control system, and all of the Work specified in the Instrumentation and Control Specifications and depicted on the Instrumentation Drawings.
 20. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
 21. PJB: Power junction box: An enclosure with terminal blocks that distribute power to multiple instruments.
 22. PLC: Programmable logic controller.
 23. RIO: Remote I/O device for the PLC consisting of remote I/O racks, or remote I/O blocks.
 24. RTU: Remote telemetry unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
 25. SCADA: Supervisory control and data acquisition system: A general name for the computerized system that gathers and processes data from sensors and applies operational controls to the process equipment.

- It includes the PLCs and/or RTUs, HMI PLC-based operator interface units, related interconnecting communications systems, and the CCS operator interface and data management system.
- 26. SPDT: Single-pole, double-throw.
 - 27. SPST: Single-pole, single-throw.
 - 28. UPS: Uninterruptible power supply.
 - 29. VCP: Vendor control panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.
 - 30. WAN: Wide area network: A control or communications network that extends beyond the physical boundaries of the facility.

1.04 SYSTEM DESCRIPTION

A. General requirements:

1. The Work includes everything necessary for and incidental to executing and completing the Instrumentation and Control System Work indicated on the Drawings and specified in the Specifications and reasonably inferable there from including but not limited to:
 - a. Preparing hardware submittals for field instrumentation.
 - b. Design, develop, and draft loop drawings, control panel designs, and all other drawing submittals specified in the Instrumentation and Control Specifications.
 - c. Prepare the test plan, the training plan, and the spare parts submittals.
 - d. Procure all hardware.
 - e. Provide all PCIS system hardware and software.
 - f. Fabricate panels.
 - g. Perform factory tests on panels.
 - h. Perform bench calibration and verify calibration after installation.
 - i. Oversee and certify installation of the PCIS system.
 - j. Oversee, document, and certify loop testing.
 - k. Oversee, document, and certify system pre-commissioning.
 - l. Conduct the performance tests.
 - m. Prepare operation and maintenance manuals.
 - n. Conduct training classes.
 - o. Prepare Record Drawings.
 - p. Integrate the PCIS with instrumentation and control devices provided under other sections.
 - q. Develop all requisite loop drawings and Record Drawings associated with equipment provided under the Contract Documents and Owner furnished and existing equipment.
 - r. Resolve signal, power, or functional incompatibilities between the PCIS and interfacing devices.
 - s. Perform all required corrective and preventative maintenance.
2. It is the intent of these Specifications that the entire electrical power, instrumentation, and control system be complete and operable. Provide all necessary material and labor for the complete system from source of power to final utilization equipment, including all connections, testing, calibration of all equipment furnished by others, as well as equipment furnished by the Contractor, whether or not specifically mentioned but which are necessary for successful operation.

3. Coordinate all aspects of the Work between Contractor and all subcontractors before bidding to ensure that all costs associated with a complete installation are included. The Owner is not responsible for any change orders due to lack of coordination of the Work between the Contractor, the ICSC, the other subcontractors or suppliers.
4. Furnish detailed, complete, and thorough operations and maintenance documentation, including but not limited to operations manuals, maintenance manuals, as-built wiring drawings, training manuals, as-built software documentation, and all other documentation required to operate, modify, and maintain all parts of the PCIS.
5. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment.
 - a. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc) before performing any Work.
 - b. Provide and document interface with, modifications to, upgrade, or replacement of existing circuits, power systems, controls, and equipment.
6. Revise in a manner as directed by the Engineer all I/O and addressing that the Engineer determines to be unacceptable as a result of a lack of Contractor coordination between Contract Documents and all suppliers.
7. Defective Work:
 - a. As specified in Document 00700.

B. New system:

1. Membrane Biological Reactor (MBR).

1.05 SUBMITTALS

A. Furnish submittals as specified in Section 01330 and this Section.

B. General:

1. Instruct all equipment suppliers of submittals and operation and maintenance manuals of the requirements in this Section.
2. Furnish the submittals required by each section in the Electrical Specifications.
3. Adhere to the wiring numbering scheme specified in Section 16075 throughout the Project:
 - a. Uniquely number each wire.
 - b. Wire numbers must appear on all Equipment Drawings.
4. Use equipment and instrument tags, as indicated on the Drawings, for all submittals.

C. Submittal organization:

1. First page:
 - a. Specification section reference.
 - b. Name and telephone number of individual who reviewed submittal before delivery to Engineer.
 - c. Name and telephone number of individual who is primarily responsible for the development of the submittal.
 - d. Place for Contractor's review stamp and comments.
2. Next pages:
 - a. Provide confirmation of specification compliance in a tabular form that individually lists each specification section, paragraph, and sub-

paragraphs and unequivocally states compliance with said requirement or takes exception to the requirement and lists the reason for said exception and offers alternative means for compliance.

- b. Include a response in writing to each of the Engineer's comments or questions for submittal packages which are re-submitted:
 - 1) In the order that the comments or questions were presented throughout the submittal.
 - 2) Referenced by index section and page number on which the comment appeared.
 - 3) Acceptable responses to Engineer's comments are either:
 - a) Engineer's comment or change is accepted and appropriate changes are made.
 - b) Explain why comment is not accepted or requested change is not made.
 - c) Explain how requirement will be satisfied in lieu of comment or change requested by Engineer.
 - 4) Any re-submittal, which does not contain responses to the Engineer's previous comments shall be returned for Revision and Re-submittal.
 - 5) No further review by the Engineer will be performed until a response for previous comments has been received.

3. Remaining pages:

a. Actual submittal data:

- 1) Organize submittals in exactly the same order as the items are referenced, listed, and/or organized in the specification section.
- 2) For submittals that cover multiple devices used in different areas under the same specification section, the submittal for the individual devices must list the area where the device is intended to be used.

D. Submittal requirements:

1. Furnish submittals that are fully indexed with a tabbed divider for every component.
2. Sequentially number pages within the tabbed sections. Submittals and operation and maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.
3. Furnish submittals in the following general order, each in a separate bound set:
 - a. Schedule of Values.
 - b. Product Data.
 - c. After approval of the Product Data, submit the Project Shop Drawing submittals.
 - d. Loop Description Submittal.
 - e. The Process Control and SCADA Software Submittal including, control system software, programming, and screens.
 - f. Testing, Calibration and Start-up procedures.
 - g. Operation and Maintenance Data.
 - h. Training Submittals.
 - i. Record Documents.

4. Edit all submittals and operation and maintenance manuals so that the submittal specifically applies to only the equipment furnished.
 - a. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
 5. Submit copies of shop drawings, and product data:
 - a. Show dimensions, construction details, wiring diagrams, controls, manufacturers, catalog numbers, and all other pertinent details.
 6. Where submittals are required, provide a separate submittal for each specification section. In order to expedite construction, the Contractor may make more than 1 submittal per specification section, but a single submittal may not cover more than 1 specification section:
 - a. The only exception to this requirement is when 1 specification section covers the requirements for a component of equipment specified in another section. (For example, circuit breakers are a component of switchgear. The switchgear submittal must also contain data for the associated circuit breakers, even though they are covered in a different specification section.)
 7. Exceptions to Specifications and Drawings:
 - a. Include a list of proposed exceptions to the Specifications and Drawings along with a detailed explanation of each.
 - b. If there is insufficient explanation for the exception or deviation, the submittal will be returned requiring revision and re-submittal.
 - c. Acceptance of any exception is at the sole discretion of the Engineer.
 - 1) Provide all items (materials, features, functions, performance, etc.) required by the Contract Documents that are not accepted as exceptions.
 - d. Replace all items that do not meet the requirements of the Contract Documents, which were not previously accepted as exceptions, even if the submittals contained information indicating the failure to meet the requirements.
- E. Submittal preparation:
1. During the period of preparation of submittals, the Contractor shall authorize direct, informal liaison between the ICSC and the Engineer for exchange of technical information. As a result of this liaison, certain minor refinements and revisions may be authorized informally by the Engineer, which do not alter the scope of Work or cause increase or decrease in the Contract price or times. During this informal exchange, no oral statement by the Engineer shall be construed to give formal approval of any component or method, nor shall any statement be construed to grant exception to, or variation from, these Contract Documents.
 2. In these Contract Documents, some items of Work are represented schematically, and are designated for the most part by numbers, as derived from criteria in ISA-5.1:
 - a. Employ the nomenclature and numbers designated in this Section and on the Drawings exclusively throughout shop drawings, data sheets, and similar submittals.
 - b. Replace any other symbols, designations, and nomenclature unique to a manufacturer's, suppliers, or subcontractor's standard methods with those identified in this Section and on the Drawings.

- F. Specific submittal requirements:
1. Shop drawings:
 - a. Required for materials and equipment listed in this and other sections.
 - b. Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.
 - c. Shop drawings requirements:
 - 1) Front, side, and, rear elevations, and top and bottom views, showing all dimensions.
 - 2) Locations of conduit entrances and access plates.
 - 3) Component layout and identification.
 - 4) Schematic and wiring diagrams with wire numbers and terminal identification.
 - 5) Connection diagrams, terminal diagrams, internal wiring diagrams, conductor size, etc.
 - 6) Anchoring method and leveling criteria, including manufacturer's recommendations for the Project site seismic criteria.
 - 7) Weight.
 - 8) Finish.
 - 9) Nameplates:
 - a) As specified in Section 16075.
 - 10) Temperature limitations, as applicable.
 - d. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
 - e. Adhere to wiring numbering scheme outlined in Section 16075 throughout the Project:
 - 1) Uniquely number each wire per the Specifications.
 - f. Wire numbers must appear on all equipment drawings.
 - g. Organize the shop drawing submittals for inclusion in the Operation and Maintenance Manuals:
 - 1) Furnish the initial shop drawing submittal bound in one or more standard size, 3-ring, D-ring, loose leaf, vinyl plastic, hard cover binders suitable for bookshelf storage.
 - 2) Binder ring size: 2 inches.
 - h. Include the letterhead and/or title block of the firm responsible for the preparation of all shop drawings. Include the following information in the title block, as a minimum:
 - 1) The firm's registered business name.
 - 2) Firm's physical address, email address, and phone number.
 - 3) Owner's name.
 - 4) Project name and location.
 - 5) Drawing name.
 - 6) Revision level.
 - 7) Personnel responsible for the content of the drawing.
 - 8) Date.
 - i. The work includes modifications to existing circuits:
 - 1) Clearly show all modifications to existing circuits.
 - 2) In addition, show all existing unmodified wiring to clearly depict the functionality and electrical characteristics of the complete modified circuits.

2. Product data:
 - a. Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.
 - b. Include:
 - 1) Catalog cuts.
 - 2) Bulletins.
 - 3) Brochures.
 - 4) Quality photocopies of applicable pages from these documents.
 - 5) Identify on the data sheets the Project name, applicable specification section, and paragraph.
 - 6) Identify model number and options for the actual equipment being furnished.
 - 7) Neatly cross out options that do not apply or equipment not intended to be supplied.
 - c. Use equipment and instrument tags as depicted on the P&IDs for all submittals.
 - d. Adhere to wiring numbering scheme outlined in Section 16075 throughout the Project:
 - 1) Uniquely number each wire per the Specifications.
 - e. Wire numbers must appear on all equipment drawings.
3. Detailed sequence of operation for all equipment or systems.
4. Completed Motor Data Sheet, as specified in Section 16222, for every motor furnished:
 - a. Submit one copy of the Motor Data Sheet to the Engineer for review as part of the associated equipment submittal.
5. Operation and maintenance manuals:
 - a. As specified in Section 01782.
 - b. Furnish the Engineer with a complete set of written operation and maintenance manuals 8 weeks before energization start-up and/or commissioning.
 - c. Submit preliminary sets of these manuals to the Engineer for review of format and content:
 - 1) Engineer will return 1 set with comments.
 - 2) Revise and/or amend as required and submit the requisite number of copies to the Engineer 15 days before Pre-commissioning of the systems.
 - d. Incorporate changes that occur during startup and submit as part of the final manuals.
 - e. Provide comprehensive information on all systems and components to enable operation, service, maintenance, and repair.
 - f. Include Record Documents and the approved shop drawing submittals, modified for conditions encountered in the field during the work.
 - g. Include signed results from Calibration, Loop Validation Tests, Pre-commissioning, and Performance Testing.
 - h. Provide installation, connection, operating, calibration, setpoints (e.g., pressure, pump control, time delays, etc.), adjustment, test, troubleshooting, maintenance, and overhaul instructions in complete detail.
 - i. Provide exploded or other detailed views of all instruments, assemblies, and accessory components together with complete parts lists and ordering instructions.

- j. Operational Manual:
 - 1) Prepare and provide a simplified version of the standard manufacturer's HMI software and system operations manual that includes basic instructions in the application of the system as required for operators in day-to-day operations.
- k. Spare parts list:
 - 1) Include a priced list of recommended spare parts for all the equipment furnished under this Contract:
 - a) Include recommended quantities sufficient to maintain the furnished system for a period of 5 years.
 - 2) Annotate the list to indicate which items, if any and quantity are furnished as part of this Contract.
 - 3) Provide the name, address, and phone number of manufacturer and manufacturer's local service representative of these parts.
- l. Control and PLC System Software Record Documents:
 - 1) Include complete documentation of all the software programs provided for the entire control and PLC systems, including:
 - a) Listings of all application software on both hard copy and CD-ROM.
 - b) Database, both hard copy and CD-ROM.
 - c) Communication protocols.
 - d) All documentation necessary to maintain, troubleshoot, modify, or update the software system.
- m. Organize the operation and maintenance manuals for each process in the following manner:
 - 1) Section A - Process and Instrumentation Diagrams.
 - 2) Section B - Control Descriptions.
 - 3) Section C - Loop Drawings.
 - 4) Section D - Instrument Summary.
 - 5) Section E - Instrument Data Sheets and Brochures.
 - 6) Section F - Sizing Calculations.
 - 7) Section G - Instrumentation Installation Details.
 - 8) Section H - Test Results.
 - 9) Section I - Operational Manual.
 - 10) Section J - Spare Parts List.
 - 11) Section K - Control and PLC System Software.
- 6. Material and equipment schedules:
 - a. Furnish a complete schedule and/or matrix of all materials, equipment, apparatus, and luminaries that are proposed for use:
 - 1) Include sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.
- 7. Itemized instrument summary:
 - a. Submit a hard copy of the instrument summary.
 - b. List all of the key attributes of each instrument including:
 - 1) Tag number.
 - 2) Manufacturer.
 - 3) Model number.
 - 4) Service.
 - 5) Area location.
 - 6) Calibrated range.
 - 7) Loop drawing number.
 - c. Associated LCP, VCP, PCM, or PLC.

8. Instrument data sheets and cut sheets:
 - a. Furnish fully completed data sheets, both electronically in Microsoft Word or Excel and in hardcopy, for each instrument and component according to ISA-20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves. The data sheets provided with the instrument specifications are preliminary and are not complete. They are provided to assist with the completion of final instrument data sheets. Additional data sheets may be required. Include the following information on the data sheet:
 - 1) Component functional description specified in this Section and indicated on the Drawings.
 - 2) Manufacturers model number or other product designation.
 - 3) Tag number specified in this Section and indicated on the Drawings.
 - 4) System or loop of which the component is a part.
 - 5) Location or assembly at which the component is to be installed.
 - 6) Input and output characteristics.
 - 7) Scale range with units and multiplier.
 - 8) Requirements for electric supply.
 - 9) Requirements for air supply.
 - 10) Power consumption.
 - 11) Response timing.
 - 12) Materials of construction and of component parts that are in contact with, or otherwise exposed to, process media, and or corrosive ambient air.
 - 13) Special requirements or features, such as specifications for ambient operating conditions.
 - 14) Features and options that are furnished.
 - b. Provide a technical brochure or bulletin ("cut sheet") for each instrument on the project. Submit with the corresponding data sheets:
 - 1) Where the same make and model of instrument is used in 2 or more applications on the project, and the process applications are nearly identical, and the materials, features and options are identical submit one brochure or bulletin for the set of identical instruments.
 - 2) Include a list of tag numbers for which it applies with each brochure or bulletin.
 - 3) Furnish technical product brochures that are complete enough to verify conformance with all Contract Document requirements, and to reflect only those features supplied with the device.
 - 4) Cross out models, features, options, or accessories that are not being provided.
 - 5) Clearly mark and identify special options and features.
 - c. Organization: Index the data sheets and brochures in the submittal by systems or loops.
9. Control panel hardware submittal:
 - a. Submit the following in 1 submittal package.
 - b. Complete and detailed bills of materials:
 - 1) Including quantity, description, manufacturer, and part number for each assembly or component for each control panel.
 - 2) Include all items within an enclosure.
 - c. Complete grounding requirements for each system component including any requirements for PLCs, process LANs, and SCADA equipment.

- d. Requirements for physical separation between control system components and 120 VAC, 480 VAC, and medium voltage power cables.
 - e. UPS and battery load calculations to show that the backup capacity and time meet the specified requirements.
 - f. Provide a data sheet for each control system component together with a technical product brochure or bulletin, which include:
 - 1) The manufacturer's model number or other identifying product designation.
 - 2) Tag and loop number.
 - 3) System to which it belongs.
 - 4) Site to which it applies.
 - 5) Input and output characteristics.
 - 6) Requirements for electric power.
 - 7) Device ambient operating requirements.
 - 8) Materials of construction.
10. Schedule of values:
- a. In addition to completing all items referred to in the schedule of values, Section 01292, submit per unit instrument and labor costs used in developing the final bid for the PCIS system, for the express purpose of pricing and cost justification for any proposed change orders. It is the responsibility of the ICSC subcontractor to prove to the Engineer's satisfaction that said per unit costs were used in the development of the final Bid amount.
11. Installation recommendations:
- a. Submit the manufacturer's printed recommendations for installation of instrumentation equipment.
12. Training submittals:
- a. Develop and submit for review a general training plan. Include complete descriptions of all planned training classes, a preliminary training schedule, a list of all proposed instructors along with resumes, examples of proposed training manuals, and a description of any special training tools to be used (simulators, self-paced modules, personal computer-based training, etc.).
 - b. The Engineer will review the general training plan. Special emphasis will be placed on review of the qualifications of the proposed instructors and the timing of the individual courses to maximize their effectiveness. If, in the opinion of the Engineer, the proposed instructors are not sufficiently qualified to conduct the specified training courses, or lack experience, where required, on the specific configuration of the system, provide more qualified instructors.
 - c. Training course plan submittals:
 - 1) For each training course or other training activity, submit a detailed, complete outline and agenda for each lesson.
 - 2) Describe any student pre-requisites for the course or training activity.
 - 3) Provide an updated schedule for all sessions of the course, including dates, times, durations, and locations.
 - 4) Submit training materials.
 - d. Incorporate all submittal review comments into the course.
 - e. Do not conduct training courses before review and acceptance of the Course Plan submittal for the course.
13. Record documents:
- a. Furnish as specified in Section 01770.

- b. Provide record documents of all Instrumentation Drawings.
- c. Record Drawing requirements:
 - 1) Update Record Drawings weekly.
 - 2) Record Drawings must be fully updated as a condition of the monthly progress payments.
 - 3) Submit Record Drawings upon completion of the Work for final review.
 - 4) Clearly and neatly show all changes.
- d. Shop drawings:
 - 1) General:
 - a) Coordinate all aspects of the Work so that a complete, instrumentation, computer, and control system for the facility is supported by accurate shop and record drawings:
 - (1) Clearly show every wire, circuit, and terminal provided under this contract on one or more submitted wiring diagrams.
 - b) Show all interfaces between any of the following: instruments, vendor control panels, motor control centers, motor starters, variable speed drives, control valves, flow meters, chemical feeders and other equipment related to the PCIS.
 - c) Generate all drawings developed for this project utilizing AutoCAD by Auto Desk Version 2004 or later:
 - (1) Furnish on CD-ROM disks containing the following for each drawing:
 - (a) Original CAD files
 - (b) PDF version.
 - (2) Provide hard copies on 11 inch by 17 inch plain bond paper.
 - d) Upon completion of the Work, update all shop drawings to indicate the final as-built configuration of the systems:
 - (1) Should an error be found in a shop drawing during installation or startup of equipment, note the correction, including any field changes found necessary, on the drawing and submit the corrections in the Record Documents.
 - (2) Update, check, and revise all wiring drawings and other submitted drawings and documents to show final installed conditions.
 - (3) Provide as-built shop drawings for all instrumentation equipment on 11-inch by 17-inch using Bond paper.
 - (4) Provide electronic copies of these documents on CD-ROM disks in AutoCAD Version 2004 or later by Autodesk. Size all drawings to be readable and legible on 11-inch by 17-inch media.
 - e) Submittal Documents:
 - (1) Provide an interim submittal of Record Documents after the PCIS system Pre-commissioning but prior to testing.
 - (2) Submit final Record Documents before Substantial Completion or earlier if so specified in Section 01782 or the General Requirements.

- f) Review and Corrections:
 - (1) Correct any Record Documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
 - (2) Promptly correct and re-submit Record Documents returned for correction.
 - 2) Furnish written information prepared specifically for this Project using Microsoft Word 2000 and printed on 8.5-inch by 11-inch plain bond paper:
 - a) Provide electronic copies of these documents on CD-ROM disks.
 - e. Review and corrections:
 - 1) Correct any record documents or other documents found to be incomplete, not accurate, of poor quality, or containing errors.
 - 2) Promptly correct and re-submit record documents returned for correction.
- 14. Loop Drawings:
 - a. Submit loop drawings for every analog, discrete, and fieldbus signal and control circuit:
 - 1) Provide a loop drawing submittal that completely defines and documents the contents of each monitoring, alarming, interlock, and control loop on this Project.
 - 2) This requirement applies to all signal and control circuits associated with equipment on this Project including vendor supplied equipment packages and control panels.
 - b. Show every instrument and I/O point on at least one loop diagram.
 - c. Provide a complete index in the front of each bound volume:
 - 1) Index the loop drawings by systems or process areas.
 - d. Provide drawings showing definitive diagrams for every instrumentation loop system:
 - 1) Show and identify each component of each loop or system using requirements and symbols from ISA-5.4.
 - 2) Furnish a separate drawing sheet for each system or loop diagram.
 - e. In addition to the ISA-5.4 requirements, show the following details:
 - 1) Functional name of each loop.
 - 2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.
 - 3) Show all terminal numbers, regardless of the entity providing the equipment.
 - 4) MCC panel, circuit, and breaker numbers for all power feeds to the loops and instrumentation.
 - 5) Designation of and, if appropriate, terminal assignments associated with, every manhole, pull-box, junction box, conduit, and panel through which the loop circuits pass.
 - 6) Show vendor control panel, instrument panel, conduit, junction box, equipment and PCIS terminations, termination identification, wire numbers and colors, power circuits, and ground identifications.
 - 7) If a circuit is continued on another drawing, show the name and number of the continuation drawing on the loop drawing. Provide complete references to all continuation drawings whether vendor control panels, other loop drawings, existing drawings provided by the Owner, or other drawings.

- f. In addition to the above requirements, provide loop diagrams in accordance with the example loop diagram as indicated on the Drawings.
- 15. Instrument Installation Drawings:
 - a. Submit, instrument installation, mounting, and anchoring details for all components and assemblies, including access requirements and conduit connection or entry details.
 - b. Furnish for each instrument a dedicated 8 1/2-inch by 11-inch installation detail that pertains to the specific instrument by tag number.
 - c. For each detail, provide certification and the hard copies, by the instrument manufacturer, that the proposed installation is in accordance with the instrument manufacturer's recommendations and is fully warrantable.
 - d. For each detail, provide, as a minimum, the following contents:
 - 1) Necessary sections and elevation views required to define instrument location by referencing tank, building or equipment names and numbers, and geographical qualities such as north, south, east, west, basement, first floor, etc.
 - 2) Ambient temperature and humidity where the instrument is to be installed.
 - 3) Corrosive qualities of the environment where the instrument is to be installed.
 - 4) Hazardous rating of the environment where the instrument is to be installed.
 - 5) Process line pipe or tank size, service and material.
 - 6) Process tap elevation and location
 - 7) Upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.
 - 8) Routing of tubing and identification of supports.
 - 9) Mounting brackets, stands, anchoring devices, and sun shades.
 - 10) Conduit entry size, number, location, and delineation between power and signal.
 - 11) NEMA ratings of enclosures and all components.
 - 12) Clearances required for instrument servicing.
 - 13) List itemizing all manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.
- 16. Control Panel Drawings:
 - a. Layout Drawings:
 - 1) Submit panel, enclosure, console, furniture, and cabinet layout drawings for all items provided.
 - 2) As a minimum, include the following information:
 - a) To scale front, side, and plan views.
 - b) Dimensions.
 - c) Interior and exterior arrangements.
 - d) Mounting information, including conduit entrance location.
 - e) Finish data.
 - f) Tag number and functional name of items mounted in and on each panel, console, and cabinet.
 - g) Nameplate legend including text, letter size, and colors.
 - b. Wiring and Piping Diagrams:
 - 1) Submit panel wiring and piping diagrams for every panel that contains wiring and/or piping.

- 2) Include the following information:
 - a) Name of panel.
 - b) Wiring and piping sizes and types.
 - c) Terminal strip numbers.
 - d) Wire tags and labels.
 - e) Functional name and manufacturer's designation for items to which wiring and piping are connected.
 - f) Electrical control schematics in accordance with ANSI standards.
- c. Installation drawings:
 - 1) Provide site-specific installation drawings for all control equipment panels, including dimensions.
 - 2) Provide scaled drawings and show the position of the equipment at its intended installation location.
 - 3) Show the placement of all equipment being provided under this Contract and its spatial relationship to all other equipment located in the abutting and adjoining areas.
 - 4) Show all required access and clearances associated with the equipment with a statement of compliance to manufacturer's recommendations, NEC, and other applicable codes.
17. Schematic Diagrams:
 - a. Submit schematic diagrams for all electrical equipment in ladder diagram format.
 - b. Include device and field connection terminal numbers on all schematic diagrams.
 - c. Incorporate equipment manufacturer's shop drawing information into the schematic diagrams in order to document the entire control system.
18. Control System Diagram:
 - a. Submit a complete set of control system diagrams including the following information:
 - 1) All PLCs, workstations, printers, communication devices, and communication links:
 - a) Show all PLCs with their current I/O allocation, and future I/O allocation, current plus spares provided, and maximum potential I/O based on available slots.
 - 2) All cables required for communication requirements.
 - 3) Show each component fully annotated with conduit size and number associated with the power source.
19. Process Control & SCADA Software Submittal:
 - a. In accordance with Product Data and Shop Drawing general requirements.
 - b. Submit a complete description of the standard application software programs, operating system and utility programs, including modifications and explanation of how the specific functional requirements are met:
 - 1) Provide a cross-reference between the Specification requirements and the software submittal, in order to provide the Engineer the ability to identify how each specified requirement or function is met.
 - c. A complete listing of the PCIS system point I/O database:
 - 1) Include for each data point, relevant parameters such as range, contact orientation, limits, incremental limits, I/O card byte, I/O hardware address, and PLC assignment.
 - 2) Organize on a site-by-site basis, separate by point type.

- 3) In addition to the active I/O points, list the implemented spare I/O points and the available I/O points remaining on each card, as well as other defined future points specified or shown.
- d. Detailed descriptions of procedures used to implement and modify control strategies and database construction.
- e. Preliminary overview, screens, station graphic displays, and preliminary reports.
- f. Refer to Section 17762 for additional requirements.
20. Instrumentation and Control System Contractor Statement of Qualifications:
 - a. Submit statement of qualifications of the proposed ICSC in accordance with subsequent requirements of this Section.
21. Control Descriptions:
 - a. For each control loop, provide a detailed functional description of the operation of the equipment, signals, and controls as shown on the P&IDs:
 - 1) Include all functions depicted or described in the Contract Documents.
 - 2) Include within the Control Description content:
 - a) All specific requirements.
 - b) All common requirements that pertain in general to all loops.
 - c) Listing all ranges, setpoints, timers, values, counter values, etc.
22. Testing, Calibration, and Start-up Submittal:
 - a. General testing submittal requirements are specified in this Section. Additional requirements are specified in Section 17950 and other Sections.
 - b. Test Procedure Submittals:
 - 1) Submit the proposed procedures to be followed during tests of the PCIS and its components in two parts:
 - a) Preliminary Submittal: Outline of the specific proposed tests and examples of proposed forms and checklists.
 - b) Detailed Submittal: After successful review of the Preliminary Submittal, submit the proposed detailed test procedures, forms, and checklists. Include a statement of test objectives with the test procedures.
 - c. Provide certified and witnessed test and calibration checklists for each of the following tests:
 - 1) Calibration, adjustment, and test details for all components and systems.
 - 2) Factory Acceptance Tests.
 - 3) Loop Validation Tests:
 - a) Loop Validation Certifications:
 - (1) After the field device loop tests have been successfully completed for all individual instruments, all separate analog control networks, all valves, all VCPs, all motors, all local operator interface panels, all motor control centers, etc., submit a certified copy of all test forms signed by the Contractor, ICSC and the Owner's Representative, with test data entered, together with a clear and unequivocal statement that all instrumentation has been successfully calibrated, inspected, and tested.
 - 4) Pre-commissioning Test.
 - 5) Performance Test.

- d. Factory Acceptance Test:
 - 1) Include complete test procedures and forms to be used during the test.
- 23. Test reports:
 - a. As specified in Section 01330.
 - b. Include the following:
 - 1) A description of the test.
 - 2) List of equipment used.
 - 3) Name of the person conducting the test.
 - 4) Date and time the test was conducted.
 - 5) All raw data collected.
 - 6) Calculated results.
 - 7) Each report signed by the person responsible for the test.
 - c. Additional requirements for acceptance test reports are specified in Section 17950.
- 24. Calculations:
 - a. Where required by specific Instrumentation Specifications:
 - 1) Because these calculations are being provided by a registered professional engineer, they will be reviewed for form, format, and content but will not be reviewed for accuracy and calculation means.
- 25. Factory acceptance test:
 - a. As specified in Section 01330.
 - b. Include complete test procedure and all forms to be used during test.

1.06 QUALITY ASSURANCE

- A. Manufacture instruments at facilities certified to the quality standards of ISO 9001.
- B. Furnish all equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.
- C. The ICSC must have their own operating UL listed panel fabrication facility. All panels must be fabricated at this facility and meet all UL 508/508A requirements.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Store all equipment and materials delivered to the job site in a location that will not interfere with the construction or the Owner's operations.
- B. Shipping precautions:
 - 1. After completion of shop assembly, successful FAT, pack all equipment, cabinets, panels, and consoles in protective crates and enclose in heavy-duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.
 - 2. Place dehumidifiers when required, inside the polyethylene coverings.
 - 3. Skid-mount the equipment for final transport.
 - 4. Provide lifting rings for moving without removing protective covering.
 - 5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.
- C. Special instructions:
 - 1. Securely attach special instructions for proper field handling, storage, and installation to each piece of equipment before packaging and shipment.

- D. Tagging:
 - 1. Tag each component and/or instrument to identify its location, instrument tag number, and function in the system.
 - 2. Firmly attach a permanent tag indelibly machine marked with the instrument tag number, as given in the tabulation, on each piece of equipment constituting the PCIS.
 - 3. Tag instruments immediately upon receipt in the field.
 - 4. Prominently display identification on the outside of the package.
 - 5. Utilize the Tag and Loop Number identifications shown on the P&IDs.
- E. Delivery and inspection:
 - 1. Deliver products in undamaged condition, in manufacturer's original container or packaging with identifying labels intact and legible. Include date of manufacture on label.

1.08 PROJECT OR SITE CONDITIONS

- A. Site conditions:
 - 1. Provide a PCIS, including all equipment, raceways and any other components required for a complete installation that meets the environmental conditions for the Site as specified in the General Requirements and below.
 - 2. Seismic classification:
 - a. Provide all equipment and construction techniques suitable for the seismic requirements for the site, as specified in Section 01612.
 - 3. Wind:
 - a. Provide all equipment and construction techniques suitable for the site wind loading criteria, as specified in Section 01614.
 - 4. Altitude, temperature and humidity:
 - a. As specified in Section 01610.
 - b. Provide all equipment and instrumentation fully rated for continuous operation at this altitude, temperature and humidity conditions with no additional derating factors applied.
 - c. Provide additional temperature conditioning equipment to maintain all equipment and instrumentation in non-conditioned spaces or outdoors subject to these ambient temperatures 10 degrees Fahrenheit above the minimum operating temperature and 10 degrees Fahrenheit below maximum operating temperature as determined by the equipment manufacturer's guidelines:
 - 1) Provide all power wiring for these devices (e.g., heaters, fans, etc.), whether or not indicated on the Drawings.
 - 5. Area classifications:
 - a. Furnish enclosures that match the area classifications as specified in Section 16050.
 - 6. Site security:
 - a. Abide by all security and safety rules concerning the Work on the Site, as specified in Section 01329.

1.09 SEQUENCING

- A. General:
 - 1. As specified in Section 01312.
 - 2. Testing requirements are specified in Section 17950 and other sections.

3. General scheduling requirements are specified in Section 01324A
 4. Work restrictions and other scheduling requirements are specified in Section 01140.
- B. FAT:
1. Before the delivery and installation of the MBR-PCIS system at the job site, but after the procurement, assembly, and configuration of all components, perform the FAT testing.
 2. Schedule the FAT after receiving approval of the FAT procedures submittal.
 3. Submit a copy of the test procedures including all forms at least 21 days before any scheduled test date.
 4. Notify the Engineer of scheduled tests a minimum of 15 days before the date of the test.
- C. Training:
1. As specified in Section 01756.
 2. Complete all training before the pre-commissioning phase of the project may start.
 3. Schedule the training sessions a minimum of [15] days before the start date of the courses.
 4. Submit training manuals to the Engineer a minimum of 10 days before starting the training session.
 5. Within 10 days after the completion of each session, submit the following:
 - a. A list of all Owner personnel that attended the session.
 - b. A copy of the training materials utilized during the lesson with all notes, diagrams, and comments.
- D. Pre-commissioning test:
1. Commence after acceptance of all training, wire test, calibration tests, and loop validation tests, and all inspections have demonstrated that the PCIS complies with all Contract requirements.
 2. Acceptance of the PCIS pre-commissioning testing must be provided in writing by the Engineer before the performance testing may begin.
- E. Provide all special tools and spare parts, as specified in the Maintenance paragraph of this Section, before performance testing commences, suitably wrapped and identified.
- F. Performance testing:
1. Complete pre-commissioning test a minimum of 7 days before the performance test.
- G. Substantial completion: The following conditions be fulfilled before the PCIS is considered complete:
1. All submittals have been completed and approved.
 2. The PCIS has been calibrated, loop tested and pre-commissioned.
 3. The Owner training has been performed.
 4. All required spare parts, expendable supplies, and test equipment have been delivered to the Owner.
 5. The performance test has been successfully completed.
 6. All debris associated with installation of instrumentation has been removed.

7. All probes, elements, sample lines, transmitters, tubing, and enclosures have been cleaned and are in like-new condition.

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. Warrant the PCIS as specified in Document 00700:
 1. Provide additional warranty as specified in the individual Instrumentation and Control Specifications.

1.12 SYSTEM START-UP

- A. Replace or modify equipment, software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:
 1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the Engineer.

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

- A. Before Substantial Completion, perform all maintenance activities required by the Contract Documents including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.
- B. Furnish all spare parts as required by the Contract Documents.
- C. Provide additional spare parts specified in other sections of the Instrumentation and Control Specifications.
- D. Submit all special tools and spare parts, suitably wrapped and identified, before performance testing commences.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Provide similar items from a single manufacturer throughout the PCIS portion of the Project.
- B. Allowable manufacturers are specified in individual instrument and equipment specifications in other sections of the Instrumentation and Control Specifications.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS

- A. Furnish all materials under this Contract that are new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these devices and that bear all approvals and labels as required by the Specifications.
- B. Provide materials complying with the applicable industrial standard as specified in the Contract Documents.

2.04 MANUFACTURED UNITS (NOT USED)

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS

- A. Furnish all meters, instruments, and other components that are the most recent field proven models marketed by their manufacturers at the time of submittal of the shop drawings unless otherwise specified to match existing equipment.
- B. Unless otherwise specified, furnish individual instruments that have a minimum accuracy of within 0.5 percent of full scale and a minimum repeatability of within 0.25 percent of full scale.
- C. Signal transmission:
 - 1. Analog signals:
 - a. Furnish analog measurements and control signals that vary in direct linear proportion to the measured variable, unless otherwise indicated.
 - b. Furnish electrical analog signals outside control panels that are 4 to 20 milliamperes 24 VDC, except as indicated.
 - c. Analog signals within enclosures may be 1 to 5 VDC.
 - d. Electrically or optically isolate all analog signals from other signals.
 - e. Furnish regulated analog signals that are not affected by changes in supply voltage or load resistance within the unit's rating.
 - f. Maintain the total 4 to 20 milliamperes loop impedance to 10 percent below the published value at the loop operating voltage.
 - g. Where necessary, reduce loop impedance by providing current-to-current (I/I) isolation amplifiers for signal re-transmission.
 - 2. All pneumatic signals: 3 to 15 pounds per square inch gauge.
 - 3. Discrete input signal as indicated in the controller hardware specification.
 - 4. Discrete output signals:
 - a. Dry contacts or TRIAC outputs (with express written approval by the Engineer) as needed to coordinate with the field device.
 - b. Provide external terminal block mounted fuse with blown fuse indication for all discrete outputs.
 - c. Provide interposing relays for all discrete outputs for voltage and/or current compatibilities.
 - d. Provide interposing relays as required for functionality of the control circuit.

- D. Discrete circuit configuration:
 - 1. Configure discrete control circuits to fail safe, on loss of continuity or loss of power.
 - 2. Alarm contacts: Fail to the alarm condition.
 - 3. Control contacts fail to the inoperative condition unless otherwise indicated on the Drawings.
- E. Grounding:
 - 1. Provide control panels with a signal ground bus, isolated from the power ground bus:
 - a. Provide multiple panels in one location with a common point for signal ground bus connection to ground.
 - 2. Ground single point ground shields and measurement loops at the source panel external terminals, unless otherwise noted, by bonding to the control panel signal ground bus.
 - 3. Provide isolating amplifiers within control panels for field equipment possessing a grounded input or output, except when the panel circuit is galvanically isolated.

2.07 ACCESSORIES

- A. Provide flow conditioning devices or other required accessories if necessary to meet the accuracy requirements in the Contract Documents.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. Provide all equipment that is new, free from defects, and standard products produced by manufacturers regularly engaged in the production of these products that bear all approvals and labels as required by the Specifications.
- B. Arrange with all manufacturers of the equipment and fabricators of panels and cabinets, to allow the Owner and Engineer to inspect and witness the testing of the equipment at the site of fabrication:
 - 1. Equipment includes the cabinets, special control systems, flow measuring devices, and other pertinent systems and devices.
- C. Factory testing is specified in Section 17950 and other sections of the Electrical, and the Instrumentation and Control Specifications.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Visit the site and examine the premises completely before bidding. It is the ICSC's responsibility to be fully familiar with the existing conditions and local requirements and regulations.

- B. Review the existing Site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.
- C. Provide a complete instrumentation and control system:
 - 1. Install all extra conduits, cables, and interfaces as may be necessary to provide a complete and operating electrical, and process control and instrumentation system.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Equipment locations indicated on the Drawings may change due to variations in equipment size or minor changes made by others during construction:
 - 1. Verify all dimensions as indicated on the Drawings:
 - a. Actual field conditions govern all final installed locations, distances, and levels.
 - 2. Review all information indicated on the Drawings, including architectural, structural, mechanical, instrumentation, and the accepted electrical, instrumentation, and mechanical shop drawings, and coordinate Work as necessary to adjust to all conditions that arise due to such changes.
 - 3. Make minor changes in location of equipment before rough in, as directed by the Owner or Engineer.
- B. Perform all related Electrical Work in accordance with the applicable sections of the Electrical Specifications.
- C. The PCIS configurations are diagrammatic:
 - 1. The locations of equipment are approximate unless dimensioned.
 - 2. Where Project conditions require, make reasonable changes in locations and arrangements.
- D. Field instruments installation:
 - 1. Install field instruments as specified in the Contract Documents, API RP 550 and RP 551, and the manufacturer's instructions.
 - 2. Mount field instruments so that they can be easily read, readily approached, and easily serviced, and so they do not restrict access to mechanical equipment:
 - a. Mount field instruments on a pipe stand or local panel, if they are not directly mounted, unless otherwise indicated on the Drawings.
 - b. Provide sun shields for all field electronic instruments exposed to direct sunlight.
 - 3. Make connections from rigid conduit systems to field instruments with PVC coated flexible conduit:
 - a. Type of flexible conduit required for the area classification:
 - 1) Area classification as specified in Section 16050.
 - b. Maximum length of 18 inches.
 - 4. Connect field instruments with cable as specified in the Electrical Specifications, except when the manufacturer requires the use of special cable, or otherwise specified in this Section:
 - a. Special cable applications shall be in accordance with the NEC.

5. Verify the correctness of each installation:
 - a. Polarity of electric power and signal connections.
 - b. Ensure all process connections are free of leaks.
- E. Process sensing lines and air tubing:
 1. Install individual tubes parallel and/or perpendicular to and near the surfaces from which they are supported.
 2. Provide supports for rigid tubing at intervals of not more than 3 feet.
 3. Slope horizontal runs of instrument tubing at a minimum of 1/16th inch per foot to allow for draining of any condensate.
 4. Bends:
 - a. Use proper tool.
 - b. Make bends for parallel lines symmetrical.
 - c. Make bends without deforming or thinning the walls of the tubing.
 5. Square-cut and clean all ends of tubing before being inserted in the fittings.
 6. Provide bulkhead fittings at all panels requiring pipe and/or tubing entries.
 7. Use stainless steel tubing for all piping hard piped from the air header, unless otherwise indicated on the Drawings or not compatible with the fluids or atmosphere in the area:
 - a. Use flexible connections only on moving equipment and under the constraint that the length shall be less than 1.5 times maximum travel of the equipment.
- F. Conduit, cables, and field wiring:
 1. Provide all PCIS equipment cables, and process LAN communication networks under the Instrumentation and Control Specifications.
 2. Provide terminations and wire identification as specified in the Electrical Specifications.
 3. Protect all wiring from sharp edges and corners.
 4. Provide all conduits, fittings, boxes, etc. in accordance with all the requirements of the Electrical Specifications.
- G. Equipment tie-downs:
 1. Anchor all instruments, control panels, and equipment by methods that comply with seismic and wind bracing requirements, which apply to the Site.
 2. All control panels, VCPs, LCPs, RTUs, PCMs, etc., shall be permanently mounted and tied down to structures.
- H. Instrument tagging:
 1. As specified in Section 16075.
 2. Provide all field-mounted instruments with nameplates:
 - a. Nameplates engraved with the instrument's full tag number as indicated on the Drawings:
 - 1) Affix tags with stainless steel wire fasteners.
 3. Provide all back of panel instruments with nameplates:
 - a. Engraved with the instrument's full tag number as indicated on the Drawings:
 4. Provide all front of panel instruments with a nameplate:
 - a. Engraving to include the instrument's full tag number and service description.
 - b. Secure nameplates to the panel with stainless steel screws.

- c. Use an approved adhesive if screws would violate the NEMA or other ratings of the enclosure.
- I. Cable and conductor termination:
 - 1. Terminate all cables and conductors on terminal blocks.
 - 2. Terminal block enclosures:
 - a. Suitable for the area classification as specified in Section 16050.
- J. Surge protection:
 - 1. Provide outdoor field instrument loops with voltage surge protection units installed on the instruments.
 - 2. Individually fuse each 4 to 20 milliamperes direct current loop with a 1/16 ampere fuse between power supplies and receiver surge protectors.
 - 3. Provide voltage surge protection for 4 wire transmitters and analyzers:
 - a. Protect both power source and signal loop.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. Inspection:
 - 1. Allow for inspection of PCIS installation as specified in **[Section 01450]**.
 - 2. Provide any assistance necessary to support inspection activities.
 - 3. Engineer inspections may include, but are not limited to, the following:
 - a. Inspect equipment and materials for physical damage.
 - b. Inspect installation for compliance with Drawings and Specifications.
 - c. Inspect installation for obstructions and adequate clearances around equipment.
 - d. Inspect equipment installation for proper leveling, alignment, anchorage, and assembly.
 - e. Inspect equipment nameplate data to verify compliance with design requirements.
 - f. Inspect cable terminations.
 - g. Inspect/witness instrument calibrations/verifications.
 - 4. Inspection activities conducted during construction do not satisfy inspection requirements specified in Section 17950.
- B. Field testing is specified in Section 17950. Additional general requirements are specified in Section 01756.
- C. Installation supervision:
 - 1. Ensure that the entire PCIS is installed in a proper and satisfactory manner. At a minimum, the ICSC shall provide the following services:
 - a. Installation resources:
 - 1) Coordinate with the Contractor regarding installation requirements of the Contract Documents.
 - b. Provide technical assistance to installation personnel by telephone:
 - 1) Furnish installation personnel with at least one copy of the approved submittals, including all installation details.

- c. Periodic inspections during the construction period.
- d. A complete check of the completed installation to ensure that it is in conformance with the requirements of the equipment manufacturer and the Contract Documents.
- e. Field verify accuracy and calibration of all instruments.

3.08 ADJUSTING

- A. Control valves:
 - 1. Stroke all control valves, cylinders, drives and connecting linkages from the control system as well as local control devices and adjust to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position.
 - 2. Check control valve actions and positioner settings with the valves in place to ensure that no changes have occurred since the bench calibration.
- B. Make all revisions necessary to the control system software, as directed by the Engineer. It is understood that the Contractor knows and agrees that changes will be required in the control system software during the factory acceptance tests, the pre-commissioning, performance testing, start-up and during the warranty period.

3.09 CLEANING

- A. As specified in Section 01770.
- B. Vacuum clean all control panels and enclosures before start-up and again after final completion of the project.
- C. Clean all panel surfaces.
- D. Return to new condition any scratches and/or defects.
- E. Wipe all instrument faces and enclosures clean.
- F. Leave wiring in panels, manholes, boxes, and other locations in a neat, clean, and organized manner:
 - 1. Neatly coil and label all spare wiring lengths.
 - 2. Shorten, re-terminate, and re-label excessive spare wire and cable lengths, as determined by the Engineer.
- G. As specified in other sections of the Contract Documents.

3.10 DEMONSTRATION AND TRAINING

- A. Demonstration requirements are specified in Section 17950.
- B. Training:
 - 1. General:
 - a. Provide system maintenance and operator training courses for all the instrumentation and control systems furnished.

- b. Provide system maintenance and operator training courses for all the instrumentation and control equipment and systems furnished, as described below.
 - 1) All training described below shall be provided by the Contractor.
 - 2) The Programmer is not responsible for the training described in this Section.
 - 3) The Programmer will provide training on software provided by the Programmer.
- c. Conduct all training at the Project Site unless another location is approved by the Engineer and Owner:
 - 1) Include instruction on the use of all maintenance equipment and special tools provided under the Contract.
- d. Tailor training classes to the specific needs of the class participants:
 - 1) Develop separate courses for operators, maintenance staff, and supervisors:
 - a) The specific categories and number of personnel in each category are identified below.
 - 2) Furnish training courses that are a combination of classroom and hands-on training:
 - a) Limit classes that include extensive hands-on activities to a maximum of 5 students per class.
 - 3) Present the minimum number of sessions, specified in Table 17050-3.10-T1, for each course in order to satisfy class size restrictions and limitations scheduling Owner staff.
 - 4) Furnish additional sessions if required to accommodate the total number of personnel identified for each course.
- e. Schedule individual training classes with the Owner at least 3 weeks before the start of the class:
 - 1) Schedule all training classes Monday - Friday between 7:30 AM and 3:30 PM.
 - 2) Each individual daily training session, travel time excluded:
 - a) Minimum duration of 4 hours.
 - b) Maximum duration of 7 hours.
 - c) Breaks scheduled at least every 90 minutes and 1 hour for lunch.
 - 3) Complete training for maintenance personnel 90 days before performance testing.
 - 4) Complete operator training classes before start-up of the SCADA system, or any part of it:
 - a) As specified in the Sequencing article of this Section.
 - 5) Schedule follow-up training classes after SCADA start-up on a schedule determined by the Owner.
- f. Furnish highly qualified training instructors for technical training with demonstrated expertise in not only control system functionality but also professional training techniques:
 - 1) Instructors are subject to the approval of the Engineer.
 - 2) Furnish training instructors thoroughly familiar with the PCIS system, who are members of the SCADA system implementation team.
 - 3) One of the individuals conducting the SCADA system training course must be the same individual responsible for the majority of the programming that was performed for the instrumentation and control system.

2. Training manuals and materials:
 - a. Furnish training manuals and other materials for training courses.
 - b. Manuals are to be professionally written to present the course material in a format that is easy to comprehend.
 - c. The manuals are to serve as teaching aids during presentation of the training classes.
 - d. Manuals are to serve as reference material after the training has been completed.

Table 17050-3.10-T1

Course Title	Minimum Course Length (days per session)	Personnel (Estimated Number of Students)	Minimum Number of Sessions
System Overview	1	10	1
Operator Training - Basic	3	10	2
Operator Training - Advanced	2	5	2

3. Training course requirements:
 - a. System overview training:
 - 1) Furnish training courses that give the Owner's supervisory level personnel an overview of all elements of the PCIS system that focus on the overall functional aspect of elements of the control system and provide an understanding of the interaction of the various components.
 - 2) Furnish a training course that gives the Owner's supervisory level personnel an overview of the new Contractor-provided elements of the PCIS system. Focus on the overall functional aspects of each new elements of the control system, particularly the mechanical system vendor-provided control packages.
 - b. Operator training:
 - 1) Furnish training courses that instruct system operators in the efficient operation of all aspects of the PCIS that include not only the general operation of the control system but also the operation of specific system features.
 - 2) Furnish training courses that instruct system operators in the efficient operation of Contractor-provided aspects of the PCIS that include not only the general operation of each control system but also the operation of specific system features.
 - 3) Operator's training shall include:
 - 4) Operator's training shall include the following for each vendor package and programmable device:
 - a) Control system overview: Architecture, equipment functions, software components, etc.
 - b) Display navigation, overview, and types of displays.
 - c) Process and equipment monitoring and control: Basic principles and operation.
 - d) Logging ON and OFF the system and description of the security and access system.
 - e) Alarm subsystem.

- f) Trending: Provide a thorough session on how to use all trending functions.
 - g) Reports: How to access, print, and review content.
 - h) Control strategies: Present an average 15-minute review of each control strategy, including a hands-on demonstration of screens and operator functions for each.
 - i) Instruction on the use of all operational functionality alarm logging, trending, displays, database, reports, and control software developed for the Project and incorporated in the installed PCIS system.
4. Recording training sessions:
- a. Record all training.
 - b. Furnish digital video disk (DVD) format.
 - c. These disks become the property of the Owner and cover, in detail, the training for the specific hardware and software of all the systems provided for the Project.
 - d. Provide all the necessary cameras and recording equipment.

3.11 PROTECTION

- A. Protect all Work from damage or degradation until date of Substantial Completion.

3.12 SCHEDULES (NOT USED)

END OF SECTION

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SECTION 17100

CONTROL STRATEGIES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Contractor-developed loop description submittal requirements.
 - 2. General programming requirements.
 - 3. Common control functions:
 - a. General control and monitoring functions to be provided throughout the PCIS system.
 - 1) These requirements apply to all systems, and supplement the specific loop descriptions in Section 17101 and information indicated on the Drawings.
- A. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - b. Section 17101 - Specific Control Strategies.

1.02 REFERENCES

- A. As specified in Section 17050.

1.03 DEFINITIONS

- A. As specified in Section 17050.
- B. Hardwired control: Control circuitry that does not utilize software to initiate functionality.
- C. Hardwired interlocks: A safety or protective feature that will interrupt operation of the equipment in all operating modes with no required operator intervention.
- D. Software interlocks: A safety or protective feature that will interrupt operation of the equipment when the PLC has control.
- E. Slew rate: Rate of change in respect to time.

- F. Clamp: Imposed upper and lower limits on setpoints to eliminate entries outside the allowable control parameters.
- G. Watchdog timer: Timers imposed to test components such as discrete I/O to verify the health of the card.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

- A. As specified in Section 17050.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 17050.

1.12 SYSTEM STARTUP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION (NOT USED)

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

- A. As specified in Section 17050.

- B. General programming requirements:
1. Use variable names or aliases derived from tag and loop identification on the P&IDs for all process values.
 2. Store all adjustable parameters in the PLC, and configure so that an operator with sufficient security access can change the parameters from the HMI or OIT. Update and display the current value at all locations, regardless of where the last change was made.
 3. Program slew rates for all setpoints to limit the effect of updated setpoints on the process:
 - a. Provide for control setpoints and manual speed and position selections.
 - b. Store new setpoints in one register, and gradually ramp the actual setpoint register at the slew rate until it reaches the new value.
 - c. Provide operator access to change slew rates from the OIT.
 4. Saved setpoints:
 - a. Provide an operator selection to save all setpoint values.
 - b. Furnish one or more screens at the OIT that display the initial values for all setpoints defined during startup and the value for each setpoint the last time they were saved.
 - c. Provide an operator selection to restore all setpoints to the initial startup value.
 - d. Provide an operator selection to restore all setpoints to the last saved value.
 5. Store a copy of all adjustable parameters and accumulated and integrated totals in SCADA:
 - a. Upon re-loading of the PLC program, re-load these values to the PLC from SCADA.
 6. Calculated values:
 - a. Program calculations such that division by zero errors cannot occur.
 - b. Prevent calculations from generating values that exceed the limits of the equipment or data type structures (integers) internal to the PLC.
 - c. Configure counting functions (start counts and operation counts) to allow a minimum of 10,000 counts, and to roll-over to zero at an even decimal interval (1 followed by 4 or more zeros).
 - d. Configure integrating functions to accurately accumulate the maximum rate from the instrument/equipment (totalizers, run time meters) for 30 years.
 7. Timers:
 - a. Provide programmable settling and proving timers in all control sequences for starting and stopping of equipment to allow the process to settle down before proceeding with any additional control functions.
 - b. Embed the timers in the PLC logic, tune in the field, and list separately as part of the software submittal and O&M manual.
 8. PCM status:
 - a. Furnish a minimum of 1 screen that depicts the status of all enclosures containing PLCs or I/O in the control system, including but not limited to the following:
 - 1) PLC cabinet over-temperatures from high temperature switch.
 - 2) Intrusion status on all enclosures equipped with intrusion switches.
 - 3) AC power failure:
 - a) Monitor ahead of UPS.

- 4) DC power supply failure:
 - a) For redundant power supplies, alarm when either power supply fails.
 - 5) UPS failure signal.
 - 6) Maintenance Bypass switch position.
 - 9. PLC system communication status:
 - a. Furnish a minimum of 1 screen to display all communication errors and status within the PCIS:
 - 1) Communication between SCADA and PLCs, PLC to PLC, PLC to RIO.
 - 2) Display status of each node, and summary of failures over the past 60 minutes.
 - b. Generate a communications alarm if any communication fault is detected or there is no response from a node for more than a user specified time.
 - c. In the event of communications loss:
 - 1) Continue normal operation at each PLC.
 - 2) Where control parameters are received over a communications link:
 - a) If a link fails where process elements use the remote value for closed-loop control, hold operating status, speed and position, of the process elements at their last state before the communication alarm, unless other I/O local to that PLC indicates shutdown or over-ride conditions:
 - (1) Ensure that the operator can control the process using PCIS HAND mode at the local HMI.
 - b) If a link fails where process elements use the remote value to determine setpoints, settings or control levels, continue to operate using the last value received:
 - (1) Provide a manual over-ride entry at the local HMI to allow an operator to enter a different value for any such remote signal.
 - (2) Generate an alarm whenever an over-ride value is in use.
- C. Common control functions:
- 1. Incorporate common control functions into all control loops and devices and into the control programming, whether or not specifically shown in the specific control descriptions or elsewhere in the Contract Documents.
 - 2. Alarms:
 - a. Generate alarms within the PLC logic.
 - b. Indicate alarms at the HMI and OIT. Enable acknowledgement from either the OIT or the HMI.
 - c. Generate high, high-high, low, and low-low level alarms where indicated:
 - 1) Provide an alarm reset deadband for each analog value to prevent excessive repeated alarms.
 - 2) Provide logic and timers to inhibit analog alarms based on process events. For example, inhibit low flow alarms when a pump is stopped, or has not been running long enough to establish flow.
 - d. Flash all alarm and fail conditions and their respective indicators on the PCIS graphic screens and local indicating lights until the condition is acknowledged by the operator, even if the alarm condition is no longer present.

- e. Once the alarm is acknowledged by an operator, display alarm conditions in a steady state (not flashing) while the alarm condition is still present:
 - 1) Flash with a cycle rate of 1/2 second on and 1/2 second off.
- f. Once the alarm has been cleared and the operator has acknowledged the alarm or fail condition, turn the graphic alarm indicator off.
- g. For all alarms that do not have inherent timers, provide an operator-adjustable proving timer to limit nuisance alarms, continuously adjustable from zero seconds to 100 minutes. The initial setting of proving timers shall be zero seconds:
 - 1) The PLC shall start the timer when it first detects an alarm condition, and shall only activate the alarm after the timer has expired.
 - 2) If the alarm condition clears while the timer is running, the timer shall reset, and the alarm shall not be activated.
- h. Use interlocks and proving timers to prevent alarms from operating due to power loss, except for loss of power alarms.
- i. Furnish an alarm silence pushbutton at each PCM, HMI, or LCP with an audible alarm to signal the PLC to turn off the audible alarm until the next alarm occurs.
- j. Any alarm that is not acknowledged after a setpoint period of time shall activate the auto dialer.
- k. Lamp test: Furnish lamp test pushbuttons at each control panel with more than 10 pilot lights, that illuminates all pilot lights on the panel:
 - 1) The lamp test may sequence through blocks of lights.
 - 2) Minimum on time for each lamp during lamp test 15 seconds.
- 3. Where a reset is shown for counts, totals and times maintained in the PLC:
 - a. Provide a reset selection on the OIT screen that displays the value.
 - b. Provide a preset function on the OIT to allow a operator-entered value to become the current accumulated total.
 - c. Limit access to the reset and preset functions to operators with suitable security level.
 - d. Log the value before reset, operator, time, and date of reset in the SCADA archive.
 - e. Log the value before preset, preset value, operator, time, and date of preset in the SCADA archive.
- 4. Where start counts are indicated on the Drawings, or required in this Section, count starts for each piece of equipment (off to on transitions of running status) in the PLC:
 - a. Display total starts on PCIS screens, and provide a reset function.
 - b. Where indicated, calculate number of starts for each day:
 - 1) Display current day and previous day starts on PCIS displays.
 - 2) Do not reset daily start count when overall count is reset.
 - 3) Archive starts for each day through SCADA.
- 5. Where run time accumulation is indicated on the Drawings, or required in this Section, integrate accumulated run time to the nearest 0.1 hour whenever the running status input indicates that the equipment is running:
 - a. Display total run time in hours on PCIS screens.
 - b. Where indicated, calculate total run time for each day:
 - 1) Display current day and previous day run time on the OIT to the nearest 0.1 hour.
 - 2) Do not reset daily run time when overall time is reset.
 - 3) Archive run time for each day through SCADA.

6. For all monitored analog values:
 - a. Convert all values to engineering units within the PLC.
 - b. Maintain trends in SCADA.
 - c. Totalize flows in the PLC logic:
 - 1) Where totalized flows are input to a discrete input, count input pulses and multiply by the volume per pulse.
 - 2) Where no totalizer input is shown, integrate the analog input over time.
 - 3) Display totals on the OIT and HMI.
 - 4) Archive totals to the historical database through SCADA.
 - d. Calculate hourly, daily, and monthly averages:
 - 1) Calculations may be performed by the PLC or SCADA.
 - 2) Display averages on the OIT, and archive through SCADA.
 - e. Calculate minimum and maximum values for each hour, day, and month:
 - 1) Calculations may be performed by the PLC or SCADA.
 - 2) Display minima and maxima on the OIT, and archive through SCADA.
 - f. Generate an alarm whenever an over-ride value is in use.
7. Analog data processing:
 - a. Engineering units conversion:
 - 1) Use engineering units for all analog point values. Convert analog inputs to engineering units.
 - b. Analog magnitude checking:
 - 1) Provide upper and lower limits to prevent operator-entered values (setpoints, etc.) from falling outside acceptable limits.
 - c. Analog value quality:
 - 1) Monitor analog values received at each PLC from analog inputs or communications from another PLC or RIO, and generate alarms for the following conditions:
 - a) Rate of change in excess of acceptable limit:
 - (1) Provide a separate rate limit for each value.
 - b) Stale value:
 - (1) For analog signals that come from analog inputs or calculations using analog inputs, which are expected to have some variation each time the input is read, alarm when there is no change in the value for 10 times the normal expected scan or communication update.
8. Analog device override (HMI and OIT):
 - a. Provide the following functions from the OIT and the local HMI for each and every analog input:
 - 1) An over-ride value to be used in place of the analog input:
 - a) Enter in engineering units:
 - (1) Display the calibrated range in engineering units.
 - (2) Only allow entries within the calibrated range of the instrument.
 - b) When the analog input is enabled, track the analog input so that the over-ride matches the analog input value when the input is initially disabled.
 - c) Maintain over-ride status and value in the PLC.
 - d) Only allow access to over-ride selections and settings to operators with sufficient security.

- 2) An enable/disable selection:
 - a) When enabled, the value used by the PCIS system is equal to the analog input value.
 - b) When disabled, the analog input is ignored, and the over-ride value is used for all control and display functions.
 - c) Generate an alarm whenever an analog input is disabled.
 - d) Enter a value for the analog input from the PCIS system to the PLC.
- 3) Use the over-ride value for all display and control functions instead of the actual analog input value.
- b. Provide the following functions in the PLC, with selections and value entry from the OIT and/or HMI:
 - 1) An over-ride value to be used in place of the normal output value:
 - a) Enter in percent of output span.
 - b) When the analog output is enabled, track the analog input so that the over-ride matches the analog output value when the output is initially disabled.
 - 2) An enable/disable selection:
 - a) When enabled, the value sent to the output is the value determined by the PLC based on the control logic or operator-entered value in PCIS HAND.
 - b) When disabled, the calculated PCIS HAND values are ignored, and the over-ride value is sent to the output.
 - c) Generate an alarm whenever an analog output is disabled.
9. Tank and vessel levels:
 - a. Display all tank and vessel levels as both a level (typically in feet) and a volume (typically in gallons):
 - 1) Some individual displays may be only level or volume, when agreed to by the Owner and Engineer during screen meetings.
 - b. Monitor rate of change of volume on all tanks and vessels:
 - 1) Establish the maximum withdraw rate at which the volume should decrease (all pumps or feeders operating at maximum output). Generate an alarm whenever the volume decreases faster than this rate.
 - 2) Establish the minimum fill rate at which the volume should increase when filling. Generate an alarm whenever the volume increases faster than this rate. Verify tank and vessel level is fluctuating to verify the validity of the IO register. If it is determined the register is not active or failed in a manner that leaves a stagnant value generate an alarm.
10. I/O filtering and processing:
 - a. Analog input filtering:
 - 1) For each analog input provide an adjustable first order filter, for the purpose of smoothing out spikes and other noise for analog transmitter input signals. By default, configure analog inputs with no filtering affect.
 - 2) Monitor analog input signal quality:
 - a) Over range: The input value is above the normal range (typically over 21 mA).
 - b) Under range: The input value is below the normal range (typically under 3 mA, indicating a probable broken connection).
 - c) Generate alarms for over or under range inputs.

- d) Do not use over or under range values for control or calculation purposes:
 - (1) Where a second instrument is provided to monitor the same condition (a redundant instrument, or additional instruments furnished for averaging or different operating modes), and has a valid signal, use that input for control.
 - (2) Otherwise, hold all outputs affected by the signal at their last values before the signal went out of range.
 - 3) Digital input filtering (proving timer):
 - a) Provide an adjustable time delay function (0-10 seconds) on discrete input for the purpose of de-bouncing.
 - b) By default, discrete inputs shall be configured with de-bounce timers set to zero seconds.
- 11. Instrument scaling (OIT/HMI):
 - a. Provide 1 or more maintenance screens to display ranges and trigger points for all field instruments:
 - 1) For analog instruments, use input scaling values in the PLC to determine minimum and maximum calibration points.
 - 2) For discrete instruments, display calibrated pick-up and drop-out values.
- 12. PCIS HAND-OFF-AUTO:
 - a. Where indicated, provide HAND-OFF-AUTO and START-STOP selections in the PCIS, accessed from an HMI or OIT for operators with sufficient security, to provide the following operating modes:
 - 1) PCIS AUTO: The normal, automatic control mode of the strategy which allows full PLC control in response to process conditions and programmed sequences.
 - 2) PCIS HAND: Enables PCIS Manual control where control decisions are made by an operator through the PCIS START-STOP, OPEN/CLOSE, or other selections as indicated.
 - 3) PCIS OFF: Automated PCIS control is disabled and PLC calls for all associated equipment to stop and valves to close or go to their identified safe state.
 - 4) Program the PLC so that switching a strategy between AUTO and HAND (either direction) occurs with a smooth transition. Keep running or position status unchanged when control is switched to HAND until a change is requested using the operator selections (START, STOP, OPEN, CLOSE). Keep running and position status unchanged when control is switched to AUTO until the control logic determines a change is required.
- 13. Display the current status of all operator selections (PCIS HAND/AUTO, PCIS START/STOP, etc.) on HMI and OIT.
- 14. Permissives:
 - a. Implement software permissives where indicated to place equipment in a safe condition in response to impending hazardous process conditions. Apply software permissives when equipment is operating in PCIS AUTO or PCIS HAND:
 - b. Use hard-wired permissives for equipment protection where indicated.

15. Process control algorithms:
 - a. Jog and hold: Unless otherwise indicated, use jog and hold control algorithms where possible:
 - 1) When the error between process variable and setpoint is beyond a setpoint deadband:
 - a) Jog valve or ramp speed in the required direction for a preset "Jog Time" or until the process variable reaches or passes the setpoint.
 - b) Then hold speed or position through a setpoint "Hold Time."
 - c) Continue alternating jog and hold until the error is less than the deadband.
 - 2) Provide operator access to Jog Time and Hold Time setpoints from the OIT.
 - b. PID algorithms: Use where indicated, or where necessary to provide fast response:
 - 1) Provide a PID faceplate with the following displays and functions for each PID control algorithm:
 - a) Display Output, CV.
 - b) Display Setpoint, SP.
 - c) Display Process Variable, PV.
 - d) Allow for operator selection of Automatic or Manual control of the output.
 - e) Under Manual control of output allow the operator to enter the desired output value.
 - f) Allow for input of the three Proportional, Integral and Derivative tuning parameters.
 - g) Configure PID loops to prevent reset windup when controlled equipment is operating in Manual (local or PCIS), or when the equipment has reached a physical limit.
 - h) When controlled equipment is being operated in remote PCIS HAND, configure the PID function to track the process variable to provide a smooth transfer between Manual and Automatic modes.
 - i) Provide selectable slew rates with adjustable setpoints to allow the PID algorithm to slowly ramp to its final value to minimize system disturbance.
16. Equipment alternating and sequencing:
 - a. Distribute number of starts and run time equally between identical equipment.
17. Motor control:
 - a. Monitor the device's LOCAL-OFF-REMOTE (LOR) switch (the hard-wired switch at the MCC, drive or equipment) to determine when the PLC has control of the associated equipment:
 - 1) Display current REMOTE status on the PCIS screens.
 - b. Monitor the device's running status from the starter auxiliary or run status input:
 - 1) Display the current status (running or stopped) on the PCIS screens.
 - 2) Use status to calculate total run time and daily run time, and to count total starts and daily starts.
 - 3) Provide time stamp for each start.

- 4) For motors 200 HP and greater, provide software to prevent exceeding the manufacturer's recommended maximum starts per hour.
- c. When equipment control has been given to the PLC as reported by the LOCAL-OFF-REMOTE switch, allow selection of PCIS AUTO or PCIS HAND control modes based upon operator selection using the PCIS screens.
- d. Starting, stopping and running when the device LOR is in LOCAL:
 - 1) With the LOR switch in the LOCAL position, the motor is controlled by the START and STOP pushbuttons.
 - 2) With the LOR switch in the OFF position, the motor is prohibited from running.
 - 3) With the LOR switch in the REMOTE position, the motor is controlled remotely.
- e. Starting, stopping and running when the device LOR is in REMOTE:
 - 1) When the motor is expected to be running (PLC has issued a START or RUN due to process conditions or operator selection), LOR is in REMOTE, and the device is not reported to be running, start an operator adjustable "Control Activation" timer:
 - a) Provide "Control Activation" timers for each piece of controlled equipment:
 - (1) If the LOR and required running status do not change, and the PLC does not receive running status within the "Control Activation" time period:
 - (a) De-activate the output.
 - (b) Place the device in a "Failed" state.
 - (c) Generate a "Failed to Respond" alarm.
 - 2) When the motor is not expected to be running (PLC has issued a STOP or removed the RUN output), LOR is in REMOTE, and the device is reported to be running, start the "Control Activation" timer:
 - a) If the LOR and required stopped status do not change, and the PLC does not lose the running status within the "Control Activation" time period:
 - (1) Keep the RUN output off or the STOP output on.
 - (2) Place the device in a "Failed" state.
 - (3) Generate a "Failed to Respond" alarm.
 - 3) Re-establish PLC control of a device in a "Failed" state only after the following:
 - a) An operator turns the device's LOR switch out of REMOTE, and back to REMOTE (i.e., REMOTE input to the PLC cycles off and back on).
 - f. Where motor winding high temperature switches or RTD temperature elements are shown, generate an alarm when high temperature is sensed (contact opens or temperature above the high alarm setpoint), but do not stop the motor unless otherwise indicated.
 - g. Control two-speed motors similar to other motors, except as listed below:
 - 1) Motor states are RUN-FAST, RUN-SLOW, and STOP.
 - 2) Start all two-speed motors in the RUN-SLOW state. If or when the high speed is required (RUN-FAST operator selection or process conditions), transition to RUN-FAST after a designated time.
 - 3) When transitioning from RUN-FAST to RUN-SLOW, remove the RUN-FAST output or issue a STOP, then wait for a "Fast to Slow"

time delay before energizing the RUN-SLOW or START-SLOW output.

h. Simultaneous starts:

- 1) Prevent more than one motor-driven load 25 HP or larger in the same facility from starting concurrently:
 - a) When starting one load, inhibit start logic for all other such equipment until the load being started is up to speed (RVSS or VFD), or after a setpoint time delay (full-voltage starters and miscellaneous equipment).
- 2) Use the same logic to prevent multiple large devices from starting concurrently on restoration of power after a power outage, whether operating on generator or utility power.

i. Speed control:

- 1) Modulate speed on VFD-driven motors using jog and hold, or PID control algorithms to maintain process conditions as described in the specific loop descriptions.
- 2) Operate speed control within a pre-defined range:
 - a) Minimum speed as determined by equipment manufacturer. The higher of:
 - (1) Minimum motor speed to maintain adequate cooling for the type of load driven (constant or variable torque).
 - (2) Minimum equipment speed, such as minimum speed to deliver flow or to deliver minimum flow for equipment cooling or lubrication.
 - b) Maximum speed 100 percent (60 hertz) or as identified by equipment manufacturer.
- 3) Where multiple equipment may operate together to maintain the same process condition:
 - a) Provide an operator selection for starting sequence.
 - b) Start the first equipment at a preset starting speed.
 - c) When one or more equipment is running and the speed control algorithm reaches a preset "Start Next" speed value (initially 95 percent of speed range) through a preset time delay:
 - (1) Start the next available equipment at the preset starting speed.
 - (2) Ramp up the started equipment and ramp down the previously running equipment to the mid operating speed (adjustable in the PLC). Determine preset values for each condition based on equipment and system characteristics to provide approximately the same total flow or process condition with the new load running at the mid speed (for example if one pump is running and the second pump will be added, then the total flow of both pumps running at mid operating speed should be approximately the same as flow of one pump at Start Next speed).
 - (3) Once both equipment reach the mid operating speed, resume the speed control algorithm for those equipment.
 - (4) Operate all equipment at the same speed following the output of the speed control algorithm.

- d) When two or more pieces of equipment are running, monitor for a "Stop Next" condition:
 - (1) Where flow rate is monitored, use a preset "Stop Next" flow rate for each possible number and combination of equipment:
 - (a) Determine initial "Stop Next" speed based on the flow that can be provided with one fewer piece of equipment running at a speed slightly below the "Start Next" speed.
 - (2) When the "Stop Next" condition exists through a preset time delay:
 - (a) Ramp speed of running equipment except for the equipment to be stopped up to a preset value based on the number of items running. Determine preset values for each condition based on equipment and system characteristics to provide approximately the same total flow or process condition with one fewer load running (typically slightly below the preset "Start Next" speed) while ramping speed of equipment to be stopped down to the preset minimum speed.
 - (b) Stop the load once it reaches minimum speed.
 - (c) Operate all remaining equipment at the same speed following the output of the speed control algorithm.
18. Gate and valve control:
- a. Monitor the device's LOCAL-OFF-REMOTE (LOR) switch(es) (the integral switch in the actuator or hard-wired switch at the local control station):
 - 1) Display current REMOTE status on PCIS screens.
 - b. Start an "Open Activation" timer whenever the device is expected to be open (PLC has issued an OPEN command in PCIS AUTO, or OPEN was selected in PCIS HAND):
 - 1) Initially set "Open Activation" time to twice the normal opening time.
 - 2) If the LOR position and open command do not change, and the PLC does not receive fully open status feedback within the "Open Activation" time period:
 - a) De-activate the open output.
 - b) Place the device in a "Failed" state.
 - c) Generate a "Failed to Open" alarm.
 - c. Start a "Close Activation" timer whenever the device is expected to be closed (PLC has issued a CLOSE command in PCIS AUTO, or CLOSE was selected in PCIS HAND):
 - 1) Initially set "Close Activation" time to twice the normal closing time.
 - 2) If the LOR position and close command do not change, and the PLC does not receive fully closed status feedback within the "Close Activation" time period:
 - a) De-activate the close output.
 - b) Place the device in a "Failed" state.
 - c) Generate a "Failed to Close" alarm.

- d. For modulating valves (valves controlled from either a 4-20 mA signal or digital communications command) with position feedback, start a "Position Error" timer whenever the position feedback differs from the required position command by more than a setpoint error when the LOR is in REMOTE:
 - 1) For analog modulating devices, error is determined by position feedback differing from position command by more than the setpoint error.
 - 2) For discrete modulating devices, error is determined by feedback not changing in the correct direction, or changing at less than a setpoint rate, when the OPEN or CLOSE PLC output is active.
 - 3) Initially set the "Position Error" time to 60 seconds.
 - 4) If the LOR position does not change, and position error stays outside of the setpoint error through the "Position Error" time period:
 - a) Hold position output.
 - b) Place the device in a "Failed" state.
 - c) Generate a "Position Fail" alarm.
 - e. Provide separate time delay settings for each function and for each device.
 - f. If the valve position inputs indicate an impossible state (i.e., valve open and closed at the same time), place the device in a "Failed" state and generate an "Illegal State" alarm.
 - g. Re-establish PLC control of a device in a "Failed" state only after one of the following:
 - 1) An operator turns the device's LOR switch out of REMOTE and back to REMOTE (i.e., REMOTE input to the PLC cycles off and back on).
 - 2) An operator acknowledges the fault from SCADA.
 - h. For all alarm conditions, control other devices (as stopping pumps, etc.) as stated in the individual loop descriptions to make the system safe.
 - i. For discrete modulating valves (valves positioned to intermediate positions to control process values through discrete OPEN and CLOSE outputs), count the number of actuations (OPEN or CLOSE commands) in the PLC:
 - 1) Display count on the OIT.
 - 2) Provide a reset function for the count.
19. Power failure:
- a. Retain all operating setpoints during power failure.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17201

LEVEL MEASUREMENT - SWITCHES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Conductivity level switch.
 - 2. Capacitance level switch.
 - 3. Tuning fork level switch.
 - 4. Ball float level switch.
 - 5. Displacement float level switch.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - c. Section 17950 - Testing, Calibration, and Commissioning.
- C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050.

1.03 DEFINITIONS

- A. As specified in Section 17050.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 17050.
- B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050.

- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. [Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.]

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following [or equal]:
 - 1. Conductivity level switch:
 - a. Gems Sensors and Controls/Warrick Series 3W wire type electrodes.
 - b. Ametek B/W Controls 6013 electrode sensor with Type SW suspension wire.
 - 2. Capacitance level switch:
 - a. E+H Liquicap M FTI51/FTI52.
 - 3. Tuning fork level switch:
 - a. E+H Liquiphant.
 - b. Drexelbrook TF-100 Series.
 - c. Siemens Sitrans LVL200 Series Switch.

4. Ball float level switch:
 - a. Siemens Water Technologies Corp 9G-EF.
 - b. ITT Flygt Model ENM-10.
 - c. Anchor Scientific Incorporated Ecofloat/Solofloat.
5. Displacement float level switch:
 - a. Gems Sensors and Controls Series LS-3.
 - b. B/W Unifloat.

2.02 MANUFACTURED UNITS

- A. Conductivity level switch:
 1. General:
 - a. Probe type conductivity level switches integrating a control relay, control and reference electrode probes as required, and electrode probe holder. Unless otherwise specified in the ISA data sheets, electrode probes shall be rigid stainless steel and probe holder pressure-tight.
 - b. All components provided by the same manufacturer.
 2. Element:
 - a. Rigid type: For probe lengths of 6 feet and less provide Type 316 stainless steel rigid probes unless otherwise specified in the instrument schedule ISA Data Sheets. Electrode probe shall be threaded at one end to fit electrode holder threads and insulated with 1/32 inch PVC sheath down to 1 inch from the other end.
 - b. Electrode probe holder.
 - c. Suspended probes: For probe lengths longer than 6 feet, provide wire suspended probes within a protective plastic shield suspended and PVC insulated wires. Provide suitable adapters for fastening upper end to electrode fitting.
 - d. **[Flange mount rated for sustained pressure of [150] [300] pound per square inch.]**
 3. Switch: The control relay senses the liquid level by conductance through electrode probes and the process liquid:
 - a. Provide a solid-state general-purpose control relay designed for single level or differential control.
 - b. Electrical connection: One 1/2 inch NPT conduit entry.
 - c. Power supply:
 - 1) 120 VAC.
 - 2) Power consumption: 10 VA maximum.
 - d. DPDT contacts rated 5 amps resistive at 120 VAC.
 - e. Secondary voltage (applied to electrodes): 12 VAC, 1.5 mA maximum.
 - f. Enclosure: NEMA Type 4X.
 4. Components:
 - a. Adjustable time delay on increasing or decreasing level.
 - b. Manufacturers: One of the following or equal:
 - 1) Standard applications:
 - a) Warrick Controls Model 16D or 16 DM.
 - b) B/W Control High Sensitivity Series 5200.
 - 2) Intrinsically Safe:
 - a) Warrick Controls Model 27.
 - b) B/W Control High Sensitivity Series 5200 N7
 5. Approvals:
 - a. Class I Div 2

- b. If wired as intrinsically safe - Class I, Div 1, Groups A, B, C & D.
- B. Capacitance level switch:
- 1. General: Capacitance type level switches shall be made up of a control relay, mechanically rigid and rugged non-metallic probe and probe housing.
 - 2. Switch:
 - a. Provide a rigid, non-metallic element.
 - b. The control relay senses the liquid level by capacitance measurement between the electrode probe, the process liquid, and the equipment ground:
 - 1) Power supply:
 - a) 120 VAC.
 - b) Power consumption: 10 VA maximum.
 - 2) Outputs:
 - a) Relay outputs:
 - (1) 1 Form C contact.
 - (2) Rated at 6 amperes at 120 VAC.
 - (3) Programmable.
 - c. Electrical connection: One 1/2-inch NPT conduit entry.
 - d. Enclosure: NEMA Type 4X.
- C. Tuning fork level switch:
- 1. General: Tuning fork level switches comprised of a control relay, mechanically rigid fork, and transmitter housing.
 - 2. Switch: The control relay senses the liquid level by frequency attenuation at the probe fork when immersed.
 - a. Power supply:
 - 1) 120 VAC.
 - 2) **[24 VDC.]**
 - 3) Power consumption: 10 VA maximum.
 - b. Outputs:
 - 1) Relay outputs:
 - a) 1 Form C contact.
 - b) 5 amperes at 120 VAC.
 - c) Programmable.
 - c. Electrical connection: One 1/2-inch NPT conduit entry.
 - d. Enclosure: NEMA Type 4X.
 - e. Approvals: Class I, Div 1 – if wired intrinsically safe.
- D. Ball float level switch:
- 1. General:
 - a. Free hanging, encapsulated body with a switch to determine position of float.
 - 2. Element:
 - a. Mechanical switch encapsulated in waterproof floating polypropylene ball of nominal diameter, supported by flexible PVC cable and jacket or heavy neoprene.
 - b. The length of the PVC cable shall be, at a minimum, equal to sump depth plus 5 feet.
 - c. Float: Provide Type 316 stainless steel, minimum 3 inches in diameter. The float shall provide a minimum of 2 pounds of buoyancy in solutions

- with specific gravity of 1 and shall have an operating temperature rating of -30 degrees Fahrenheit to +150 degrees Fahrenheit.
- d. Mercury switches are not acceptable.
- e. Lead wires: Mounted in flexible waterproof PVC cable from switch to junction box terminals without splices.
- 3. Switch:
 - a. Single pole double throw contacts rated 10 amps resistive at 120 VAC.
 - b. Provide the number of floats per level system as indicated on the Drawings.
 - c. Suspend ball float and adjust for level setpoint as required.
- 4. Components:
 - a. Floats shall include Type 316 stainless steel clamp and brackets and 1/4 inch cable to allow testing of the float without entering the basin or wet well.
 - b. Provide strain relief at both ends of the float cable.
 - c. **[Float anchors:**
 - 1) **Furnish [15-pound] PVC coated anchor kit with [10 feet] of Type 316 stainless steel chain.**
 - 2) **Provide stainless steel shackles and float clamps.**
 - 3) **Manufactured by:**
 - a) **Conery Mfg. Inc.**
 - b) **Approved equal.]**
- E. Displacement float level switch:
 - 1. General: Float with a permanent magnet encircles a stationary stem. A hermetically sealed magnetically operated latching reed switch(es) mounted in the stem:
 - a. Mercury switches are not acceptable.
 - 2. Lead wires: Mounted in flexible waterproof PVC cable from switch to junction box terminals without splices.
 - 3. Switch:
 - a. Single pole single throw (SPST).
 - 4. The number of floats per level system shall be as indicated on the Drawings.

2.03 ACCESSORIES

- A. Provide sunshades for outdoor installation.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050.

3.05 ADJUSTING

- A. As specified in Section 17950.

3.06 CLEANING

- A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050.

3.08 PROTECTION

- A. As specified in Section 17050.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be as indicated on the Drawings, as specified in the Specifications or both.

END OF SECTION

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SECTION 17206

LEVEL MEASUREMENT - ULTRASONIC

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Ultrasonic level instruments.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050.

1.03 DEFINITIONS

- A. As specified in Section 17050.
- B. Specific definitions:
 - 1. FDT: Field Device Tool.
 - 2. DTM: Device Type Manager.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 17050.
- B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050.

- B. Examine the complete set of Contact Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: One of the following or equal:
 - 1. Ultrasonic Level sensor with 4-wire remote transmitter:
 - a. Endress+Hauser: Prosonic S FDU Series Sensor with FMU Series Transmitter.
 - b. Siemens: Echomax Series sensor with HydroRanger 200 Series Transmitter.
 - 2. Ultrasonic Level sensor with 2-wire integral transmitter:
 - a. Siemens: SITRANS Probe.
 - b. Endress+Hauser: Prosonic M FMU Series.
 - c. Magnetrol: Echotel Model 355.
 - d. Ametek Drexelbrook: USonic Series.

2.02 MANUFACTURED UNITS

A. Ultrasonic level measurement with 4-wire remote transmitter:

1. General:
 - a. Continuous non-contact level measurement device with remote transmitter using ultrasonic echo sensing. The transducer generates an ultrasonic pulse in the range of 12 to 50 kHz and measures the time required for the pulse to travel to the process surface and return. The distance is calculated from the send and receive times. Each 4-wire level transmitter system includes, but is not limited to:
 - 1) Ultrasonic Transducer.
 - 2) Signal cable.
 - 3) Transmitter.
2. Performance requirements:
 - a. Accuracy:
 - 1) 0.25 percent of range.
 - b. Repeatability:
 - 1) 0.1 percent of range.
3. Ultrasonic transducer:
 - a. Encapsulated in chemical and corrosion-resistant material as indicated on the Instrument Data Sheet or Instrument index.
 - b. Class I, Division 1 for transducer only.
 - c. Operating temperature range: -5 to 122 degrees Fahrenheit (-20 to 50 degrees Celsius).
 - d. Operating relative humidity range: 5 to 95 percent.
 - e. Functions:
 - 1) Temperature compensation.
 - f. Mounting: As indicated in the Contract Documents.
4. Transmitter:
 - a. Level indicating transmitter:
 - 1) Indicator: Liquid crystal display with approximately 0.50-inch display scaled to read in engineering units.
 - 2) Sensitivity: Able to ignore momentary level spikes or momentary loss of echo and indicate loss of echo condition on indicating transmitter unit.
 - 3) Ability to allow for signal profiles and echo mapping:
 - a) Provide manufacturers software for re-mapping the signal.
 - b. Functions:
 - 1) Level measurement.
 - 2) Tank volume.
 - 3) Flow measurement.
 - c. Power supply:
 - 1) 120 VAC.
 - 2) Power consumption: 36 VA maximum.
 - d. Outputs:
 - 1) Isolated 4 to 20 milliamperes DC with HART communication protocol.
 - 2) Relay outputs:
 - a) 3 Form A or Form C contacts.
 - b) Rated 5 amps at 250 VAC.
 - c) Programmable.
 - 3) Enclosure: NEMA Type 4X

- 4) Mounting: As indicated in the Contract Documents.
- 5) Operating temperature range from -5 to 122 degrees Fahrenheit (-20 to 50 degrees Celsius), relative humidity of 10 to 100 percent.

B. Ultrasonic Level measurement with 2-wire integral transmitter:

1. General:
 - a. Continuous non-contact level measurement device with integral transmitter using ultrasonic echo sensing.
 - b. The transducer generates an ultrasonic pulse in the range of 12 to 60 kHz and measures the time required for the pulse to travel to the process surface and return. The level is measured based on constant velocity of sound in air with temperature compensation to adjust for velocity changes relative to temperature.
 - c. Each 2- or 3-wire level transmitter system includes, but is not limited to:
 - 1) Ultrasonic transducer with integral transmitter.
2. Performance requirements:
 - a. Accuracy:
 - 1) 0.25 percent of range.
 - b. Repeatability:
 - 1) 0.1 percent of range.
3. Transducer (Integral):
 - a. Encapsulated in chemical and corrosion-resistant material as indicated on the Instrument Data Sheet or Instrument index.
 - b. Class I, Division 1 – if wired as intrinsically safe.
 - c. Operating temperature range: -5 to 122 degrees Fahrenheit (-20 to 50 degrees Celsius).
 - d. Operating relative humidity range: 5 to 95 percent.
4. Transmitter:
 - a. Functions:
 - 1) Single Level measurement.
 - 2) Programmable for:
 - a) Level.
 - b) Tank volume.
 - b. Power supply:
 - 1) 24 VDC - 2-wire loop powered.
 - 2) Power consumption: 6 VA maximum.
 - c. Outputs:
 - 1) Isolated 4 to 20 milliamperes DC with HART communication protocol.
 - d. Indicator: Liquid Crystal Display with approximately 0.50-inch display scaled to read in engineering units.
 - e. Sensitivity: Able to ignore momentary level spikes or momentary loss of echo and indicate loss of echo condition on indicating transmitter unit.
 - f. Enclosure:
 - 1) NEMA Type 4X.
 - g. Mounting: As indicated in the Contract documents.
 - h. Approvals: Class 1, Div 1 if wired as intrinsically safe.

2.03 ACCESSORIES

- A. Mounting brackets: As indicated on the Drawings.
- B. Provide sunshades for outdoor installations.

- C. Provide handheld programmers for all transmitters.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 ~~PREPARATION (NOT USED)~~

3.03 INSTALLATION

- A. As specified in Section 17050.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050.

3.05 ADJUSTING

- A. As specified in Section 17950.

3.06 CLEANING

- A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050.

3.08 PROTECTION

- A. As specified in Section 17050.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments.
Provide all instruments identified in the Contract Documents:
1. Instruments may be as indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E: Carollo Engineers			ULTRASONIC LEVEL INSTRUMENTS						
Contractor: Project: Customer: Plant: Location: BOM No.: File:			No	By	Date	Revision	Spec. No.	Rev.	
							17206		
							Contract	Date	
							Req.	P.O.	
							By	Chk	App
G E N	1	Instrument Tag Number	LE/LIT-						
	2	Service							
	3	P&ID							
	4	Other							
P R O B E	5	Type	Ultrasonic						
	6	Housing Material							
	7	Measurement Range							
	8	Op. Temp. Range							
	9	Manufacturer							
	10	Model							
C A B L E	11	Model Number							
	12	Style	Mfg. Std						
	13	Length							
	14	Other							
	15	Other							
	16	Other							
T R A N S M I T T E R	17	Type							
	18	Operating Mode							
	19	Enclosure							
	20	Mounting							
	21	Temperature Range							
	22	Voltage Requirements	115 VAC, 60 Hz						
	23	Power							
	24	Accuracy							
	25	Display							
	26	Output	4-20 mA						
	27	Calibration							
	28	Status Relay							
	29	Manufacturer							
	30	Model No.							
	31	Elect. Entry							
	32	Other							
O P T S	33								
	34								
	35								
	36								
Notes:									

SECTION 17301

FLOW MEASUREMENT - SWITCHES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Thermal dispersion flow switches.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - a. Items involving electrical, control, and instrumentation construction may be indicated on the Drawings or specified in the Specifications that do not apply specifically to electrical, control and instrumentation systems.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- C. Provide all instruments identified in the Contract Drawings.

1.02 REFERENCES

- A. As specified in Section 17050.
- B. National Institute of Standards and Technology (NIST).

1.03 DEFINITIONS

- A. As specified in Section 17050.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 17050.
- B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050.

- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures

1.08 WARRANTY

- A. As specified in Section 17050.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal.
 - 1. Thermal dispersion type:
 - a. Fluid Components International LLC FLT93.
 - b. Micro-Processor Based Kurz Instruments Model 6500 or 6300.

2.02 MANUFACTURED UNITS

- A. Thermal dispersion type:
 - 1. General:
 - a. Instrument uses a heated probe and a reference probe.
 - 1) Deviation in the amount of heat measured by the reference probe deviates beyond the setpoint an adjustable relay closes.

- 2) Switch:
 - a) Micro-processor based with continuous self diagnostics, "Smart Heater" to prevent sensor failure, no mechanical jumpers or trim pots, and a 3-year warranty.
 - b) Capability to offer a 4 to 20 milliamperes output.
 - c) LEDs to display the performance of the level, flow rate or performance of the switch at all times via through the glass switch enclosure lid.
2. Performance requirements:
 - a. Accuracy: Within 2 degrees Fahrenheit.
 - b. Repeatability: Within 1 percent of setpoint range.
 - c. Response time: 0.5 to 2.5 seconds.
3. Switch characteristics:
 - a. Exposed parts: Powder coated aluminum housing.
 - b. Wetted parts:
 - 1) Materials as recommended by the manufacturer and approved by the Engineer.
 - c. Power supply:
 - 1) 115 VAC.
 - 2) Power consumption: 13 VA maximum.
 - d. Operating temperature range: -40 degrees Fahrenheit to 140 degrees Fahrenheit.
 - e. Enclosure: NEMA Type 4X.

2.03 ACCESSORIES

- A. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the National Institute of Standards and Technology.
 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 INSTALLATION

- A. As specified in Section 17050.

3.02 FIELD QUALITY CONTROL

- A. As specified in Section 17050.
- B. **[Manufacturer's field services.]**

3.03 ADJUSTING

- A. As specified in Section 17950.

3.04 CLEANING

- A. As specified in Section 17050.

3.05 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050.
- B. Demonstrate performance of all instruments to the ENGINEER before commissioning.
- C. Furnish 4 hours of OWNER training.

3.06 PROTECTION

- A. As specified in Section 17050.

3.07 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

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SECTION 17302

FLOW MEASUREMENT - MAGNETIC FLOWMETERS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Full-body magnetic flowmeters.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- C. Provide all instruments identified in the Contract Drawings.

1.02 REFERENCES

- A. As specified in Section 17050.
- B. National Institute of Standards and Technology (NIST).
- C. NSF International (NSF).

1.03 DEFINITIONS

- A. As specified in Section 17050.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 17050.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.

- b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050.

1.08 WARRANTY

- A. As specified in Section 17050.

1.09 MAINTENANCE

- A. As specified in Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Endress+Hauser: Promag 53.
 - 2. Rosemount: 8700E.
 - 3. Krohne: IFC.
 - 4. Yokogawa: AXF.
 - 5. ABB: Watermaster.

2.02 MANUFACTURED UNITS

- A. Magnetic flowmeter:
 - 1. General:
 - a. Magnetic flowmeters obtain the flow velocity by measuring the changes of induced voltage of the conductive fluid passing across a controlled magnetic field.
 - b. Complete zero stability shall be an inherent characteristic of the flowmeter system.
 - c. Include for each magnetic flow metering system:
 - 1) A metering tube with electrodes (sensor).
 - 2) Signal cable.
 - 3) Transmitter integral or remote as indicated on the Drawings.
 - 4) Flowmeter grounding rings.
 - 2. Performance requirements:
 - a. Accuracy:
 - 1) 0.25 percent of flow rate from 10 to 100 percent of full scale for velocities ranging between 1.9 to 10 feet per second.

- b. Repeatability:
 - 1) 0.25 percent of rate.
- 3. Element:
 - a. Metering tube:
 - 1) Constructed of carbon steel or Type 304 stainless steel (unless specifically noted otherwise in the instrument data sheets) with flanged connections to match with piping material.
 - 2) Liner material in conformance with:
 - a) Manufacturer's recommendations for the intended service.
 - b) NSF certified for all drinking water applications.
 - 3) Electrodes type and material in conformance with:
 - a) Manufacturer's recommendations for the intended service.
 - b) Utilize a minimum of 2, self-cleaning electrodes.
 - 4) Meter terminal housing NEMA Type 4X unless specifically noted otherwise in the instrument data sheets.
 - 5) Meter coating consisting of epoxy painted finish.
 - 6) Components:
 - a) 2 grounding rings:
 - (1) Which are in conformance with the manufacturer's bore and material recommendation for the meter's intended service.
 - (2) Designed to protect and shield from abrasion of the liner's edge interface at the meter's end.
- 4. Transmitter:
 - a. Power supply:
 - 1) 120 VAC.
 - 2) Power consumption: 60 VA maximum.
 - b. Outputs:
 - 1) As noted in the instrument data sheets.
 - 2) For all instruments with 4 to 20 mA HART or digital bus protocol, provide a Device Type Manager (DTM) certification by FDT group.
 - c. Microprocessor-based signal converter/transmitter.
 - d. Utilize DC pulse technique to drive flux-producing coils.
 - e. Contain a 6-digit display for flow rate, percent of span, and totalizer.
 - f. Operator keypad interface.
 - g. Integral zero return to provide consistent zero output signals in response to an external dry contact closure.
 - h. Integral low flow cut-off zero return.
 - i. Programmable parameters including:
 - 1) Meter size.
 - 2) Full-scale flow rate.
 - 3) Magnetic field frequency.
 - 4) Time constant.
 - j. Data retention for a minimum of 5 years without auxiliary main or battery power.
 - k. Self-diagnostics and automatic data checking.
 - l. Protected terminals and fuses in a separate compartment which isolates field connection from electronics.
 - m. Ambient operating temperature limits of -5 to 140 degrees Fahrenheit (-20 to 60 degrees Celsius).

2.03 ACCESSORIES

- A. Stainless steel tag labeled as specified in the Contract Documents.
- B. Provide sunshades for all transmitters located outdoors.
- C. Provide galvanic isolation gaskets, nylon/Teflon flange bolt insulation bushings and nylon washers on all meters installed on pipes with cathodic protection.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050.
- B. Factory calibrate each flow metering system at a facility that is traceable to the NIST.
- C. A real-time computer generated printout of the actual calibration date indication actual velocities and as read values of the flow tube.
 - 1. Flow calibration report of the manufacturers flow lab calibration procedure shall be shipped with the meter system.
 - 2. Minimum calibration shall be a 3 point calibration including 1, 3, and 10 feet per second velocities for every meter and transmitter system.
 - 3. Manufacturer shall archive all calibration reports for future reference.

PART 3 EXECUTION

3.01 ~~EXAMINATION~~ (NOT USED)

3.02 ~~PREPARATION~~ (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050.
- B. Provide manufacturer's services to perform start-up and calibration or verification.

3.05 ADJUSTING

- A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
 - 1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

- A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050.
- B. Demonstrate performance of all instruments to the Engineer before commissioning.

3.08 PROTECTION

- A. As specified in Section 17050.

3.09 SCHEDULES

- A. Instrument Data Sheets included in this Section.
- B. The provided information does not necessarily include all required instruments.
- C. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E: Carollo Engineers		MAGNETIC FLOWMETERS				INSTRUMENT DATA SHEETS		
		No	By	Date	Revision	Spec. No.	Rev.	
Contractor:						17302		
Project:						Contract	Date	
Customer:								
Plant:						Req.	P.O.	
Location:								
BOM No.:						By	Chk	App
File:								
1	Instrument Tag No.							
2	Service							
3	P&ID							
4	C	Line Size / Schedule						
5	O	Line Material						
6	N	Connection Type/ Pressure Rating						
7	N	Connection Materials						
8		Tube Size						
9		Tube Material						
10		Liner Material						
11	M	Electrode Type	Mfg Standard					
12	E	Electrode Material						
13	T	Meter Casing						
14	E	Power Sply	Phase	120 VAC	1P			
15	R	Grounding Type & Matl.						
16		Enclosure Class	NEMA 4X					
17		Other						
18		Fluid						
19	F	Max Flow						
20	L	Min Velocity						
21	U	Min Flow	Norm Flow					
22	I	Min Temp	Max Temp					
23	D	Min Press	Max Press					
24		Vacuum Possibility						
25		Conductivity						
26	T	Function						
27	R	Mounting	Integral					
28	A	Enclosure Class	NEMA 4X					
29	N	Length Signal Cable						
30	S	Type Span Adjustment						
31	M	Power Supply						
32	I	Transmitter Output	4-20 mA HART					
33	T	Relay Outputs	Form C					
34	T	Accuracy	0.25%					
35	E	Calibrated Range						
36	R	Empty Pipe Detection						
37		Bi-Directional Flow						
38		Display Scale Size	Range					
39		Alarm Contact No.	Form					
40		Manufacturer						
41		Element (Meter) Model No.						
42		Transmitter (Inst.) Model No.						
Notes:								

SECTION 17316

FLOW MEASUREMENT - ROTAMETERS (VARIABLE AREA FLOWMETERS)

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Rotameters (variable area flowmeters).
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050.

1.03 DEFINITIONS

- A. As specified in Section 17050.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 17050.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050.
- B. **EXAMINE THE COMPLETE SET OF CONTACT DOCUMENTS AND VERIFY THAT THE INSTRUMENTS ARE COMPATIBLE WITH THE INSTALLED CONDITIONS INCLUDING:**
 - 1. **PROCESS CONDITIONS: FLUIDS, PRESSURES, TEMPERATURES, FLOWS, MATERIALS, ETC.**
 - 2. **PHYSICAL CONDITIONS:**
 - A. **INSTALLATION AND MOUNTING REQUIREMENTS.**
 - B. **LOCATION WITHIN THE PROCESS.**

C. ACCESSORIES: VERIFY THAT ALL REQUIRED ACCESSORIES ARE PROVIDED AND ARE COMPATIBLE WITH THE PROCESS CONDITIONS AND PHYSICAL INSTALLATION.

- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050.

1.08 WARRANTY

- A. As specified in Section 17050.

1.09 MAINTENANCE

- A. As specified in Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
1. ABB.
 2. Brooks.
 3. King Instrument Company.

2.02 MANUFACTURED UNITS

- A. Rotameters:
1. General:
 - a. Variable area type flowmeters with local flow indication.
 - b. Glass tube type.
 2. Performance requirements:
 - a. Flow range:
 - 1) As specified in instrument data sheets or instrument index.
 - b. Accuracy:
 - 1) Glass tube: Within 2.0 percent of range.
 - 2) Metal tube: Within 5.0 percent of range.
 - 3) Repeatability: 0.50 percent of range.
 3. Element:
 - a. Flow tube:
 - 1) Glass tube: Borosilicate glass, or as required to be compatible with the process conditions.
 - b. Metal tube with magnetic follower: Type 316 stainless steel.
 - c. Turndown: 10 to 1.
 - d. Process temperature:

- 1) Glass tube: 32 to 200 degrees Fahrenheit.
- 2) Metal tube: -20 to 320 degrees Fahrenheit.
- e. Maximum process pressure:
 - 1) Glass tube: 100 pounds per square inch gauge.
 - 2) Metal tube: 450 pounds per square inch gauge.
 - 3) Size tube for the largest of the following:
 - a) 2.0 times the normal flow rate.
 - b) 1.2 times the maximum flow rate.
 - c) 4.0 times the minimum flow rate.
4. Other:
 - a. Process connection:
 - 1) As indicated on the Mechanical Drawings.
 - b. Mounting:
 - 1) As indicated on the Drawings.
 - 2) Provide all necessary hardware for rotameter mounting.

2.03 SOURCE QUALITY CONTROL

- A. As specified in Section 17050.

PART 3 EXECUTION

3.01 INSTALLATION

- A. **AS SPECIFIED IN SECTION 17050.**
- B. **COORDINATE THE INSTALLATION WITH ALL TRADES TO ENSURE THAT THE MECHANICAL SYSTEM HAS ALL NECESSARY APPURTENANCES INCLUDING WELD-O-LETS, VALVES, ETC. FOR PROPER INSTALLATION OF INSTRUMENTS.**

3.02 FIELD QUALITY CONTROL

- A. **AS SPECIFIED IN SECTION 17050.**

3.03 ADJUSTING

- A. **VERIFY FACTORY CALIBRATION OF ALL INSTRUMENTS IN ACCORDANCE WITH THE MANUFACTURER'S INSTRUCTIONS:**
 1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04 CLEANING

- A. **AS SPECIFIED IN SECTION 17050.**

3.05 DEMONSTRATION AND TRAINING

- A. **AS SPECIFIED IN SECTION 17050.**
- B. **DEMONSTRATE PERFORMANCE OF ALL INSTRUMENTS TO THE ENGINEER BEFORE COMMISSIONING.**

3.06 PROTECTION

- A. **AS SPECIFIED IN SECTION 17050.**

3.07 SCHEDULES

- A. **THE PROVIDED INFORMATION DOES NOT NECESSARILY INCLUDE ALL REQUIRED INSTRUMENTS. PROVIDE ALL INSTRUMENTS IDENTIFIED IN THE CONTRACT DOCUMENTS:**
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E: Carollo Engineers				VARIABLE AREA FLOWMETERS (ROTAMETERS)				Spec. No.		Rev.	
Contractor:				No	By	Date	Revision	17316			
Project:								Contract		Date	
Customer:								Req.		P.O.	
Plant:											
Location:											
BOM No.:								By	Chk	App	
File:											
G E N E	1	Instrument Tag Number									
	2	Service									
	3	P&ID									
	4	Function		Local Indicator							
	5	Mounting		Line							
	6	Power Supply		N/A							
R A L	7	Conn. Size	Type	1/2 inch	Glass Tube						
	8	Inlet Dir.	Outlet Dir.	Vert.	Vert.						
	9	Fitting Material		316 SST							
	10	Packing or O-ring Mat'l.		BUNA-N							
	11	Enclosure Type		N/A							
M E T E R	12	Size	Float Guide	1/2 inch							
	13	Tube Mat'l.	Float Mat'l.	Glass	SS						
	14	Meter Scale: Lgth. & Type									
	15	Meter Scale Range									
	16	Meter Factor		1							
	17	Rated Accuracy		±2 %							
	18	Hyd. Calib. Required									
F L U I D	19	Fluid		Seal Water							
	20	Color or Transparency		Clear							
	21	Max. Flow Rate									
	22	Norm Flow	Min Flow								
	23	Oper. Sp. Gr. (Liq.)									
	24	Max. Oper. Viscosity									
	25	Oper. Press.	Oper. Temp.								
	26	Oper. Density (Gas)									
	27	Std. Dens.	Mol. Wgt.								
	28	Max. Allow. Press. Drop									
	29	Other									
E X T	30	Extension Well Mat'l.		N/A							
	31	Gasket Mat'l.		N/A							
	32	Other		N/A							
X M T	33	Xmtr Output		N/A							
	34	Xmtr Enclosure Class		N/A							
	35	Scale Range		N/A							
	36	Other		N/A							
A L M	37	# Contacts	Form	N/A	N/A						
	38	Rating	Housing	N/A	N/A						
	39	Action		N/A							
	40	Other		N/A							
O P T S	41	Valve Size & Material		N/A							
	42	Valve Location		N/A							
	43	Cnst. Diff. Relay Mat'l.		N/A							
	44	Purge Meter Tubing		N/A							
	45	Airset		N/A							
	46	Other		N/A							
	47	Manufacturer									
	48	Model Number									
	49	Tube Number									
	50	Float Number									
Notes:											

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SECTION 17401

PRESSURE/VACUUM MEASUREMENT - DIAPHRAGM AND ANNULAR SEALS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Diaphragm seals.
 - 2. Annular seals.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- C. Provide all seals identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050.

1.03 DEFINITIONS

- A. As specified in Section 17050.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 17050.
- B. Additional requirements:
 - 1. Product data:
 - a. Manufacturer's installation instructions.
 - b. Seal type.
 - c. Body materials.
 - d. Diaphragm material.
 - e. Fill fluid type.
 - f. Seal size.
 - g. Options.
 - h. Process connection.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the ENGINEER if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050.

1.08 WARRANTY

- A. As specified in Section 17050.

1.09 MAINTENANCE

- A. As specified in Section 17050.
- B. Provide spare annular seal for every size indicated in the project.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Diaphragm seals:
 - 1. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch gauge: One of the following or equal:
 - a. Ashcroft:
 - 1) Flushing connection: Type 741.
 - 2) Without flushing connection: Type 740.
 - b. Mansfield and Green:
 - 1) Flushing connection: Type SGT.
 - 2) Without flushing connection: Type SBT.
 - c. Wika, Type L990.40.
 - d. Rosemount.

2. For chemical applications, liquids containing solids, and liquids with pulsating flow having pressures greater than or equal to 15 pounds per square inch gauge: One of the following or equal:
 - a. Ashcroft:
 - 1) Flushing connection: Type 201.
 - 2) Without flushing connection: Type 200.
 - b. Mansfield and Green:
 - 1) Flushing connection: Type SG.
 - 2) Without flushing connection: Type SB.
 - c. Wika:
 - 1) Type L990.10.
 - d. Rosemount.
- B. Annular seals:
1. One of the following or equal:
 - a. Red Valve.
 - b. Ashcroft Iso-Ring.
 - c. Onyx Valve.

2.02 MANUFACTURED UNITS

- A. Diaphragm seals:
1. General:
 - a. Diaphragm seal and pressure instrument shall be assembled by pressure instrument manufacturer and shipped as an assembly.
 2. Requirements:
 - a. Seal type:
 - 1) Metallic diaphragm: Welded to upper housing.
 - 2) Elastomer diaphragm: Bonded to upper housing.
 - b. Process connection: 1 inch NPT.
 - c. Instrument connection: 1/2 inch NPT.
 - d. Provide 1/4-inch flushing connection in diaphragm lower housing or provide flushing ring.
 - e. Flush port plug: Same material of construction as diaphragm lower housing.
 - f. Provide fill/bleed connection.
 - g. Mounting: As indicated in the Contract Documents.
 - h. Provide Type 316 stainless steel armored capillary for all remote installations.
 - i. Nuts and bolts: Type 316 stainless steel.
 - j. Materials of construction:
 - 1) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures less than or equal to 15 pounds per square inch:
 - a) Diaphragm: Type 316 stainless steel.
 - b) Lower housing: Type 316 stainless steel.
 - c) Upper housing: Manufacturer's standard.
 - d) Fill fluid: Silicon oil.
 - 2) Sewage, sludge, liquids containing solids, and liquids with pulsating flow having pressures greater than 15 pounds per square inch:
 - a) Diaphragm: Type 316 stainless steel.
 - b) Lower housing: Type 316 stainless steel.

- c) Upper housing: Manufacturer's standard.
- d) Fill fluid: Silicon oil.

B. Annular seals:

1. General:

- a. Inside diameter of annular seal shall provide uninterrupted flow:
 - 1) There shall be no dead ends or crevices.
 - 2) Process flow shall be sufficient to make the annular seal self-cleaning.
- b. The pressure sensing flexible cylinder shall measure pressure around the full inside circumference of the pipeline.

2. Requirements:

- a. Pressure rating: Equivalent to the ANSI flanges.
- b. Materials of construction:
 - 1) Inner flexible cylinder: Manufacturer's standard.
 - 2) Body: Carbon steel.
 - 3) Assembly flanges: To match adjacent piping.
 - 4) Fill fluid: Silicon oil.
- c. Nominal pipe size: As indicated on the Drawings.
- d. Process connection: Class 150 Raised Face Flange.
- e. Instrument connection: 1/2 inch NPT.
- f. Provide isolating needle valve between annular seal and pressure instrument.

2.03 ACCESSORIES

- A. Provide field fill kits.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050.

PART 3 EXECUTION

3.01 INSTALLATION

- A. As specified in Section 17050.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.
- C. Do not use Teflon thread seal tape on pressure instruments with silicon oil fill fluid.

3.02 FIELD QUALITY CONTROL

- A. As specified in Section 17050.

3.03 CLEANING

- A. As specified in Section 17050.

3.04 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050.

3.05 PROTECTION

- A. As specified in Section 17050.

3.06 SCHEDULES

- A. The provided information does not necessarily include all required instruments.
Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, in the Specifications or both.

END OF SECTION

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SECTION 17402

PRESSURE/VACUUM MEASUREMENT - INSTRUMENT VALVES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Valve manifolds and instrument valves.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050.
- B. International Organization for Standardization (ISO):
 - 1. 9001 – Quality Management Systems – Requirements.
- C. National Institute of Standards and Technology (NIST).

1.03 DEFINITIONS

- A. As specified in Section 17050.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 17050.
- B. Provide complete documentation covering the traceability of all calibration instruments.
- C. Additional requirements:
 - 1. Product data:
 - a. Valve type.
 - b. Body material.

- c. Size.
 - d. Options.
- 2. Shop drawings:
 - a. Mounting details for all manifold valves.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050.
- B. Examine the complete set of Contact Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050.
- B. Protect valve manifolds and protective coatings from damage during handling and installation. Repair coating where damaged.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050.

1.09 MAINTENANCE

- A. As specified in Section 17050.
- B. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Valve manifold manufacturers: One of the following or equal:
 - 1. Anderson Greenwood.
 - 2. Hex Valve.
 - 3. Noshok.
 - 4. Rosemount.
- B. Block and bleed valve manufacturers: One of the following or equal:
 - 1. Anderson Greenwood.
 - 2. Hex Valve.
- C. Gauge valve manufacturers: One of the following or equal:
 - 1. Anderson Greenwood.
 - 2. Hex Valve.
- D. Level sensor isolation valve manufacturers: One of the following or equal:
 - 1. Indu-Tech Level Sensor Isolation Valve.
 - 2. DeZURIK Level Sensor Isolation Valve.
 - 3. Tyco Rovalve Isolation Knife Gate Valve.

2.02 MANUFACTURED UNITS

- A. Valve manifolds:
 - 1. General:
 - a. Provide 2-valve, 3-valve, blowdown type 5-valve, or metering type 5-valve manifolds as indicated on the Drawings.
 - b. Valve manifolds shall have one piece bonnet with a metal to metal seal to the valve body below the bonnet threads.
 - 2. Requirements:
 - a. Bonnet lock pin to prevent accidental loosening.
 - b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
 - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
 - d. Manifold valves shall have straight through portion for bi-directional flow and easy roddable cleaning.
 - e. Manifold valves shall allow for direct or remote instrument mounting.
 - f. Shall be able to withstand pressures up to 6,000 psi for soft seat valves and 10,000 psi for hard seat valves at maximum 200 degrees Fahrenheit.
 - g. Materials of construction:
 - 1) Body material: Type 316 stainless steel.
 - 2) O-Ring: Teflon.
 - h. 2-Valve manifolds:
 - 1) 1 isolation valve and 1 drain/vent and calibration valve.
 - i. 3-Valve manifolds:
 - 1) 2 isolation valves and 1 equalizing valve for differential pressure applications.
 - 2) Plugged vent connections used for vent/drain or calibration.
 - j. Blowdown 5-valve manifold:
 - 1) 2 isolation valves, 1 equalizing valve, 2 blowdown valves for differential pressure applications.

- k. Metering 5-valve manifold:
 - 1) 2 isolation valves, 2 equalizing valves, 1 vent/drain and calibration valve for differential pressure applications.
 - B. Block and bleed valves:
 - 1. General:
 - a. Valve shall provide process isolation and venting/draining capabilities.
 - b. Gas leak tested metal-to-metal hard seat design for hard seat valves.
 - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
 - d. Valve shall not be used with fluids with high solids content, such as raw wastewater or sludge.
 - 2. Requirements:
 - a. Materials of construction:
 - 1) Body material: Type 316 stainless steel.
 - 2) O-Ring: Teflon.
 - C. Gauge valves:
 - 1. General:
 - a. Valve shall provide process isolation from pressure instrument.
 - b. Gas leak tested, metal-to-metal hard seat design for hard seat valves.
 - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
 - 2. Requirements:
 - a. Materials of construction:
 - 1) Body material: Type 316 stainless steel.
 - 2) O-Ring: Teflon.
 - D. Level sensor isolation valves:
 - 1. General:
 - a. Valve shall provide process isolation from level diaphragm.
 - b. Gas leak tested, metal-to-metal hard seat design for hard seat valves.
 - c. Gas leak tested soft seat design with replaceable seat for soft seat valves.
 - 2. Requirements:
 - a. Materials of construction:
 - 1) Body material: Type 316 stainless steel.
 - 2) Flange diameter size: 3 inches.

2.03 ACCESSORIES

- A. Provide tube fitting, female NPT, or pipe butt weld connections if necessary.
- B. Provide stainless steel concentric or eccentric pipe nipples when necessary.
- C. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 INSTALLATION

- A. As specified in Section 17050.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.03 FIELD QUALITY CONTROL

- A. As specified in Section 17050.

3.04 ADJUSTING

- A. As specified in Section 17950.
- B. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
 - 1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.05 CLEANING

- A. As specified in Section 17050.

3.06 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050.
- B. Demonstrate performance of all instruments to the Engineer before commissioning.
- C. Furnish 4 hours of OWNER training.

3.07 PROTECTION

- A. As specified in Section 17050.

3.08 SCHEDULES

- A. The provided information does not necessarily include all required instruments.
Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

SECTION 17403

PRESSURE/VACUUM MEASUREMENT - SWITCHES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Pressure/vacuum switches.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - c. Section 17401 - Pressure/Vacuum Measurement - Diaphragm and Annular Seals.
 - d. Section 17402 - Pressure/Vacuum Measurement - Instrument Valves.
- C. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050.
- B. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).
- C. National Institute of Standards and Technology (NIST).

1.03 DEFINITIONS

- A. As specified in Section 17050.
- B. NEMA:
 - 1. Type 4X enclosure in accordance with NEMA 250.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 17050.

- B. Additional requirements:
 - 1. Product data:
 - a. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050.
- B. Examine the complete set of Contact Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Mechanical type pressure switch: One of the following or equal:
 - 1. Ashcroft B Series Type 400.
 - 2. United Electric Controls 400 Series.
 - 3. ASCO S-Series.

2.02 MANUFACTURED UNITS

- A. Mechanical type pressure switches:
 - 1. General:
 - a. Pressure switch shall be diaphragm or diaphragm-sealed piston type.
 - 2. Performance requirements:
 - a. Pressure range:
 - 1) As specified in data sheets following this Section.
 - b. Accuracy:
 - 1) Within 1.0 percent of range.
 - c. Repeatability:
 - 1) Within 1.0 percent of range.
 - 3. Element:
 - a. Type: Diaphragm, diaphragm-sealed piston, or bourdon tube.
 - b. Overpressure:
 - 1) Minimum 130 percent of maximum range pressure without damage to switch or sensing element.
 - 2) Minimum 400 percent of nominal range without leakage or rupture.
 - c. Sensing element shall not require ambient temperature compensation.
 - d. Wetted materials: Stainless steel.
 - e. Setpoint:
 - 1) Dual.
 - 2) Switch shall activate at setpoint on increasing pressure for high-pressure alarm applications and on decreasing pressure for low-pressure alarm applications.
 - f. Fixed deadband.
 - g. Switch elements:
 - 1) Snap acting.
 - 2) Single pole-double throw (SPDT).
 - 3) Hermetically sealed.
 - 4) Rated at 5 A, 125/250 VAC.
 - 5) Automatic reset type.
 - h. Enclosure: Epoxy coated NEMA Type 4X.
 - i. Switch mounting:
 - 1) Process connection: 1/2-inch NPT.
 - 4. Components:
 - a. Provide all necessary hardware for pressure switch mounting.

2.03 ACCESSORIES

- A. Pulsation dampeners and snubbers:
 - 1. Provide pulsation dampener or snubber with each pressure switch installed on discharge of positive displacement type pump.
 - 2. Materials: Stainless steel.
 - 3. Mount pulsation dampener or snubber integrally to the pressure switch.
 - 4. Connection: 1/2-inch NPT.
- B. Provide integral diaphragm seals as specified in data sheets following this Section and as specified in Section 17401:
 - 1. Diaphragm seal and pressure switch shall be assembled by manufacturer and shipped as an assembly.

- C. Furnish block and bleed valves as specified in Section 17402.
- D. Furnish gauge valves as specified in Section 17402.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 INSTALLATION

- A. As specified in Section 17050.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.02 FIELD QUALITY CONTROL

- A. As specified in Section 17050.
- B. Provide manufacturer's services to perform start-up and calibration or verification.

3.03 ADJUSTING

- A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
 - 1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04 CLEANING

- A. As specified in Section 17050.

3.05 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050.
- B. Demonstrate performance of all instruments to the Engineer before commissioning.
- C. Furnish 1 hour of Owner training.

3.06 PROTECTION

- A. As specified in Section 17050.

3.07 SCHEDULES

- A. The provided information does not necessarily include all required instruments.
Provide all instruments specified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

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SECTION 17404

PRESSURE/VACUUM MEASUREMENT - GAUGES

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Pressure/vacuum gauges.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - c. Section 17401 - Pressure/Vacuum Measurement - Diaphragm and Annular Seals.
 - d. Section 17402 - Pressure/Vacuum Measurement - Instrument Valves.
- C. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050.
- B. American Society of Mechanical Engineers (ASME):
 - 1. B40.100 - Pressure Gauges and Gauge Attachments.
- C. National Institute of Standards and Technology (NIST).

1.03 DEFINITIONS

- A. As specified in Section 17050.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 17050.
- B. Additional requirements:
 - 1. Product data:
 - a. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050.

1.08 WARRANTY

- A. As specified in Section 17050.

1.09 MAINTENANCE

- A. As specified in Section 17050.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: One of the following or equal:
 - 1. Ashcroft:
 - a. Maximum pressure less than 10 pounds per square inch: Model 1188.
 - b. Maximum pressure greater than or equal to 10 pounds per square inch: Model 1009.
 - 2. Wika.
 - 3. Ametek U.S. Gauge.

2.02 MANUFACTURED UNITS

- A. General:
 - 1. Pressure gauge assembly shall include pressure sensing element, gauge case, and dial mechanism.

- B. Performance requirements:
1. Pressure range:
 - a. As specified in the Contract Documents.
 2. Accuracy:
 - a. Grade 2A, as defined by ASME B40.100.
 - b. Within 1.0 percent of span after friction errors are eliminated by tapping or vibration.
 - c. Maximum allowable friction inaccuracy: Within 1.0 percent of span.
 3. Element:
 - a. Where the maximum pressure is less than 10 pounds per square inch, provide socket and bellows; for all other pressure ranges, employ a Bourdon tube.
 - b. Socket tips for bellows and Bourdon tube:
 - 1) Materials: Type 316 stainless steel.
 - c. Overpressure: Minimum 130 percent of maximum range pressure without damage to gauge or sensing element.
 - d. Wetted materials: Type 316 stainless steel.
 4. Dial gauge:
 - a. Dial size: 4-1/2 inches.
 - b. Dial case material:
 - 1) Maximum pressure less than 10 pounds per square inch:
 - a) Phenolic.
 - c. Maximum pressure greater than or equal to 10 pounds per square inch:
 - 1) Phenolic.
 - d. Provide safety gauge with rupture disk and blow out back.
 - e. Dial face: Gasketed shatterproof glass or polycarbonate.
 - f. Provide gauge locks where possible.
 - g. Hermetically sealed.
 - h. Connection and mounting:
 - 1) Direct mounted and suitable for outdoor installation.
 - 2) 1/2 inch NPT.
 - 3) Connection material: Stainless steel.
 - i. Pointer: Externally adjustable.

2.03 ACCESSORIES

- A. Pulsation dampeners and snubbers:
1. Provide pulsation dampener or snubber with each pressure gauge installed on discharge of positive displacement type pump.
 2. Provide piston-type snubber if pressure spikes will exceed 130 percent of gauge maximum range.
 3. Materials: Type 316 stainless steel.
 4. Mount pulsation dampener or snubber integrally to the pressure gauge.
 5. Connection: 1/2-inch NPT.
- B. Provide diaphragm seals as specified in the Contract Documents and in Section 17401:
1. Diaphragm seal and pressure gauge shall be assembled by manufacturer and shipped as an assembly.
- C. Provide means for gauge isolation as specified in Section 17402:
1. Mount valve manifold integrally to the gauge.

2. Valve manifold and pressure gauge shall be assembled by manufacturer and shipped as an assembly.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050.
- B. Factory calibrate each pressure gauge at a facility that is traceable to the NIST.
- C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 INSTALLATION

- A. As specified in Section 17050.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.02 FIELD QUALITY CONTROL

- A. As specified in Section 17050.
- B. Provide manufacturer's services to perform start-up and calibration or verification.

3.03 ADJUSTING

- A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
 1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.04 CLEANING

- A. As specified in Section 17050.

3.05 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050.
- B. Demonstrate performance of all instruments to the Engineer before commissioning:
 1. Furnish 0.5 hours of Owner training.

3.06 PROTECTION

- A. As specified in Section 17050.

3.07 SCHEDULES

- A. The provided information does not necessarily include all required instruments.
Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

pw://Carollo/Documents/Client/WA/Oak Harbor/8549A10/Specifications/Procurement/MBR/17404 (PREPUR1)

SECTION 17405

PRESSURE/VACUUM MEASUREMENT - DIRECT

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Pressure transmitters and indicators.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - c. Section 17401 - Pressure/Vacuum Measurement - Diaphragm and Annular Seals.
 - d. Section 17402 - Pressure/Vacuum Measurement - Instrument Valves.
 - e. Section 17950 - Testing, Calibration, and Commissioning.
- C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050.

1.03 DEFINITIONS

- A. As specified in Section 17050.
- B. NEMA:
 - 1. Type 4X enclosure in accordance with NEMA 250.
- C. Specific definitions:
 - 1. Lower range value (LRV): Lowest pressure that the pressure transmitter is capable of measuring.
 - 2. Upper range value (URV): Highest pressure that the pressure transmitter is capable of measuring.
 - 3. Calibrated range: The range that the pressure transmitter is configured to measure. The low end of the calibrated range must be greater than the LRV of the transmitter. The high end of the calibrated range must be less than or

equal to the URV. The calibrated range corresponds to the flow signal sent from the transmitter.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 17050.
- B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050(40_61_00).
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the ENGINEER if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050(40_61_00).
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Rosemount: 3051 Series.
 - 2. Yokogawa: EJA Series.
 - 3. ABB: 264 Series.
 - 4. Endress & Hauser: Cerabar S Series.
 - 5. SMAR: LD300 Series.

2.02 MANUFACTURED UNITS

- A. Pressure transmitters – direct:
 - 1. General:
 - a. Pressure transmitter assembly shall include a diaphragm type pressure transducer and microprocessor based transmitter for measurement of gauge, vacuum, or absolute pressure.
 - 2. Performance requirements:
 - a. Maximum ratio of total instrument range to calibrated span: 10 to 1.
 - b. Accuracy:
 - 1) Reference accuracy: Plus or minus 0.075 percent of calibrated span, including effects of hysteresis, nonlinearity, and repeatability.
 - 2) Total performance accuracy: Plus or minus 0.30 percent of calibrated span, including reference accuracy effects, static pressure and ambient temperature effects.
 - 3) Stability: Plus or minus 0.15 percent of upper range limit over 5 years.
 - 3. Element:
 - a. Diaphragm type transducer integral to pressure transmitter.
 - b. Diaphragm material: Stainless steel or ceramic.
 - c. Process material compatibility:
 - 1) Verify all material compatibilities with the instrument manufacturer.
 - d. Process connection: As specified in the Instrument Data Sheets.
 - 4. Transmitter:
 - a. Power supply:
 - 1) 24 VDC - 2 wire loop powered.
 - 2) Power consumption: 3 VA maximum.
 - b. Outputs:
 - 1) Isolated 4-20 mA DC with HART communication protocol.
 - c. Provided with electronic microprocessor.
 - d. Adjustments: Adjustable electronic zero and span, with elevated or suppressed zero as required by application. Adjustment shall be possible without mechanical fulcrum points or handheld configurator.
 - e. Local display:
 - 1) 5-digit LCD.
 - 2) Scaled in engineering units.
 - f. Enclosure: NEMA Type 4X.
 - g. Over range protection: To maximum process line pressure.
 - h. Conduit: 1/2 inch male NPT.

5. Components:
 - a. Transmitter mounting:
 - 1) As specified in the Instrument Data Sheets.
 - 2) Provide all necessary hardware for transmitter mounting.

2.03 ACCESSORIES

- A. Provide valve manifolds as specified in Section 17402:
 1. Mount valve manifold integrally to the transmitter.
 2. Valve manifold and transmitter shall be assembled by Manufacturer and shipped as an assembly.
 3. Provide remote or integral diaphragm seals as specified in the Instrument Data Sheets and in Section 17401.
- B. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the National Institute of Standards and Technology.
 1. Submit calibration data sheets to the ENGINEER at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 1. Notify the ENGINEER promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 ~~PREPARATION~~ (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050.
- B. Provide manufacturer's services to perform start-up and calibration or verification.

3.05 ADJUSTING

- A. As specified in Section 17950.

3.06 CLEANING

- A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050.

3.08 PROTECTION

- A. As specified in Section 17050.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments.
Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

A/E: Carollo Engineers Contractor: Project: Customer: Plant: Location: BOM No.: File:			PRESSURE TRANSMITTERS				Spec. No.		Rev.	
			No	By	Date	Revision	17405			
							Contract		Date	
							Req.		P.O.	
							By	Chk	App	
GENERAL	1	Instrument Tag No.	PIT-xxx							
	2	Service	Water							
	3	P&ID								
SERVICE	4	Pressure								
	5	Process Temperature	35-70 deg F							
	6	Ambient Temperature								
TRANSMITTER	7	Manufacture								
	8	Model No.								
	9	Pressure Transmitter Type	Direct							
	10	Calibrated Span								
	11	Accuracy								
	12	Adjustable Range								
	13	Output Signal	4-20 Ma HART							
	14	Body Rating								
BODY	15	Process Flange Type	Threaded							
	16	Drain/Vent	None							
	17	Process Flange	MNPT							
	18	Adapters								
	19	Wetted O-Ring								
	20	Housing								
	21	Bolts								
	22	Mounting Brackets								
	23	Conduit Entry Size								
ELEMENT	24	Isolating Diaphragm	[Not Required]							
	25	Fill Fluid	[Not Required]							
OPTIONS	26	Certification / Approval Type								
	27	Meter								
	28	Zero Span & Adjustment								
	29	Surge Protection								
MANIFOLD	30	Custom Configuration								
	31	Manufacturer								
	32	Model Number								
	33	Manifold Style	Reference Details							
	34	Manifold Type	Block and Bleed							
Notes: Refer to Section 17402 for additional instrument valve requirements.										

END OF SECTION

SECTION 17406

PRESSURE/VACUUM MEASUREMENT - DIFFERENTIAL

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Differential pressure transmitters and indicators.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - c. Section 17401 - Pressure/Vacuum Measurement - Diaphragm and Annular Seals.
- C. Provide all instruments specified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050.
- B. National Institute of Standards and Technology (NIST).

1.03 DEFINITIONS

- A. As specified in Section 17050.
- B. Specific definitions:
 - 1. Lower range value (LRV): Lowest pressure that the pressure transmitter is capable of measuring.
 - 2. Upper range value (URV): Highest pressure that the pressure transmitter is capable of measuring.
 - 3. Calibrated range: The range that the pressure transmitter is configured to measure. The low end of the calibrated range must be greater than the LRV of the transmitter. The high end of the calibrated range must be less than the URV. The calibrated range corresponds to the pressure signal sent from the transmitter.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 17050.
- B. Product data:
 - 1. Accessories such as diaphragm seals, valve manifold, snubbers, and pulsation dampeners.
- C. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050.

1.07 PROJECT CONDITIONS

- A. Project environmental conditions as specified in Section 17050.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following no equal:
 - 1. Rosemount Series.
 - 2. Yokogawa EJA Series.
 - 3. ABB 264 Series.
 - 4. Endress + Hauser Deltabar S Series.
 - 5. SMAR LD300 Series.

2.02 MANUFACTURED UNITS

- A. Pressure transmitters - differential:
 - 1. General:
 - a. Differential pressure transmitter assembly shall include a diaphragm-type pressure transducer and microprocessor-based transmitter for measurement of differential pressure.
 - b. Differential pressure transmitters shall be used for differential pressure, flow, or liquid level measurement as indicated on the Drawings.
 - 2. Performance requirements:
 - a. As specified in data sheets or instrument index.
 - b. Maximum ratio of total instrument range to calibrated span: 10 to 1.
 - c. Accuracy:
 - 1) Reference accuracy: Plus or minus 0.075 percent of calibrated span, including effects of hysteresis, nonlinearity, and repeatability.
 - 2) Total performance accuracy: Plus or minus 0.30 percent of calibrated span, including reference accuracy effects, static pressure and ambient temperature effects.
 - 3) Stability: Plus or minus 0.15 percent of upper range limit over 5 years.
 - 3. Element:
 - a. Diaphragm-type transducer integral to differential pressure transmitter.
 - b. Diaphragm material: Stainless steel or ceramic.
 - c. Wetted materials: Stainless steel:
 - 1) Process material compatibility:
 - a) Verify all material compatibilities with the instrument Manufacturer.
 - d. Diaphragm fill fluid: Silicon Oil.
 - e. Process connection: 1/2-inch NPT.
 - 4. Transmitter:
 - a. Power supply:
 - 1) 24 VDC - loop powered.
 - b. Outputs:
 - 1) Isolated 4-20 mA DC with HART communication protocol.
 - c. Provided with electronic microprocessor.
 - d. Adjustments: Adjustable electronic zero and span, with elevated or suppressed zero as required by application. Adjustment shall be possible without mechanical fulcrum points or handheld configurator.
 - e. Square root extraction for flow calculation.
 - f. Local display:
 - 1) 5-digit LCD.

- 2) Scaled in engineering units.
- g. Enclosure: NEMA Type 4X.
- h. Overrange protection: To maximum process line pressure.
- i. Conduit connection: 1/2 inch male NPT.
- 5. Components:
 - a. Transmitter mounting:
 - 1) As specified in the data sheets or instrument index.
 - 2) Provide all necessary hardware for transmitter mounting.

2.03 ACCESSORIES

- A. Provide remote diaphragm seals as specified in data sheets or instrument index or as indicated on the Drawings and as specified in Section 17401.
 - 1. Diaphragm seal and transmitter shall be assembled by manufacturer and shipped as an assembly.
- B. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050.
- B. Each differential pressure transmitter shall be factory calibrated with 5-point calibration at a facility that is traceable to the NIST.
- C. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 EXECUTION

3.01 ~~EXAMINATION~~(NOT USED)

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 ~~PREPARATION~~(NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050.
- B. Provide manufacturer's services to perform start-up and calibration or verification.

3.05 ADJUSTING

- A. Verify factory calibration of all instruments in accordance with the manufacturer's instructions:
 - 1. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

3.06 CLEANING

- A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050.

3.08 PROTECTION

- A. As specified in Section 17050.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E: Carollo Engineers Contractor: Project: Customer: Plant: Location: BOM No.: File:			DIFFERENTIAL PRESSURE TRANSMITTERS									
							Spec. No.		Rev.			
							17406					
							Contract		Date			
							Req.		P.O.			
							By		Chk		App	
GENERAL	1	Instrument Tag No.	DPIT-									
	2	Service										
	3	P&ID										
SERVICE	4	Pressure										
	5	Process Temperature										
	6	Ambient Temperature										
TRANSMITTER	7	Manufacturer										
	8	Model No.										
	9	Pressure Transmitter Type										
	10	Calibrated Span										
	11	Accuracy										
	12	Adjustable Range										
	13	Output Signal	4-20 mA									
	14	Body Rating										
BODY	15	Process Flange Type										
	16	Drain/Vent										
	17	Process Flange										
	18	Adapters										
	19	Wetted O-Ring										
	20	Housing										
	21	Bolts										
	22	Mounting Brackets										
	23	Conduit Entry Size										
ELEMENT	24	Isolating Diaphragm										
	25	Fill Fluid										
OPTIONS	26	Certification / Approval Type										
	27	Meter										
	28	Zero Span & Adjustment										
	29	Surge Protection										
	30	Custom Configuration										
MANIFOLD	31	Manufacturer										
	32	Model Number										
	33	Manifold Style										
	34	Manifold Type										
Notes: Refer to Section 17401 for additional diaphragm seal requirements. Refer to Section 17402 for additional instrument valve requirements.												

SECTION 17407

PRESSURE MEASUREMENT - SUBMERSIBLE

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Submersible pressure transmitters.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - c. Section 17950 - Testing, Calibration, and Commissioning.
- C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050.

1.03 DEFINITIONS

- A. As specified in Section 17050.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330, and 17050.
- B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050.
- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.

- 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the ENGINEER if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Submersible level measurement with 2-wire integral transmitter:
 - 1. One of the following or equal:
 - a. Endress+Hauser, Waterpilot FMX21.
 - b. GE Druck, PTX-1830.
 - c. Siemens, A1000i.

2.02 MANUFACTURED UNITS

- A. Submersible level measurement with 2-wire integral transmitter:
 - 1. General:
 - a. Pressure is measured through a diaphragm-type measuring cell and converted to linear pressure measurement.
 - b. Each submersible pressure transmitter system shall include:
 - 1) Signal cable, including pressure compensation tube.
 - 2) Transducer probe with integral transmitter.

- 3) Transmitter cable termination box.
2. Performance requirements:
 - a. Accuracy:
 - 1) 0.3 percent of range.
 - b. Repeatability:
 - 1) 0.25 percent of full scale.
 - c. Rangeability:
 - 1) 3:1.
 - d. Range:
 - 1) As indicated on the contract documents.
3. Element:
 - a. Sensor housing shall be Type 316L stainless steel or titanium with ceramic, teflon-coated, or titanium diaphragm.
 - b. Protective cap shall be manufacturer's recommended material, chemically resistant to process fluid.
 - c. Slip resistant extension cable with pressure compensation tube with Teflon filter.
 - d. Enclosure for probe and transmitter assembly shall be NEMA Type 4X.
4. Transmitter:
 - a. Power supply:
 - 1) 24 VDC: 2 wire loop powered.
 - 2) Power consumption: 18 VA maximum.
 - b. Outputs:
 - 1) Isolated 4 to 20 milliamperes DC.
 - c. Without display.
 - d. Ambient operating temperature limits of -10 to 70 degrees Celsius (-14 to 158 degrees Fahrenheit).
 - e. Transmitter shall be integral to probe housing.
5. Transmitter cable termination box:
 - a. NEMA Type 4X.
 - b. Equipped with filter or desiccant chamber to eliminate moisture from the pressure compensation tube.
 - c. Termination for signal wires and pressure compensation tube.

2.03 ACCESSORIES

- A. Type 316L stainless steel mounting clamp with Type 304 stainless steel mounting screws.
- B. Provide additional anchor to prevent movement.
- C. Provide cable clamp and strain relief.
- D. Provide computer cable adapter with Windows® software.
- E. Provide sunshade for outdoor installations.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050.

- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration data sheets to the ENGINEER at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 - 1. Notify the ENGINEER promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 ~~PREPARATION~~(NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050.
- B. Provide manufacturer's services to perform start-up and calibration or verification.

3.05 ADJUSTING

- A. As specified in Section 17950.

3.06 CLEANING

- A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050.

3.08 PROTECTION

- A. As specified in Section 17050.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E: Carollo Engineers		SUBMERSIBLE PRESSURE INSTRUMENTS				Spec. No.			Rev.					
						17407								
Contractor:			No	By	Date	Revision	Contract			Date				
Project:														
Customer:														
Plant:							Req.			P.O.				
Location:														
BOM No.:						By			Chk			App		
File:														
GENERAL	1	Instrument Tag Number	LIT-xxx											
	2	Service												
	3	P&ID												
	4	Fluid Type	Water											
	5	Fluid Specific Gravity	1.0											
PROCESS	6	Type	Submersible											
	7	Measuring Cell Material	Diaphragm											
	8	Probe Body Material												
	9	Op. Temp. Range	40-80 deg F											
	10	Op. Pressure Range	0- ft											
	11	Other												
	12	Other												
CABLE	13	Style	Mfg. Std											
	14	Signal Cable Length	As Required											
	15	Other												
	16	Other												
	17	Other												
TRANSMITTER	18	Type												
	19	Operating Mode	Continuous											
	20	Enclosure												
	21	Mounting												
	22	Temperature Range												
	23	Measurement Range												
	24	Power Supply	24 VDC											
	25	Accuracy	0.3 % of range											
	26	Display												
	27	Output	4-20 mA											
	28	Calibration												
	29	Status Relay												
	30	Manufacturer												
	31	Model No.												
	32	Elect. Entry												
	33	Other												
	OPTIONAL	33												
34														
35														
36														
Notes:														

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SECTION 17501

ANALYZERS – PH GENERAL

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. pH instruments.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - c. Section 17950 - Testing, Calibration, and Commissioning.
- C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050.
- B. CSA International (CSA).
- C. National Institute of Standards and Technology (NIST).

1.03 DEFINITIONS

- A. As specified in Section 17050.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 17050.
- B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050.

- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Endress+Hauser:
 - a. Sensor Model CPS11D.
 - b. Transmitter Model Mycom S CPM253.
 - 2. Rosemount:
 - a. Sensor Model 396P.
 - b. Transmitter Model 1056.
 - 3. ABB:
 - a. Sensor Model TB551.
 - b. Transmitter model AX460.
 - 4. Yokogawa:
 - a. Sensor Model FU20.
 - b. Transmitter Model PH202.

2.02 MANUFACTURED UNITS

A. pH analyzers:

1. General:

- a. pH measurement shall use the potentiometric measurement method utilizing a glass electrode. The pH sensitive glass membrane surface reacts to the acid content of the solution with a specific voltage, which is measured relative to a reference electrode.

2. Performance requirements:

- a. Accuracy: Within 0.01 pH.
- b. Stability: Within 0.01 pH/month.
- c. Repeatability: Within 0.01 pH.

3. Element:

a. Sensor material:

- 1) Glass pH sensor housed in a molded reinforced polypropylene body threaded for insertion, submersion, or flow-through installation as indicated on the Drawings and/or instrument data sheets.
- 2) Built in temperature sensor.
- 3) The reference electrode junction shall be capable of maintaining steady reference signal by resisting plugging in dirty applications.

b. pH measuring range: 2 to 12 pH.

c. Temperature measuring range: 0 to 70 degrees Celsius.

d. Operating temperature range: 0 to 80 degrees Celsius.

e. Operating pressure range: 0 to 87 pounds per square inch.

f. Connections:

- 1) Process: as specified in the Instrument Data Sheets.

g. Power supply:

- 1) 120 VAC.
- 2) 24 VDC.
- 3) Power consumption: 15 VA maximum.
- 4) Powered via network.

h. Outputs:

- 1) Two isolated 4 to 20 milliamperes DC with HART communication protocol.
 - a) Proportional to pH and temperatures.

i. Display:

- 1) Backlit LCD digital display.

j. Measurement ranges: 0 to 14 pH.

k. Temperature: 0 to 50 degrees Celsius.

l. Displayed resolution: Within 0.01 pH.

m. Ambient conditions:

- 1) Operable from 0 to 50 degrees Celsius.
- 2) Relative humidity 0 to 95 percent.

n. Mechanical:

1) Enclosure rating:

- a) NEMA Type 4X (IP65).

2) Mounting:

- a) Panel mount suitable for mounting in an enclosure that includes gasket to maintain weather rating of the panel.
- b) Surface mount enclosures, include self-tapping screws.
- c) Pipe mounting accessories shall be included for mounting enclosures to a 2-inch pipe.

- 3) Provide all mounting hardware for proper installation and servicing of the sensor assembly.
 - o. Electrical certification: NRTL certified to UL and CSA standards, and CE approved.
- 4. Components:
 - a. Sensor cable:
 - 1) Shall be provided with watertight sensor-to-cable connector that prevents cable twisting and eliminates rewiring when replacing the sensor.
 - 2) Cable length: As required to connect sensor to transmitter plus 10 percent.

2.03 ACCESSORIES

- A. Sensor:
 - 1. Process assemblies:
 - a. As specified on contract document.
- B. Transmitter:
 - 1. DAT module.
 - 2. Flat gasket.
 - 3. Stainless steel tag:
 - a. Marking specified on Instrument Data Sheets.
- C. Preamplifier:
 - 1. Use Manufacturer recommended preamplifier on coaxial cable runs longer than 15 feet.
- D. Provide sunshades for outdoor applications.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST:
 - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050.
- B. Provide manufacturer's services to perform start-up and calibration or verification.

3.05 ADJUSTING

- A. As specified in Section 17950.

3.06 CLEANING

- A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050.

3.08 PROTECTION

- A. As specified in Section 17050.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

A/E: Contractor: Project: Customer: Plant: Location: BOM No.: File:					pH ANALYZERS						
					Spec. No.		Rev.				
					17501						
					Contract		Date				
					Req.		P.O.				
					By		Chk		App		
G E N	1	Tag No.	Element	Transmitter	AE/AIT-						
	2	Service									
	3	P&ID									
E L E M E N T	4	Type									
	5	Body Style									
	6	Enclosure									
	7	Electrodes									
	8	Ambient Conditions									
	9	Connection									
	10	Sample Flow Required									
	11	pH Measuring Range									
	12	Temperature Measuring Range									
	13	Manufacturer									
C A B L E	14	Model No.									
	15	Length									
	16	Other			Built in Temperature Sensor						
	17	Style			N/A						
T R A N S M I T T E R	18	Length									
	19	Model No.									
	20	Pre-Amplifier									
	21	Other									
	22	Type			Control Unit and Display						
	23	Enclosure									
	24	Mounting									
	25										
	26	Power Requirements			115 VAC, 60 Hz						
	27	Resolution									
	28	Accuracy									
	29	Calibrated Range									
O P T I C A L	30										
	31	Outputs			4-20 mA						
	32	Contacts									
	33	Manufacturer									
	34	Model No.									
	35	Display									
	36	Other									
	37	Other									
	38	Other									
	39										
Notes:											

SECTION 17509
ANALYZERS - TURBIDITY

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Turbidity analyzers (turbidimeters).
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - c. Section 17950 - Testing, Calibration, and Commissioning.
- C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050.
- B. CSA International (CSA).
- C. United States Environmental Protection Agency (USEPA):
 - 1. Method 180.1 – Determination of Turbidity by Nephelometry.

1.03 DEFINITIONS

- A. As specified in Section 17050.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 17050.
- B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050.

- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the ENGINEER if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Low range turbidimeters: Incandescent type:
 - 1. HACH 1720E sensor with sc200 controller.
- B. Low range turbidimeters: LED type:
 - 1. GLI T53 Analyzer with 8320T Sensor (Accu4 System).

2.02 MANUFACTURED UNITS

- A. Low range turbidimeters: Incandescent type:
 - 1. Turbidimeter:
 - a. The turbidimeter shall be a microprocessor-based, continuous-reading, on-line nephelometric instrument meeting all design and performance

- criteria in accordance with USEPA method 180.1. Each turbidity system shall consist of a 1 sensor and 1 transmitter.
- b. Light shall be directed through the surface of the sample and the detector shall be immersed in the sample, eliminating glass windows and flow cells.
 - c. Optical components shall be mounted in a sealed head assembly that can be removed easily for calibration/service, without disturbing sample flow.
 - d. The turbidimeter body shall be constructed of corrosion-resistant polystyrene, and shall include an internal bubble trap to vent entrained air from the sample stream.
 - e. The turbidimeter shall offer the choice of Formazin-based (20 or 1 NTU) or instrument comparison-based calibration methods.
 - f. User selectable signal averaging, bubble rejection, alarm, and recorder output hold, and self-test diagnostics shall be provided.
2. Performance requirements:
- a. Range: 0 to 10 nephelometric turbidity units (NTU).
 - b. Accuracy:
 - 1) Within 2 percent of reading or within 0.020 NTU (whichever is greater) from 0 to 40 NTU.
 - 2) Within 5 percent of reading from 40 to 100 NTU.
 - c. Resolution: 0.001 NTU.
 - d. Repeatability: Better than within 1.0 percent of reading or within 0.020 NTU, whichever is greater.
 - e. Response time:
 - 1) Initial response in 1 minute.
 - 2) 15 seconds with internal bubble trap.
 - f. Sample flow required: 250 to 750 milliliter per minute (4.0 to 11.9 gallons per hour).
 - g. Storage temperature: -20 degrees Celsius to 60 degrees Celsius (- 4 degrees Fahrenheit to 140 degrees Fahrenheit).
 - h. Operating temperature: 0 degrees Celsius to 40 degrees Celsius (32 degrees Fahrenheit to 104 degrees Fahrenheit).
 - i. Operating humidity: 5 to 95 percent non-condensing.
 - j. Sample temperature: 0 degrees Celsius to 50 degrees Celsius (32 degrees Fahrenheit to 122 degrees Fahrenheit).
3. Transmitter:
- a. The graphical interface unit shall be a microprocessor-based device capable of functioning with a single sensor, and as a digital interface link between turbidimeters and other communication devices through a digital bus communications.
 - b. All turbidimeters on the network shall have RS232 serial input/output capability for 2-way communication to a computer or 1-way communication to a printer to record or print real-time turbidity data, calibration history, and current set points.
 - c. The interface unit shall allow operators to control sensor and network functions with user-friendly, menu-driven software, and shall provide data logging of measurement data from up to 8 turbidimeters for 1 hour, 24 hours or 30 days, and the capability to transfer data to a computer or printer via an RS232 serial input/output device.
 - d. The interface unit and separate DC power supply shall be housed in NEMA Type 4X (indoor) industrial plastic enclosures.

- e. Piping connections:
 - 1) Sample inlet fitting: 1/4 inch NPT female, 1/4 inch compression fitting.
 - 2) Drain fitting 1/2 inch NPT female, 1/2 inch hose barb.
- f. Communications distance:
 - 1) Maximum node-to-node distance: 400 meters (1,312 feet).
 - 2) Maximum total cable length: 500 meters (1,640 feet).
- g. Enclosures NEMA Type 4X/IP66.
- h. Certification:
 - 1) Safety listed by ETL in accordance with UL3101-1.
 - 2) Certified by ETL in accordance with CSA C22.2 No. 1010.1.
 - 3) CE Certified by HACH Company in accordance with EN 61010-1.
 - 4) Emissions FCC Part 15, Class A Canadian Interference-Causing Equipment Regulation ICES-003, Class A.
- i. Power supply:
 - 1) 120 VAC.
 - 2) Power consumption: 40 VA maximum.
- j. Outputs:
 - 1) Isolated 4 to 20 milliamperes DC with HART communication protocol.
 - 2) MODBUS communication protocol.
 - 3) Relay outputs:
 - a) 2 Form C contact.
 - b) Rated 5 amps at 230 VAC.
 - c) Programmable.
 - 4) Output span programmable over any portion of the 0 to 10 NTU range.

B. Low range turbidimeters: LED type:

- 1. General:
 - a. The turbidimeter shall be a microprocessor-based, continuous-reading, on-line nephelometric instrument utilizing a 4-beam radiometric measurement. Each turbidity system shall consist of a 1 sensor and 1 transmitter.
- 2. Performance requirements:
 - a. Range:
 - 1) 0 to 10 NTU.
 - 2) 0 to 1.0 NTU.
 - b. Accuracy:
 - 1) Within 2 percent of reading or within 0.020 NTU (whichever is greater) from 0 to 40 NTU.
 - 2) Within 5 percent of reading from 40 to 100 NTU.
 - c. Resolution: 0.001 NTU.
 - d. Repeatability: Better than within 0.1 percent of span or better.
 - e. Response time:
 - 1) Initial response in 1 minute.
 - 2) 9.5 seconds with internal bubble trap.
 - f. Sample flow required: 0.19 to 1.8 milliliter per minute (0.05 to 0.5 gallon per hour).
 - g. Storage temperature: -20 degrees Celsius to 60 degrees Celsius (4 degrees Fahrenheit to 140 degrees Fahrenheit).
 - h. Operating temperature: 0 degrees Celsius to 40 degrees Celsius (32 degrees Fahrenheit to 104 degrees Fahrenheit).

- i. Operating humidity: 5 to 95 percent non-condensing.
- j. Pressure:
 - 1) Low pressure kit: 0 to 50 pounds per square inch gauge at 68 degrees Fahrenheit.
 - 2) High pressure kit - 0 to 150 pounds per square inch gauge at 68 degrees Fahrenheit.
- 3. Element:
 - a. Light sources shall be emitted by 2 separate LED sources one shall illuminate and measure both the transmittance (reference) and 90 degree scatter (active) through the sample, once measured the second LED illuminates and same measurements are made with the exception that the Reference becomes the Active. The transmitter shall use both measurements and a comparison algorithm to calculate the NTU.
 - b. Optical components shall be mounted in a sealed head assembly that can be removed easily for calibration/service, without disturbing sample flow.
 - c. The turbidimeter body shall be constructed of corrosion-resistant polystyrene, and shall include an internal bubble trap to vent entrained air from the sample stream.
 - d. The turbidimeter shall offer the choice of Formazin-based (20 or 1 NTU) or instrument comparison-based calibration methods and the quartz calibration cube.
 - e. Unit shall be capable of signal averaging.
- 4. Transmitter:
 - a. The transmitter unit shall be a microprocessor-based device capable of functioning with a single sensor, and as a digital interface link between turbidimeters and other communication devices through a digital bus communications.
 - b. Interface module:
 - c. The interface unit shall allow operators to control sensor and network functions with user-friendly, menu-driven software, and shall provide data logging of measurement data, and the capability to transfer data to a computer or printer via an RS232 serial input/output device.
 - d. The interface unit and power supply shall be housed in NEMA Type 4X industrial plastic enclosures.
 - e. Power supply:
 - 1) 120 VAC.
 - 2) Power consumption: 40 VA maximum.
 - f. Outputs:
 - 1) Isolated 4 to 20 milliamperes DC with HART communication protocol.
 - 2) Relay outputs:
 - a) 2 Form C contact.
 - b) Rated 5 amps at 230 VAC.
 - c) Programmable.
 - 3) Output span programmable over any portion of the 0 to 10 NTU range.
 - g. Piping connections:
 - 1) Sample inlet fitting 1/2 inch NPT female, adaptable to 3/8 inch or 1/4 inch barb or tube fittings.
 - 2) Drain fitting 1/2 inch NPT female
 - h. Enclosures NEMA Type 4X/IP66.
 - i. Certification:
 - 1) Certified in accordance with CSA type 4.

- 2) CE compliant.
- 3) Class I Division 2 Groups A, B, C and D.
- 4) Class II Division 2 Groups E, F and G.

2.03 ACCESSORIES

- A. Mounting brackets as required or as indicated on the Drawings.
- B. Provide sunshades for outdoor installations.
- C. Flushing solenoids for cleaning the probe as recommended by the manufacturer.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to manufacturer's standard at a facility that is traceable to the NIST.
 1. Submit calibration data sheets to the ENGINEER at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 1. Notify the ENGINEER promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 ~~PREPARATION~~ (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050.
- B. Provide manufacturer's services to perform start-up and calibration or verification.

3.05 ADJUSTING

- A. As specified in Section 17950.

3.06 CLEANING

- A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050.

3.08 PROTECTION

- A. As specified in Section 17050.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments.
Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E: Carollo Engineers				TURBIDITY ANALYZER									
Contractor: Project: Customer: Plant: Location: BOM No.: File:								Spec. No.		Rev.			
				No				By		Date		Revision	
												17509	
												Contract	
												Date	
								Req.		P.O.			
								By		Chk			
										Ap p			
G E N	1	Tag No.	Sample Unit	Transmitter	AE/AIT-								
	2	Service											
	3	P&ID											
S M P L U N I T	4	Type											
	5	Enclosure											
	6	Sampling Method											
	7	Operating Temperature Range											
	8	Sample Temperature Range											
	9	Sample Flow Required											
	10	Manufacturer											
	11	Model No.											
C A B L E	12	Other											
	13	Style			N/A								
	14	Length											
	15	Model No.											
	16	Other											
T R A N S M I T T E R	17	Other											
	18	Type			Control Unit and Display								
	19	Enclosure											
	20	Mounting											
	21	Accuracy											
	22	Range											
	23	Power Requirements			115 VAC, 60 Hz								
	24	Display											
	25	Resolution											
	26	Output			4-20 mA								
	27	Calibration											
	28	Manufacturer											
	29	Model No.											
	O P T S	30	Other										
31		Other											
32		Other											
33													
34													
35													
36													
37													
38													
Notes:													

SECTION 17602

TEMPERATURE MEASUREMENT - TEMPERATURE GAUGE

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Temperature gauges.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - c. Section 17950 - Testing, Calibration, and Commissioning.
- C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050.
- B. National Institute of Standards and Technology (NIST).

1.03 DEFINITIONS

- A. As specified in Section 17050.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 17050.
- B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050.

- B. Examine the complete set of Contact Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050.
 - 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 WARRANTY

- A. As specified in Section 17050.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Bimetallic type temperature gauge: One of the following or equal:
 - 1. Ashcroft Type EI.
 - 2. Weiss Instruments Series BM.
 - 3. Noshok 300 Series.
- B. Liquid filled temperature thermometer: One of the following or equal:
 - 1. Weksler Type AS5.
 - 2. Dwyer Type IT.
- C. Gas actuated temperature gauge: One of the following or equal:
 - 1. Ashcroft Series 600.
 - 2. Weiss Instruments Series G.
 - 3. Noshok.

2.02 MANUFACTURED UNITS

- A. Bimetallic type temperature gauges:
 - 1. General:
 - a. Temperature gauges shall consist of a bimetallic temperature sensor with a dial-type temperature gauge.
 - 2. Performance requirements:
 - a. Temperature range:
 - 1) As indicated in the Contract Documents.
 - b. Accuracy:
 - 1) ± 1.0 percent of range.
 - 3. Element:
 - a. Type: Bimetallic.
 - b. Stem material: Stainless steel.
 - c. Temperature gauge sensor shall be tamperproof, hermetically sealed, and silicon dampened.
 - d. Process connection: 1/2 inch NPT.
 - 4. Dial gauge:
 - a. Dial size: 3 inches.
 - b. Dial case material: Stainless steel.
 - c. Dial face: Gasketed shatterproof glass.
 - d. Orientation: Straight or angled as required to provide most convenient direct viewing.
 - e. Mounting: Direct mounted and suitable for outdoor installation.
 - f. External adjustable recalibration screw.
- B. Liquid filled thermometer:
 - 1. General:
 - a. Liquid-filled thermometer shall consist of a liquid filled tube.
 - 2. Performance requirements:
 - a. Temperature range:
 - 1) As indicated in the Contract Documents.
 - b. Accuracy:
 - 1) ± 1.0 percent of range.
 - 3. Element:
 - a. Type: Liquid filled in a tube.
 - b. Stem material: Stainless steel.
 - c. Stem length: 3.5 inches.
 - d. Easy adjustment permits case and stem to be rotated 360 degrees.
 - 4. Thermometer:
 - a. Scale size: 9 inches.
 - b. Scale material: White aluminum scale with bold black graduations and figures.
 - c. Mounting: Direct mounted and suitable for outdoor installation.
 - 5. Thermowell: As specified in this Section.
- C. Gas actuated temperature gauges:
 - 1. General:
 - a. Temperature gauges shall consist of a gas actuated temperature sensor with a dial-type temperature gauge.

2. Performance requirements:
 - a. Temperature range:
 - 1) As indicated in the Contract Documents.
 - b. Accuracy:
 - 1) ± 1.0 percent of range.
3. Element:
 - a. Type: Gas actuated.
 - b. Bulb and capillary material shall be stainless steel.
 - c. Temperature gauge sensor shall be tamperproof and hermetically sealed.
 - d. Process connection: 1/2 inch NPT.
4. Dial gauge:
 - a. Dial size: 4-1/2 inches.
 - b. Dial case material: Stainless steel.
 - c. Dial face: Gasketed shatterproof glass.
 - d. Orientation: Straight or angled as required to provide most convenient direct viewing.
 - e. Mounting: As indicated in the contract documents.

2.03 ACCESSORIES

- A. Thermowell:
 1. Unless otherwise noted, provide thermowell with each temperature gauge.
 2. Process connection: As indicated in the contract documents.
 3. Thermowell material: Material compatible with the service fluid identified and recommended by the manufacturer for the process condition.
 4. Stem style: Straight or tapered.
 5. Immersion depth:
 - a. Minimum 3 inches or 10 times the diameter of the sensor protection tube or thermowell, whichever is larger.
- B. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050.
- B. Factory calibrate each instrument with a minimum 3-point calibration or according to manufacturer's standard at a facility that is traceable to the NIST.
 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050.

3.05 ADJUSTING

- A. As specified in Section 17950.

3.06 CLEANING

- A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050.

3.08 PROTECTION

- A. As specified in Section 17050.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications or both.

END OF SECTION

SECTION 17604

TEMPERATURE MEASUREMENT - RTD

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. RTD temperature instruments.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - c. Section 17950 - Testing, Calibration, and Commissioning.
- C. Provide all instruments identified in the Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050.

1.03 DEFINITIONS

- A. As specified in Section 17050.
- B. Specific definitions:
 - 1. RTD - Resistance temperature detector.

1.04 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 17050.
- B. Provide complete documentation covering the traceability of all calibration instruments.

1.05 QUALITY ASSURANCE

- A. As specified in Section 17050.

- B. Examine the complete set of Contract Documents and verify that the instruments are compatible with the installed conditions including:
 - 1. Process conditions: Fluids, pressures, temperatures, flows, materials etc.
 - 2. Physical conditions:
 - a. Installation and mounting requirements.
 - b. Location within the process.
 - c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.
- C. Notify the Engineer if any installation condition does not meet the instrument manufacturer's recommendations or specifications.
- D. Provide instruments manufactured at facilities certified to the quality standards of ISO 9001.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050.

1.07 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050.

1.08 WARRANTY

- A. As specified in Section 17050.

1.09 MAINTENANCE

- A. Furnish all parts, materials, fluids, etc. necessary for operation, maintenance, and calibration purposes throughout the warranty period. Deliver all of these supplies before project substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Rosemount Model 3144P transmitter with Series 68 sensor.
 - 2. Acromag 1500 Series.
 - 3. Siemens SITRANS T.
 - 4. Foxboro Model RTT20.

2.02 MANUFACTURED UNITS

- A. RTDs:
 - 1. General:
 - a. Temperature measuring instrument shall include an RTD temperature element, transmitter, and thermowell.

2. Performance requirements:
 - a. Accuracy:
 - 1) Within 0.25 percent of calibrated span.
 - b. Repeatability:
 - 1) 0.25 percent of full scale.
 - c. Sensor lead wire compensation: Maximum zero shift of 0.2 percent of the temperature range.
3. Element:
 - a. 100-Ohm platinum thin film resistance temperature detector (RTD).
 - b. 3-wire.
 - c. Hermetically sealed, and enclosed in Type 316 stainless steel outer sheath.
 - d. Single element temperature sensor shall be spring-loaded.
4. Transmitter:
 - a. Microprocessor based.
 - b. Compatible with 3-wire and 4-wire RTD inputs:
 - c. Local display:
 - 1) 5-digit LCD.
 - 2) Scaled in engineering units.
 - d. Power supply:
 - 1) 24 VDC - loop powered.
 - e. Outputs:
 - 1) Isolated 4 to 20 milliamperes DC with HART communication protocol.
 - f. Transmitter enclosure: NEMA Type 4X 7.
 - g. Transmitter mounting:
 - 1) As specified on the Instrument Data Sheets or Instrument Index.
 - 2) Connection to thermowell: 1/2-inch NPT.
 - 3) Provide all necessary hardware for transmitter mounting.

2.03 ACCESSORIES

- A. Thermowell:
 1. Unless otherwise noted, provide a thermowell with each RTD.
 2. Process connection: As identified on instrument data sheet.
 3. Thermowell material: Type 316L stainless steel.
 4. Stem style: As identified on instrument data sheet.
 5. Immersion depth:
 - a. Minimum 3 inches or 10 times the diameter of the thermowell, whichever is larger.
 - b. Where pipe diameter is inadequate for appropriate immersion depth, install thermowell in an elbow on the axis of the pipe.
 - c. As identified on instrument data sheet.
- B. Provide sunshades for outdoor installations.

2.04 SOURCE QUALITY CONTROL

- A. As specified in Section 17050.

- B. Factory calibrate each instrument with a minimum 3-point calibration or according to Manufacturer's standard at a facility that is traceable to the NIST.
 - 1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 ~~PREPARATION~~(NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050.
- B. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.
- C. Apply thermally conductive silicone grease to the sensor tip before insertion in thermowell.

3.04 FIELD QUALITY CONTROL

- A. As specified in Section 17050.
- B. Provide manufacturer's services to perform start-up and calibration or verification.

3.05 ADJUSTING

- A. As specified in Section 17950.

3.06 CLEANING

- A. As specified in Section 17050.

3.07 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050.

3.08 PROTECTION

- A. As specified in Section 17050.

3.09 SCHEDULES

- A. The provided information does not necessarily include all required instruments.
Provide all instruments identified in the Contract Documents:
 - 1. Instruments may be indicated on the Drawings, specified in the Specifications, or both.

END OF SECTION

A/E: Carollo Engineers				TEMPERATURE TRANSMITTERS - RTD							
								Spec. No.		Rev.	
Contractor: Project: Customer: Plant: Location: BOM No.: File:				No	By	Date	Revision	17604			
								Contract		Date	
								Req.		P.O.	
								By		Chk	App
GENERAL	1	Instrument Tag No.	TE/TIT-								
	2	Service									
	3	P&ID									
SERVICE	4	Process Temperature									
	5	Ambient Temperature									
TRANSMITTER	6	Manufacturer									
	7	Model No.									
	8	Display									
	9	Calibrated Span									
	10	Adjustable Range									
	11	Accuracy									
	12	Output Signal									
	13	Body Rating									
TEMPERATURE ELEMENT	14	Manufacturer									
	15	Model No.									
	16	Type									
	17	Temperature Range									
	18	Mounting									
	19	Connection	2-Wire: 3-Wire: 4-Wire:								
	20	Leads	Standard: Potted: Hermetically Sealed:								
	21	Sheath Material	Stainless Steel								
	22	Element Length									
THERMOWELL	23	Type	Straight: Tapered: Stepped:								
	24	Material									
	25	Insertion Length									
	26	Process Connection	1/2-inch Thread: 3/4-inch Thread: Flange: Weld Mount:								
OPTIONS	27										
	28										
	29										
	30										
	31										
Notes:											

SECTION 17710

CONTROL SYSTEMS - PANELS, ENCLOSURES, AND PANEL COMPONENTS

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Design, fabrication and assembly of all instrumentation enclosures, control panels and components provided under this contract, including but not limited to:
 - a. Custom built instrumentation and control panels, including all enclosures for hand stations controllers, low voltage power distribution and marshalling panels.
 - b. Control panels furnished as part of equipment systems specified in other Divisions, such as vendor control panels (VCPs) and chemical feed panels.
 - c. Control components.
 - d. Control panel installation.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 01612 - Seismic Design Criteria.
 - c. Section 16050 - Common Work Results for Electrical.
 - d. Section 16075 - Electrical Identification.
 - e. Section 16412 - Low Voltage Molded Case Circuit Breakers.
 - f. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
- C. Provide all instruments identified in Contract Documents.

1.02 REFERENCES

- A. As specified in Section 17050.
- B. Institute of Electrical and Electronics Engineers (IEEE):
 - 1. C62.41.1 – Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.

- C. National Electrical Code (NEC).
- D. National Electrical Manufacturer's Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
- E. National Institute of Standards and Technology (NIST).
- F. Underwriters Laboratories Inc. (UL):
 - 1. 508 - Industrial Control Equipment.
 - 2. 508A - Standard for Industrial Control Panels.
 - 3. 1283 - Standard for Electromagnetic Interference Filters.
 - 4. 1449 - Standard for Surge Protective Devices.

1.03 DEFINITIONS

- A. As specified in Section 17050.
- B. NEMA:
 - 1. Type 1 enclosure in accordance with NEMA 250.
 - 2. Type 4 enclosure in accordance with NEMA 250.
 - 3. Type 4X enclosure in accordance with NEMA 250.
 - 4. Type 7 enclosure in accordance with NEMA 250.
 - 5. Type 12 enclosure in accordance with NEMA 250.
- C. Specific definitions:
 - 1. The term "panel" in this Section is interchangeable with the term "enclosure."

1.04 SYSTEM DESCRIPTION

- A. Panel dimensions:
 - 1. Minimum dimensions are scalable from or as indicated on the Drawings and are based upon manufacturer's non-certified information. It is the responsibility of the Contractor or manufacturer to design and size all panels:
 - a. Size panels to provide space for all equipment, wiring, terminations, and other items in the panel, including space for future build out.
 - b. Panel sizes that substantially deviate (within 3 inches in any dimension) from the sizes indicated on the Drawings must be approved by the Engineer.
 - c. Maximum panel depth: 30 inches, unless otherwise indicated.
- B. Structural design:
 - 1. Completed and installed panel work shall safely withstand seismic requirements at the project site as specified in Section 16050. Enclosures and internal equipment shall be braced to prevent damage from specified forces.

1.05 SUBMITTALS

- A. Provide submittals as specified in Sections 01330 and 17050.
- B. Provide a control panel hardware submittal, for each control panel and enclosure being provided on this project, including but not limited to:
 - 1. Product data:
 - a. Enclosure construction details and NEMA type.

- b. Manufacturer's literature and specification data sheets for each type of equipment to be installed within or on the panel or enclosure.
 - 2. Shop drawings:
 - a. Scaled, detailed exterior panel (front and side views) and interior panel layout showing equipment arrangement and dimensional information:
 - 1) Provide draft for review and approval by Engineer. The Engineer has the authority to substantially alter initial panel layouts.
 - b. Complete nameplate engraving schedule.
 - c. Structural details of fabricated panels.
 - 3. Calculations:
 - a. Provide installation details based on calculated shear and tension forces:
 - 1) Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.
 - b. For assembled enclosures and other equipment with a weight of 200 pounds or more, provide calculations for:
 - 1) Weight including panel internal components.
 - 2) Seismic forces and overturning moments.
 - 3) Shear and tension forces in connections.
 - c. Cooling calculations, to include but not limited to:
 - 1) Highest expected ambient temperature for the enclosure's location
 - 2) Internal heat load.
 - 3) Exposure to direct sunlight.
 - 4) Dimensions of the enclosure in inches.
 - 5) Maximum allowable temperature inside the enclosure, based on the lowest operating temperature limit of the installed components.

C. Seismic design:

- 1. Seismic panel construction:
 - a. Seismic anchorage: Provide seismic design calculations and installation details for anchorage of all panels, enclosures, consoles, etc. to meet seismic requirements in Section 01612:
 - 1) Stamped by a Professional Engineer registered in the state where the project is being constructed.
 - b. For floor mounted free standing panels weighing 200 pounds or more (assembled, including contents), submit calculations, data sheets, and other information to substantiate that panel, base, and framing meet minimum design strength requirements and seismic requirements as specified in Section 01612. Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.

1.06 QUALITY ASSURANCE

- A. As specified in Section 17050.
- B. Assemble panels, enclosures, and rack systems along with all internal and external devices, wiring, equipment, and materials in a facility that is recognized by UL to assemble and certify UL-labeled control panels:
 - 1. Provide all components and equipment with UL 508 listing.

2. All control panels shall be UL 508A labeled, unless the equipment in the panel and the design in the contract documents cannot be reasonably modified to meet the requirements for UL 508A labeling:
 - a. Non-listed, complex and unique equipment may be evaluated and approved by a third party testing agency, with prior approval by the Owner. Provide report documenting the testing standard, specification, method of testing and that the equipment and materials meet appropriate designated standards or have been tested and found suitable for use in a specified manner.
3. Provide fuses for all equipment that is not UL or UR listed.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Project environmental conditions as specified in Section 17050.
 1. Provide instruments suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, site seismic conditions, humidity, and process and ambient temperatures.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 17050.

1.12 SYSTEM STARTUP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. As listed below in the individual component paragraphs.
- B. Provide instruments and other components performing similar functions of the same type, model, or class, and from 1 manufacturer.

2.02 MATERIALS

- A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service:
1. Enclosures shall have the following properties:
 - a. NEMA Type 1: Steel.
 - b. NEMA Type 4: Steel with gasketed door, rain tight.
 - c. NEMA Type 4X: Type 316 stainless steel (unless indicated Type 304 on the drawings)
 - d. NEMA Type 4X: Polycarbonate or fiberglass reinforced polyester (FRP) in corrosive areas where stainless steel is incompatible.
 - e. NEMA Type 12: Steel with gasketed door, dust-tight.
 - f. NEMA Type 7: Cast aluminum.
- B. Bolting material:
1. Commercial quality 1/2-inch diameter, stainless steel hex-head grade 5 bolts, nuts and washers, with unified coarse (UNC) threads.
 2. Carriage bolts for attaching end plates.
 3. All other bolted joints shall have S.A.E. standard lock washers.

2.03 MANUFACTURED UNITS

- A. Panels/enclosures:
1. Manufacturers: One of the following or equal:
 - a. Rittal.
 - b. Hoffman Engineering.
 - c. Saginaw Control & Engineering.
 2. Panel assembly:
 - a. General guidelines for panel fabrication include:
 - 1) Continuous welds ground smooth.
 - 2) Exposed surfaces free of burrs and sharp edges.
 - 3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2 inch holes at 12 inch spacing to accommodate anchoring of freestanding enclosures to floor.
 - b. Construct enclosure and mounting panel using stretcher level quality sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Up to 57	12	12
57 - 69	12	10
69 - 82	12, except 10 on back	10
82 or more	10	10

- 1) Use heavier sheet metal to meet seismic requirements at the project site or when required due to equipment requirements.
- c. Construct supporting frame structure with angled, channeled, or folded rigid section of sheet metal, rigidly attached to and having essentially the same outer dimensions as the enclosure surface and having sufficient

- torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected.
- d. Provide stiffeners for back mounting panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.
 - e. Door construction:
 - 1) Turned-back edges suitably braced and supported to maintain alignment and rigidity without sagging.
 - 2) Sufficient width to permit door opening without interference with rear projection of flush mounted instruments.
 - 3) Heavy gauge piano type continuous stainless steel hinges.
 - 4) For NEMA Type 12, Type 4 and Type 4X, provide oil resistant neoprene sealing gasket and adhesive to seal cover to enclosure.
 - 5) Gasket installed to seal against roll lip on the enclosure opening.
 - f. Latches:
 - 1) For panels each door provided with a 3-point latching mechanism and locking handle with rollers on the ends of the latch rods. Latch rods connected to a common door handle, hold doors securely, forming a compressed seal between door and gasket, at the top, side, and bottom.
 - a) Provide padlock for each enclosure with padlock provisions.
 - 2) Include an oil-tight key-locking, 3-point latching mechanism on each door:
 - a) Provide 2 keys per panel.
 - b) All locks keyed alike.
 - 3) For large type NEMA Type 4 and NEMA Type 4X cabinets, not available with 3-point latching hardware, provide multiple clips and padlock hasps.
 - 4) Provide quick release latches for all NEMA Type 4 and Type 4X enclosures.
 - g. Panel cut-outs:
 - 1) Cut, punch, or drill cutouts for instruments, devices, and windows. Smoothly finish with rounded edges.
 - 2) Allow a minimum of 3-inch envelope around all displays, controllers, and monitors.
 - 3) Reinforce around cut-outs with steel angles or flat bars for the following:
 - a) Large panel cutouts; for example, openings for local operator interfaces.
 - b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.
3. In addition to the requirements specified above the following requirements for NEMA Type 4X powder coated stainless steel enclosures apply:
- a. Minimum 14 gauge, Type 304 stainless steel.
 - b. Captive stainless steel cover screws threaded into sealed wells.
 - c. Inside finish: White polyester powder coating.
 - d. Specifically designed for use with flange-mounted disconnect handles where required or as indicated on the Drawings.
4. Outdoor panels. Supplementary requirements for panels located outdoors are as follows:
- a. All enclosures located outdoors shall be explicitly designed and rated for outdoor service by the manufacturer.

- b. Door hardware: stainless steel.
 - c. Provide rain canopy and sun shield.
 - d. Bases: Heavy channel, gasketed stainless steel bases, flanges up, for anchoring to pad.
- B. Arrangement of components:
 - 1. Arrange panel internal components for external conduit and piping to enter into panel either from above or below.
 - 2. Arrange panel instruments and control devices in a logical configuration associating pushbutton and selector switches with related readout devices, or as indicated on the Drawings.
 - 3. Mount internal control components on an internal back-panel. Devices may be mounted on the side-panel only by special permission from the Engineer.
 - 4. All control panel mounted operator interface devices shall be mounted between 3 feet and 5 feet above finished floor.
- C. Overcurrent protection:
 - 1. Main overcurrent device:
 - a. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a flange mounted disconnect handle operating a molded case circuit breaker, and provide a control power transformer for 120 VAC circuits:
 - 1) Door-mounted disconnect handles are not acceptable.
 - 2) Mechanically interlocked the disconnect switch with the control enclosure doors so that no door can be opened unless the power is disconnected, and the disconnect switch cannot be closed until all doors are closed.
 - 3) Provide means to defeat the interlock.
 - 4) Lockable in the off position.
 - b. Control panels supplied with 120 VAC:
 - 1) Provide an internal breaker with the line side terminals covered by a barrier.
 - 2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring the source to be disconnected before opening the door to the enclosure.
 - 2. Provide circuit breakers as specified in Section 16412.
 - 3. Selection and ratings of protective devices:
 - a. Interrupting ratings: Not less than the system maximum available fault current at the point of application.
 - b. Voltage rating: Not less than the voltage of the application.
 - c. Select current rating and trip characteristics to be suitable for:
 - 1) Maximum normal operating current.
 - 2) Inrush characteristics.
 - 3) Coordination of the protective devices to each other and to the source breaker feeding the panel.
 - 4. Provide a separate protective device for each powered electrical device:
 - a. An individual circuit breaker for each 120 VAC instrument installed within its respective control panel and clearly identified for function.
 - b. An individual fuse for each PLC discrete output. Provide with individual blown fuse indication external of the I/O card:
 - 1) Size external fuse to open before any I/O card mounted fuses.

- c. An individual 5-ampere fuse for each discrete input loop.
 - d. An individual 1/2-ampere fuse for each 4 to 20 milliamperes analog loop powered from the control panel.
 - e. Install protective devices on the back mounting panel and identify by a service nameplate in accordance with the wiring diagrams.
5. Fuses for 4 to 20 milliamperes signals:
- a. Provide durable, readily visible label for each fuse, clearly indicating the correct type, size, and ratings of replacement fuse:
 - 1) Label shall not cover or interfere with equipment manufacturer's instructions.
 - b. Provide fuses rated for the voltage and available short circuit current at which they are applied.
 - c. Manufacturer: One of the following or equal:
 - 1) Ferraz Shawmut.
 - 2) Littelfuse.
 - 3) Bussmann.
6. Fuse holders:
- a. Modular type:
 - 1) DIN rail mounting on 35 millimeters rail.
 - 2) Touch safe design: All connection terminals to be protected against accidental touch.
 - 3) Incorporates blown fuse indicator.
 - b. Provide nameplate identifying each fuse:
 - 1) As specified in Section 16075.
 - c. Manufacturer: One of the following or equal:
 - 1) Phoenix Contact.
 - 2) Allen-Bradley 1492-FB Series B.
7. Control circuit breakers:
- a. DIN rail mounting on 35 millimeters rail.
 - b. Manual OPEN-CLOSE toggle switch.
 - c. Rated 250 VAC.
 - d. Interrupting rating: 10 kiloampere (kA) or available fault current at the line terminal, whichever is higher.
 - e. Current ratings: As indicated on the Drawings or as required for the application.
 - f. Provide nameplate identifying each circuit breaker:
 - 1) As specified in Section 16075.
 - g. Manufacturer: One of the following or equal:
 - 1) Phoenix Contact.
 - 2) ABB.
 - 3) Allen-Bradley Series.
 - 4) Square D.
- D. Conductors and cables:
1. Power and control wiring:
- a. Materials: Stranded, soft annealed copper.
 - b. Insulation: 600 volts type MTW.
 - c. Minimum sizes:
 - 1) Primary power distribution: 12 AWG.
 - 2) Secondary power distribution: 14 AWG.
 - 3) Control: 16 AWG.

- d. Color:
 - 1) AC power (line and load): BLACK.
 - 2) AC power (neutral): WHITE.
 - 3) AC control: RED.
 - 4) DC power and control (ungrounded): BLUE.
 - 5) DC power and control (grounded): WHITE with BLUE stripe.
 - 6) Ground: GREEN.
- 2. Signal cables:
 - a. Materials: Stranded, soft annealed copper.
 - b. Insulation: 600 volts, PVC outer jacket.
 - c. Minimum size: 18 AWG paired triad.
 - d. Overall aluminum shield (tape).
 - e. Copper drain wire.
 - f. Color:
 - 1) 2 Conductor:
 - a) Positive (+): BLACK.
 - b) Negative (-): WHITE, RED.
 - 2) 3 Conductor:
 - a) Positive (+): BLACK.
 - b) Negative (-): RED.
 - c) Signal: WHITE.
 - g. Insulate the foil shielding and exposed drain wire for each signal cable with heat shrink tubing.

E. Conductor identification:

- 1. Identify each conductors and cables with unique wire numbers as specified in Section 16075.
- 2. Readily identified without twisting the conductor.

F. General wiring requirements:

- 1. Wiring methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise specified.
- 2. Install all components in accordance with the manufacturer's instructions included in the listing and labeling.
- 3. Provide a nameplate on the cover of the control panel identifying all sources of power supply and foreign voltages within the control panel.
- 4. Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.
- 5. Provide surge protection for all control panels.
- 6. Provide nonmetallic ducts for routing and organization of conductors and cables:
 - a. Size ducts for ultimate build-out of the panel, or for 20 percent spare, whichever is greater.
 - b. Provide separate ducts for signal and low voltage wiring from power and 120 VAC control wiring:
 - 1) 120 VAC: Grey colored ducts.
 - 2) 24 VDC: White colored ducts.
- 7. Cables shall be fastened with cable mounting clamps or with cable ties supported by any of the following methods:
 - a. Screw-on cable tie mounts.
 - b. Hammer-on cable tie mounting clips.

- c. Fingers of the nonmetallic duct.
- 8. The free ends of cable ties shall be cut flush after final adjustment and fastening.
- 9. Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.
- 10. Support panel conductors where necessary to keep them in place.
- 11. Wiring to rear terminals on panel-mount instruments shall be run in nonmetallic duct secured to horizontal brackets run adjacent to the instruments.
- 12. Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:
 - a. Factory applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.
- 13. The control panel shall be the source of power for all 120 VAC devices interconnected with the control panel including, but not limited to:
 - a. Solenoid valves.
 - b. Instruments both mounted in the control panel and remotely connected to the control panel.

2.04 EQUIPMENT (NOT USED)

2.05 COMPONENTS

- A. Thermal management:
 - 1. Provide heating, cooling, and dehumidifying devices in order to maintain all instrumentation and control devices to within a range as specified in Section 17050.
 - 2. Air conditioner:
 - a. Provide solid-state cabinet coolers or air conditioning units on all outdoor panels containing electronic components such as local operator interface (LOI) units, panel instruments, programmable logic controllers, or remote I/O.
 - b. Provide filters on intake and exhaust openings.
 - c. Increase panel sizes as needed to accommodate cooling units.
 - d. Enclosure rating: NEMA Type 4X.
 - e. Closed loop design.
 - f. Power Supply: 120 VAC.
 - g. Utilize a CFC-free refrigerant.
 - h. Manufacturers: The following or approved equal:
 - 1) Kooltronic Integrity Series 21.
 - 3. Heating:
 - a. Provide all panels located in areas that are not climate controlled with thermostatically controlled strip heaters; except, where all of the following conditions apply:
 - 1) The panel is not supplied with 120 VAC power.
 - 2) There are no electronics or moisture-sensitive devices in the enclosure.
 - 3) The panel is smaller than 38 inches high.
 - 4. Heat exchanger:
 - a. Closed-loop design ensuring separation of ambient air and clean air inside the cabinet.
 - b. Filterless design to facilitate easy cleaning of the core.
 - c. Mounting: Indicated on the Drawings.

5. Enclosure temperature sensor as indicated on the Drawings:
 - a. Provide wall mount RTD transmitter to measure internal cabinet temperature, in all enclosures containing electrical components such as PLCs, RTUs, RIO, and VFDs.
 - b. Platinum RTD.
 - c. 4 to 20 milliamperes output.
 - d. Sensor and electronic enclosure.
 - e. Accuracy: Within 2.0 degrees Fahrenheit.
 - f. Manufacturer: One of the following or equal:
 - 1) Omega, EWS series.
 - 2) TCS Basys Controls, TS Series as indicated on the Drawings:
6. Enclosure temperature switch:
 - a. Provide wall mount bimetallic switch transmitter (to measure internal cabinet temperature in all enclosures) containing electrical components such as PLCs, RTUs, RIO, and VFDs.
 - b. Sensor and electronic enclosure.
 - c. Accuracy: Within 2.0 degrees Fahrenheit.
 - d. Manufacturer: The following or equal:
 - 1) Hoffman ATEMNC.
7. Fan ventilation:
 - a. Provide Hoffman fan speed control:
 - 1) Automatically adjust fan speed depending on remote temperature sensor input.
 - 2) Field adjustable temperature sensitivity.
 - 3) Polycarbonate control housing.
 - 4) 120 VAC 60 hertz.
 - 5) NEMA Type 5-15R cord connections.
 - b. Muffin style:
 - 1) Provide 2 door/cabinet mounted vent fans for every 72 inches of cabinet width.
 - 2) Provide Finger Guard kit.
 - 3) Filter kit with 2 spare filters for each intake fan.
 - 4) Provide bezel and gasket kit.
 - 5) Provide fan shroud.
 - c. Temperature control switch and alarm:
 - 1) Power: 120 VAC.
 - 2) Bimetallic temperature sensor.
 - 3) Adjustable setpoint range 30 degrees Fahrenheit to 140 degree Fahrenheit.
 - 4) Hoffman ATEM series or equal.

B. Panel meters:

1. Pointer type:
 - a. Suitable for panel mounting.
 - b. Minimum scale length: 3-inches.
 - c. Calibrated in engineering units.
 - d. Accuracy: Within 2 percent of span.
 - e. NEMA Type 4/IP65 sealed front metal bezel.
 - f. Manufacturer: The following or equal:
 - 1) Yokogawa.

2. Digital process indicators:
 - a. General:
 - 1) Integral provisions for scaling.
 - 2) Scale to process engineering units.
 - 3) Switch programmable decimal points.
 - 4) NEMA Type 4/IP65 sealed front bezel.
 - b. Current and voltage indicators:
 - 1) 3 1/2 - digit minimum.
 - 2) Minimum character height: 0.5 inches.
 - 3) Accuracy:
 - a) AC/DC volts: Within (0.1 percent of reading plus 2 digit).
 - b) DC current: 4 to 20 milliamperes: within (0.1 percent of reading plus 1 digit).
 - c) DC voltage: 0 to 10 volts: Within (0.1 percent of reading plus 1 digit).
 - c. Operating voltage: 120 VAC.
 - d. Operating temperature: 0 degrees Celsius to 60 degrees Celsius.
 - 1) Manufacturer: One of the following or equal:
 - a) Red Lion.
 - b) Action Instruments Visipak.
3. Digital bar graph meter:
 - a. Self-contained instruments that display process signals directly in engineering units, both in decimal format and as a bar graph display.
 - b. Suitable for panel mounting.
 - c. LED display:
 - 1) Not less than 3 decimal digits.
 - 2) Not less than a 101 segment LED bar graph.
 - d. Input signal:
 - 1) All conventional current loops and voltage control signals.
 - e. Minimum sample rate of once per second.
 - f. Provisions for field adjustable scaling and/or offset.
 - g. Accuracy shall be within 1 least significant digit.
 - h. Manufacturer: One of the following or equal:
 - 1) Ametek Dixon.
 - 2) Yokogawa.
 - 3) Weschler Instruments.
4. Counters:
 - a. 6 digits.
 - b. Switch selectable inputs:
 - 1) Switch contacts.
 - 2) CMOS.
 - 3) TTL.
 - 4) Magnetic pickup.
 - 5) RLC sensors.
 - c. Selectable up/down control via external signal.
 - d. Remote reset.
 - e. Remote inhibit to prevent accumulating counts.
 - f. Programmable to enable or disable front panel reset.
 - g. Non-volatile memory to retain all data upon loss of supply power.
 - h. Sunlight readable.
 - i. Operating temperature: 0 degrees Celsius to 50 degrees Celsius.

- j. Manufacturer: The following or equal:
 - 1) Red Lion PAX Series.

C. Pilot devices:

1. General:

- a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
- b. Size:
 - 1) 30.5 millimeters.
- c. Heavy duty.
- d. Pushbuttons:
 - 1) Contacts rated:
 - a) NEMA Type A600.
 - 2) Furnish 1 spare normally open and normally closed contact with each switch.
- e. Selector switches:
 - 1) Contacts rated:
 - a) NEMA Type A600.
 - b) Knob type:
 - 2) Furnish 1 spare normally open contact and normally closed contact with each switch.
 - 3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.
- f. Pilot lights:
 - 1) Type:
 - a) LED for interior installations.
 - 2) Push to test.
 - 3) Lamp color:
 - a) On/Running/Start: Red.
 - b) Off/Stop: Green.
 - c) Power: White.
 - d) Alarm: Amber.
 - e) Status or normal condition: White.
 - f) Opened: Amber.
 - g) Closed: Blue.
 - h) Failure: Red.

2. Indoor and outdoor areas:

- a. NEMA Type 4/13.
- b. Manufacturer: One of the following or equal:
 - 1) Allen-Bradley Type 800T.
 - 2) Square D Class 9001 Type K.
 - 3) General Electric Type CR104P.
 - 4) IDEC TWTD.

3. Corrosive areas:

- a. NEMA Type 4X.
- b. Corrosion resistant.
- c. Exterior parts of high impact strength fiberglass reinforced polyester or multiple-layer epoxy coated zinc.
- d. Manufacturer: One of the following or equal:
 - 1) Cutler Hammer Type E34.
 - 2) Square D Class 9001 Type SK.
 - 3) Allen-Bradley Type 800H.

4) IDEC TWTD.

- D. Potentiometer and slidewire transmitters:
1. Provide a DC output in proportion to a potentiometer input.
 2. Potentiometer input:
 - a. 100 ohms to 100 K ohms.
 - b. Impedance Greater or equal to 1 M ohms.
 - c. Zero turn-up: 80 percent of full scale input.
 - d. Span turn-down: 80 percent of full scale input.
 3. Field configurable output:
 - a. Voltage and current: All conventional current loops and voltage control signals.
 4. Accuracy including linearity and hysteresis within 0.1 percent max at 25 degrees Celsius.
 5. Operating temperature: 0 degrees Celsius to 55 degrees Celsius.
 6. Supply power: 9 to 30 VDC.
 7. Manufacturer: The following or equal:
 - a. Phoenix Contact.
- E. Signal isolators and converters:
1. Furnish signal isolators that provide complete isolation of input, output, and power input:
 - a. Minimum isolation level: 1.5 kilovolts AC/50 hertz for at least 1 minute.
 - b. Adjustable span and zero.
 - c. Accuracy: Within 1.0 percent of span.
 - d. Ambient temperature range: -20 degrees Celsius to +65 degrees Celsius.
 2. Manufacturer: One of the following or equal:
 - a. Phoenix Contact MCR Series.
 - b. Acromag 1500, 600T, 800T, Flat Pack or ACR Series.
 - c. Action Instruments Q500 Series or Ultra SlimPakII.
 - d. AGM electronics Model TA-4000.
- F. Relays:
1. General:
 - a. For all types of 120 VAC relays, provide surge protection across the coil of each relay.
 - b. For all types of 24 VDC relays, provide a free-wheeling diode across the coil of each relay.
 2. General purpose:
 - a. Magnetic control relays.
 - b. NEMA Type A300 rated:
 - 1) 300 volts.
 - 2) 8 Amps continuous (minimum).
 - 3) 7,200 volt-amperes make.
 - 4) 720 volt-amperes break.
 - c. Plug-in type.
 - d. LED indication for energization status.
 - e. Coil voltages: As required for the application.
 - f. Minimum poles: DPDT.
 - g. Touch safe design: All connection terminals to be protected against accidental touch.
 - h. Enclose each relay in a clear plastic heat and shock-resistant dust cover.

- i. Quantity and type of contact shall be as indicated on the Drawings or as needed for system compatibility.
 - j. Relays with screw-type socket terminals.
 - k. Provide additional (slave/interposing) relays when the following occurs:
 - 1) The number or type of contacts shown exceeds the contact capacity of the specified relays.
 - 2) Higher contact rating is required in order to interface with starter circuits or other equipment.
 - l. DIN rail mounting on 35 millimeters rail.
 - m. Ice cube type relays with retainer clips to secure relay in socket.
 - n. Integrated label holder for device labeling.
 - o. Manufacturer: One of the following or equal:
 - 1) Phoenix Contact PLC series.
 - 2) Potter and Brumfield Type KRP or KUP.
 - 3) IDEC R* series. (* = H, J, R, S, U).
 - 4) Allen-Bradley Type 700 H Series.
 - 5) Square D Type K.
3. Latching:
- a. Magnetic latching control relays.
 - b. NEMA Type B300 rated:
 - 1) 300 volts.
 - 2) 10 Amps continuous.
 - 3) 3,600 volt-amperes make.
 - 4) 320 volt-amperes break.
 - c. Plug-in type.
 - d. DIN rail mounting on 35 millimeters rail.
 - e. Coil voltage: As required for the application.
 - f. Minimum poles: 2PDT; as required for the application. Plus 1 spare pole.
 - g. Touch safe design: All connection terminals to be protected against accidental touch.
 - h. Clear cover for visual inspection.
 - i. Provide retainer clip to secure relay in socket.
 - j. Manufacturer: One of the following or equal:
 - 1) Square D type 8501 Type K.
 - 2) IDEC TWTD.
4. Time delay:
- a. Provide time delay relays to control contact transition time.
 - b. Contact rating:
 - 1) 240 volts.
 - 2) 10 Amps continuous.
 - 3) 3,600 volt-amperes make.
 - 4) 360 volt-amperes break.
 - c. Coil voltage: as required for the application.
 - d. Provide pneumatic or electronic type with on-delay, off-delay, and on/off delay:
 - 1) For off delay use true power off time delay relays. Where the required timing range exceeds capability of the off delay relay use signal off delay where power loss will not cause undesirable operation or pneumatic time delay relays.
 - e. Minimum poles: 2PDT.
 - f. Units include adjustable dial with graduated scale covering the time range in each case.

- g. Minimum timing range: 0.1 seconds to 10 minutes, or as required for the application.
 - h. Manufacturer: One of the following or equal:
 - 1) IDEC RTE series.
 - 2) Agastat type Series 7000 series (pneumatic).
 - 3) Allen-Bradley type 700HR Series.
- G. Terminal blocks:
- 1. Din rail mounting on 35 mm rail.
 - 2. Suitable for specified AWG wire.
 - 3. Rated for 30 amperes at 600 volts.
 - 4. Screw terminal type.
 - 5. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.
 - 6. Finger safe protection for all terminals for conductors.
 - 7. Construction: Polyamide insulation material capable of withstanding temperature extremes from - 40 degree Celsius to 105 degrees Celsius.
 - 8. Terminals: Plainly identified to correspond with markings on the diagrams:
 - a. Permanent machine printed terminal identification.
 - 9. Disconnect type field signal conductor terminals with socket/screw for testing.
 - 10. Identify terminals suitable for use with more than 1 conductor.
 - 11. Position:
 - a. So that the internal and external wiring does not cross.
 - b. To provide unobstructed access to the terminals and their conductors.
 - 12. Provide minimum 25 percent spare terminals.
 - 13. Manufacturer: One of the following or equal:
 - a. Phoenix Contact UK5 Series.
 - b. Allen-Bradley Series 1492.
 - 14. Wire duct:
 - a. Provide flame retardant plastic wiring duct, slotted with dust cover.
 - b. Type:
 - 1) Wide slot.
 - 2) Narrow slot.
 - 3) Round hole.
 - c. Manufacturer: The following or equal:
 - 1) Panduit.
- H. Surge protection devices:
- 1. Control panel power:
 - a. 120-volt control power source: Non-UPS powered:
 - 1) Provide surge protection device (SPD) for panel power entrances:
 - a) Nominal 120 VAC with a nominal clamping voltage of 200 volts.
 - b) Non-faulting and non-interrupting design.
 - c) A response time of not more than 5 nanoseconds.
 - 2) Control panel power system level protection, non-UPS powered:
 - a) Design to withstand a maximum 10 kA test current of a 8/20 μ s waveform according to IEEE C62.41.1 Category C Area.
 - b) For panels receiving power at 120 VAC, provide surge protection at secondary of main circuit breaker.

- c) Provide both normal mode noise protection (between current carrying conductors) and common mode (between current carrying conductor and neutral) surge protection.
 - d) DIN rail mounting.
 - e) Attach wiring to the SPD by means of a screw type cable-clamping terminal block:
 - (1) Gas-tight connections.
 - (2) The terminal block: Fabricated of non-ferrous, non-corrosive materials.
 - f) Visual status indication of MOV status on the input and output circuits.
 - g) Dry contact rated for at least 250 VAC, 1 Amp for remote status indication.
 - h) Meeting the following requirements:
 - (1) Response time: Less than or equal to 100 ns.
 - (2) Attenuation: Greater than or equal to -40 dB at 100 kilovolt-hertz as determined by a standard 50 ohms insertion test.
 - (3) Safety approvals:
 - (a) UL 1283 (EMI/RFI Filter).
 - (b) UL 1449 2nd Edition.
 - i) Manufacturer: One of the following or equal:
 - (1) Phoenix Contact type SFP TVSS/Filter.
 - (2) Liebert Accuvar series.
 - (3) Islatrol.
- b. 120-volt control power source: UPS powered.
- 1) Provide surge protection on the control power source at each panel containing power supplies, or electronic components including PLCs, I/O, HMI, and digital meters.
 - 2) Location:
 - a) For panels with a UPS, install surge protection ahead of UPS and maintenance bypass switch.
 - (1) Surge protection is not required for 120 VAC circuits that are only used for panel lights and receptacles.
 - b) For panels receiving power at 480 VAC, provide surge protection on the 120 VAC control power transformer secondary.
 - 3) MCOV: 150 VAC.
 - 4) Surge capability (8/20 microsecond wave): 10 kA.
 - 5) Peak let-through: 620V L-N, 850V L-G.
 - 6) Manufacturer: One of the following or equal:
 - a) Phoenix Contact Plugtrab PT series
 - b) MTL Surge Technologies MA15 series
2. Instrument, data and signal line protectors (traditional I/O) – panel mounted:
- a. Surge protection minimum requirements: Withstand a 10 kA test current of a 8/20 μ s waveform in accordance with IEEE C62.41.1 Category C Area.
 - b. DIN rail mounting on 35 millimeters rail (except field mounted SPDs).
 - c. SPDs consisting of 2 parts:
 - 1) A base terminal block.
 - 2) A plug protection module:
 - a) Replacing a plug shall not require the removal of any wires nor interrupt the signal.
 - b) Base and plug coded to accept only the correct voltage plug.

- d. SPD Manufacturer: One of the following or equal:
 - 1) Phoenix Contact Plugtrab Series.
 - 2) Bournes Series 1800.
 - 3. Instrument, data and signal line protectors (traditional I/O)– field mounted:
 - a. Surge protection minimum requirements: Withstand a minimum 10 kA test current of a 8/20 μ s waveform in accordance with IEEE C62.41.1 Category C Area.
 - b. Manufacturer: One of the following or equal:
 - 1) Plugtrab PT Series
 - 2) MTL TP48 Series.
- I. Beacons:
 - 1. Manufacturer: One of the following or equal:
 - a. Federal Signal Corp Starfire Series.
 - b. Allen-Bradley 855 B *-* 10 Series.
 - c. Edwards Model: Model 102.
- J. Horns:
 - 1. Electromechanical:
 - a. Manufacturer: One of the following or equal:
 - 1) Federal Signal 350 or 31X Series.
 - 2) Edwards: 878EX or 879EX Series.
 - 2. Electronic:
 - a. Manufacturer: One of the following or equal:
 - 1) Federal Signal 300GCX or 300X Series.
 - 2) Allen-Bradley 855H or 855XH Series.
 - 3) Edwards 5530M 5533MD Series.
 - 3. Rated 80 dB minimum at 10 feet.
- K. Power supplies:
 - 1. Design power supply systems so that either the primary or backup supply can be removed, repaired, and returned to service without disrupting the system operation.
 - 2. Convert 120 VAC to 24 volt DC or other DC voltages required or as required for the application.
 - 3. Provide backup 24 VDC power supply units to automatically supply the load upon failure of the primary supply.
 - 4. Provide power supply arrangement that is configured with several modules to supply adequate power in the event of a single module failure:
 - a. Provide Automatic switchover upon module failure.
 - b. Alarm contacts monitored by the PLC.
 - 5. Sized to provide 40 percent excess rated capacity.
 - 6. UL 508C listed to allow full rated output without de-rating.
 - 7. Provide fuse or short-circuit protection.
 - 8. Provide a minimum of 1 set of dry contacts configured to change state on failure for monitoring and signaling purposes.
 - 9. Output regulation: Within 0.05 percent for a 10 percent line change or a 50 percent load change:
 - a. With remote voltage sensing.
 - 10. Operating temperature range: 0 degrees Celsius to 50 degrees Celsius.
 - 11. Touch safe design: All connection terminals to be protected against accidental touch.

12. DIN rail mounting on 35 millimeters rail.
13. Provide self-protecting power supplies with a means of limiting DC current in case of short circuit.
14. Manufacturer: One of the following or equal:
 - a. Phoenix Contact Quint series.
 - b. IDEC PS5R series.
 - c. Sola.
 - d. Acopian.
 - e. PULS.

L. Starters:

1. Magnetic motor starters:
 - a. As specified in Section 16422.
2. Integral self-protected starters:
 - a. As specified in Section 16422.

M. Limit switches:

1. NEMA Type 4X.
2. AC contact rating 120 volts, 10 A.
3. DC contact rating 125 volts, 0.4 A.
4. Provide robust actuation mechanism not prone to degradation.
5. Provide complete actuator mechanism with all required hardware.
6. Allows for contact opening even during contact weld condition.
7. UL approved.
8. Operating temperature range: -18 degrees to +110 degrees Celsius (0 degrees to 230 degrees Fahrenheit).
9. Manufacturer: One of the following or equal:
 - a. Allen-Bradley 802.
 - b. Honeywell HDLS.
 - c. Omron D4.
 - d. Eaton E47, E49, E50.
 - e. ABB equal.

2.06 ACCESSORIES

- A. As specified in Section 17050.
- B. Provide panels with an inside protective pocket to hold the panel Drawings. Ship panels with 1 copy of accepted Shop Drawings including, but not limited to, schematic diagram, connection diagram, and layout drawing of control wiring and components in a sealed plastic bag stored in the panel drawing pocket.
- C. Provide 15 inch floor stands or legs where needed or as indicated on the Drawings.
- D. Provide a folding shelf for enclosures that contain programmable controllers. The shelf shall be mounted on the inside surface of the door, capable of supporting a laptop computer.
- E. Provide nameplate to each panel as indicated on the Drawings:
 1. Provide as specified in Section 16075 on all internal and external instruments and devices.

2. Provide a nameplate with the following markings that is plainly visible after installation:
 - a. Manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
 - b. Supply voltage, phase, frequency, and full-load current.
 - c. Short-circuit current rating of the panel based on one of the following:
 - 1) Short-circuit current rating of a listed and labeled assembly.
 - 2) Short-circuit current rating established utilizing an approved method.
 3. Provide enclosures with a flange mounted disconnect that is interlocked with the doors.
- F. Provide a window kit where indicated on the Drawings. The window shall meet the following requirements:
1. Safety plate glass.
 2. Secured by rubber locking seal.
 3. Allow full viewing of devices issuing visual process data or diagnostics.
- G. Lighting:
1. Provide 1 luminaire for each section, on the interior of the panel, spaced evenly along the top-front of the enclosure door opening(s):
 - a. Covered or guarded.
 - b. Provide On-Off door-activated switches where indicated on the Drawings.
 - c. Provide 18-watt fluorescent lamp for indoor enclosures:
 - 1) Provide additional fixtures for every 36 inches of width.
 - d. Provide 40 watt incandescent lamp for exterior enclosures:
 - 1) Provide additional fixtures for every 36 inches of width.
- H. Receptacles:
1. Provide 1 duplex receptacle located every 4 feet of enclosure width, spaced evenly along the back mounting panels.
 2. GFCI, 125-volt, single-phase, 15-amp style plug.
 3. Provide circuit breaker or fuse to limit receptacle draw to 5 amperes.
- I. Grounding:
1. Provide the following:
 - a. Grounding strap between enclosure doors and the enclosure.
 - b. Equipment grounding conductor terminals.
 - c. Provide equipment ground bus with lugs for connection of all equipment grounding wires.
 - d. Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding bus.
 2. Identify equipment grounding conductor terminals with the word "GROUND," the letters "GND" or the letter "G," or the color green.
 3. Signal (24 VDC) Grounding: Terminate each drain wire of a signal (shielded) cable to a unique grounding terminal block, or common ground bus at the end of the cable as shown on the Loop Drawings.
 4. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members.
 5. Design so that removing a device does not interrupt the continuity of the equipment grounding circuit.
 6. Provide an equipment-grounding terminal for each incoming power circuit, near the phase conductor terminal.

7. Size ground wires in accordance with NEC and UL Standards, unless noted otherwise.
8. Connect all exposed, noncurrent-carrying conductive parts, devices, and equipment to the equipment grounding circuit.
9. Connect the door stud on the enclosures to an equipment-grounding terminal within the enclosure using an equipment-bonding jumper.
10. Bond together all control panels both remote and local, processor racks, and conductive enclosures of power supplies and connect to the equipment grounding circuit to provide a common ground reference.

J. Provide sunshades for outdoor installations.

2.07 MIXES (NOT USED)

2.08 FABRICATION (NOT USED)

2.09 FINISHES

A. Finishes:

1. Metallic (non-stainless):
 - a. Metal surfaces of panels shall be prepared by chemical cleaning and mechanical abrasion in accordance with the finish manufacturer's recommendations to achieve a smooth, well-finished surface.
 - b. Scratches or blemishes shall be filled before finishing. 1 coat of zinc phosphate shall be applied per the manufacturer's recommended dry film thickness, and allowed to dry before applying the finish coat.
 - c. Finish coat shall be a baked polyester urethane powder, aliphatic air-dry polyurethane, or epoxy enamel to meet NEMA rating specified application.
 - d. Exterior of enclosures located outdoors shall be UV resistant polyester powder coating. Total dry film thickness shall be 3 mils, minimum.
2. Stainless steel:
 - a. Stainless enclosures shall be provided with a number 4 brushed finish - not painted.

B. Colors:

1. Exterior color of panels mounted indoors shall be manufacturer's standard light gray.
2. Exterior of panels mounted outdoors shall be manufacturer's standard white.
3. Panel interiors shall be manufacturer's standard white.

2.10 SOURCE QUALITY CONTROL

A. As specified in 17050.

B. Factory calibrate each instrument with a minimum 3-point calibration or according to manufacturer's standard at a facility that is traceable to the NIST.

1. Submit calibration data sheets to the Engineer at least 30 days before shipment of the instruments to the project site.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine the installation location for the instrument and verify that the instrument will work properly when installed.
 - 1. Notify the Engineer promptly if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Install enclosures so that their surfaces are plumb and level within 1/8 inch over the entire surface of the panel; anchor securely to wall and structural supports at each corner, minimum. Direct attachment to dry wall is not permitted.
- B. Install the enclosure per guidelines and submitted installation instructions to meet the seismic requirements at the project site.
- C. Provide floor stand kits for wall-mount enclosures larger than 48 inches high.
- D. Provide 3-1/2 inch high concrete housekeeping pads for free-standing enclosures.
- E. Install gasket and sealing material under panels with floor slab cutouts for conduit:
 - 1. Undercoat floor mounted panels.
- F. Provide a full size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.
- G. All holes for field conduits, etc. shall be cut in the field, there shall be no additional holes, factory cut holes, or hole closers allowed. Incorrect holes, additional holes, or miss-cut holes shall require that the entire enclosure be replaced.
- H. Control panels that are adjacent to motor control centers shall be fully wired to the motor control centers using wireways integral to the motor control center or additional conduits as needed. These interconnections are not shown or reflected on the conduit schedule, but shall be shown on the Loop Drawings prepared by the Contractor.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIRS/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. As specified in Section 17050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

A. As specified in Section 17050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

A. As specified in Section 17050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

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SECTION 17712

CONTROL SYSTEMS - UNINTERRUPTIBLE POWER SUPPLIES 10 KVA AND BELOW

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Single-phase double conversion uninterruptible power supplies rated 10 kilovolt-amperes and below.
 - 2. Single-phase line-interactive uninterruptible power supplies rated 10 kilovolt-amperes and below.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - a. Items involving electrical, control, and instrumentation construction may be indicated on the Drawings or specified in the Specifications that do not apply specifically to electrical, control and instrumentation systems.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 01612 - Seismic Design Criteria.
 - c. Section 16050 - Common Work Results for Electrical.
 - d. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.02 REFERENCES

- A. As specified in Sections 16050 and 17050.
- B. Federal Communications Commission (FCC):
 - 1. FCC Part 15, Class A.
 - 2. FCC Part 15, Class B.
- C. Institute of Electrical and Electronic Engineers (IEEE):
 - 1. 519 - IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
 - 2. 1184 - IEEE Guide for Batteries for Uninterruptible Power Supply Systems.
 - 3. C62.41 - IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
- D. Underwriters Laboratories, Inc. (UL):
 - 1. UL 1778 - Standard for Uninterruptible Power Supply Systems and Equipment.

1.03 DEFINITIONS

- A. As specified in Sections 16050 and 17050.
- B. Specific definitions:
 - 1. Critical load: Load supplied by the UPS.
 - 2. MOV: Metal oxide varistor.

1.04 SYSTEM DESCRIPTION

- A. Provide complete, factory-assembled, wired, and tested, true on-line double conversion UPS equipment including, but not limited to, rectifier, DC bus, inverter, battery charger, batteries, automatic bypass, and ancillary components as specified herein and as indicated on the Drawings.
- B. UPS loads as indicated on the Drawings.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 17050.
- B. Product data:
 - 1. Manufacturer and model number.
 - 2. Catalog data.
 - 3. Dimensions:
 - a. Height.
 - b. Width.
 - c. Depth.
 - d. Weight.
 - 4. Ratings:
 - a. Input voltage.
 - b. Output voltage.
 - c. Input/output power factor.
 - d. Efficiency.
 - e. Harmonic distortion.
 - f. Runtime.
 - 5. Noise specifications.
 - 6. Heat dissipation.
 - 7. Warranties and maintenance contracts:
 - 8. All communications requirements such as software, cards, etc.
 - 9. Alarms and status available for remote monitoring and system health.
- C. Shop drawings:
 - 1. Power distribution block diagrams.
 - 2. Front and rear views of equipment enclosures:
 - a. Front elevation including all control and indicating devices.
 - 3. Support points and weight of overall equipment.
 - 4. Schematic and control wiring diagrams including, but not limited to:
 - a. Line and load terminals.
 - b. Alarm and status terminals.
 - c. Manual maintenance bypass switch terminals.
 - d. External wiring requirements for all communication signals.
 - 5. Switching and overcurrent protective devices.

- D. Calculations:
 - 1. Include derating for temperature and elevation as necessary.
 - 2. UPS sizing computation:
 - a. Apply safety factors as specified in this Section.
 - b. Provide itemized list of critical loads, including individual VA and watt ratings.
 - 3. Battery time calculation based on specified runtime.
 - 4. Total battery recharge time as a function of capacity utilized.
- E. Design data:
 - 1. Design mounting and anchorage for seismic design criteria specified in Section 01612:
 - a. Provide seismic kits as required to meet design criteria.
- F. Record documents:
 - 1. Provide Record Drawings of installed unit(s) including layout and wiring.
- G. Manufacturer's field reports.
- H. Operation and maintenance manuals:
 - 1. System instruction manuals that describe troubleshooting, installation, operations, and safety procedures.
 - 2. Recommendations for maintenance procedures and intervals.
 - 3. Battery data / replacement information.
 - 4. Parts list.

1.06 QUALITY ASSURANCE

- A. Manufacturer qualifications:
 - 1. A minimum of 10 years experience in the design, manufacture, and testing of solid-state UPS systems.
 - 2. ISO 9001 certified.
- B. Regulatory requirements for complete UPS system:
 - 1. UL listed per UL Standard 1778
 - 2. IEEE C62.41, Categories A & B.
 - 3. FCC 15:
 - a. Greater than 2,000 VA - Class A.
 - b. Less than 2,000 VA - Class B.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 17050.

1.12 SYSTEM START-UP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Double-conversion true-online UPS manufacturers, one of the following or equal:
 - 1. Free-standing UPS, 700-3,000 VA:
 - a. Emerson Network Power - Liebert GXT3 (700 - 3,000 VA).
 - b. Eaton Corporation - Powerware 9120 (700 - 3,000 VA).
 - 2. Rack-mounted UPS, 700-3,000 VA:
 - a. Emerson Network Power - Liebert GXT3 (700 - 3,000 VA).
 - b. Eaton Corporation - Powerware 9125 RM (700 - 3,000 VA).
 - 3. Free-standing UPS, above 3 kVA:
 - a. Emerson Network Power - Liebert GXT3-6000RT208 (6 kVA).
 - b. Emerson Network Power - Liebert GXT3-10000RT208 (10 kVA).
 - c. Eaton Corporation - Powerware 9155 (5.0 and 6.0 kVA).
 - d. Eaton Corporation - Powerware 9355 (8 and 10 kVA).
 - 4. Rack-mounted UPS, above 3 kVA:
 - a. Emerson Network Power - Liebert GXT3-6000RT208 (6 kVA).
 - b. Emerson Network Power - Liebert GXT3-10000RT208 (10 kVA).
 - c. Eaton Corporation - Powerware 9125 RM (5.0 and 6.0 kVA).
 - d. Eaton Corporation - Powerware 9140 (7.5 and 10 kVA).

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

- A. Double conversion true on-line UPS system requirements:
 - 1. System characteristics:
 - a. Provide rack-mount or free-standing UPS as specified and as indicated on the Drawings.
 - b. The minimum VA rating of the UPS shall be greater than or equal to the safety factor (as indicated in the UPS schedule) times the connected load or 700 VA, whichever is greater.
 - c. Battery runtime at full load and site ambient temperature as indicated in the UPS schedule.
 - d. Efficiency greater than 85 percent AC-AC, all modes.
 - e. Acoustical noise:
 - 1) Less than 55 dBA at 5 feet.

- f. Output connections:
 - 1) Receptacles:
 - a) 700-2,500 VA units:
 - (1) Provide a minimum of four NEMA Type 5-15R or Type 5-20R receptacles.
 - b) 3,000 VA units:
 - (1) Provide a minimum of four NEMA Type 5-20R receptacles.
 - (2) Provide at least one NEMA Type L5-30R receptacle.
 - c) Greater than 3,000 VA units:
 - (1) Provide a minimum of four NEMA Type 5-20R receptacles.
 - (2) Provide at least one NEMA Type L14-30R receptacle.
 - 2) Provide hardwired connections as indicated on the Drawings.
- g. Protection:
 - 1) Undervoltage:
 - a) Operate on battery power if incoming source voltage goes below UPS system limits of operation.
 - 2) Overvoltage:
 - a) Operate on battery power if incoming source voltage exceeds UPS system limits of operation.
 - 3) Overcurrent:
 - a) Provide input and output current-limiting protection to ensure adequate overcurrent protection for UPS.
 - 4) Surge protection:
 - a) MOV-based.
- 2. Electrical characteristics:
 - a. AC input:
 - 1) Single phase.
 - 2) Voltage as indicated in the UPS schedule.
 - a) Fully functional within +10 percent, -15 percent of nominal voltage at full load without depleting battery.
 - b) 120 V input:
 - (1) 2-wire plus ground.
 - c) 208/120 V or 240/120 input:
 - (1) 3-wire plus ground.
 - 3) Current:
 - a) Reflected total harmonic distortion (THD) less than 25 percent at rated load.
 - 4) Frequency range of operation:
 - a) 57-63 Hz.
 - 5) Power factor:
 - a) Not less than 0.95 lagging at rated load.
 - b. AC output:
 - 1) Single phase.
 - 2) Voltage:
 - a) Regulation:
 - (1) ± 3 percent for 3,000 VA rating and below.
 - (2) ± 5 percent for greater than 3,000 VA rating - static load.
 - (3) ± 10 percent for greater than 3,000 VA rating - dynamic load.

- b) Total harmonic distortion (THD) when operating on incoming power:
 - (1) Not more than 3 percent for linear loads with a crest factor of 3:1.
 - (2) Not more than 5 percent for non-linear loads with a crest factor of 3:1.
 - c) Transient response:
 - (1) Within 7 percent for a 20-100 percent step load.
 - (2) Transient recovery time to nominal voltage within 166 milliseconds.
 - 3) Load power factor:
 - a) UPS shall be capable of supporting the critical loads for all power factors experienced for their full range of operation.
 - 4) Frequency regulation:
 - a) Within 3.5 Hz when on utility power.
 - b) Within 1.0 Hz when on UPS power.
- 3. Environmental requirements:
 - a. Operating ambient temperature:
 - 1) UPS module: 50 degrees Fahrenheit to 104 degrees Fahrenheit (10 degrees Celsius to 40 degrees Celsius).
 - 2) Battery: 68 degrees Fahrenheit to 86 degrees Fahrenheit (20 degrees Celsius to 30 degrees Celsius).
 - b. Operating altitude:
 - 1) Project site conditions as specified in Sections 16050 and 17050
- 4. System components:
 - a. Surge protective devices:
 - 1) MOV-supplied protection.
 - b. Inverter:
 - 1) Pulse-width modulated AC output signal.
 - 2) Overload withstand minimum time without transferring to bypass:
 - a) 101 to 110 percent for 2 minutes.
 - b) 111 to 125 percent for 10 seconds.
 - c) 126 to 150 percent for 1 second.
 - d) Greater than 150 percent for 96 milliseconds.
 - 3) Transfer load to bypass when overload capacity is exceeded.
 - c. Battery rectifier/charger:
 - 1) Recharge batteries to 90 percent in 6 hours or less.
 - d. Batteries:
 - 1) VRLA (valve regulated lead acid), sealed, maintenance free.
 - 2) Minimum 3-year float service life at 25 degrees Celsius.
 - 3) Integral to UPS enclosure or housed in a matching enclosure.
 - 4) Less than and including 6,000 VA: Hot-swappable.
 - 5) Automatically perform routine battery health monitoring and provide visual, audible, and/or serial warnings if abnormal battery conditions exist.
 - e. Automatic bypass switch:
 - 1) Integral to UPS system.
 - 2) Sense UPS overload, inverter failure, or overtemperature, and automatically transfer loads to source power.
 - 3) Maximum detect and transfer time of 4-6 milliseconds.
 - 4) Automatic re-transfer without power interruption to critical load.
 - 5) Input shall match output in phase, voltage, frequency, and grounding.

- 6) Rated to carry the full input current of the UPS.
- 7) Provide ability for manual operation.
- f. Manual maintenance bypass switch:
 - 1) Provides isolation of the UPS for maintenance purposes.
 - 2) Make-before-break design so that UPS can be isolated from the critical loads by placing these loads on source power without interruption of operation.
 - 3) Utility and UPS status indications.
 - 4) Supply necessary input/output cords and receptacles for connections with power source and UPS.
 - 5) Transfer time less than 6 milliseconds.
 - 6) Rated to carry the full input current of the UPS.
 - 7) Standalone UL-listed.
 - 8) Input match output in phase, voltage, frequency, and grounding.
 - 9) UPS input connection and UPS output plug:
 - a) 700 to 3,000 VA units: NEMA receptacle and plug to match UPS connections.
 - b) Above 3,000 VA units: NEMA receptacle and plug or hardwiring to match UPS connections.
 - 10) Utility and load connections:
 - a) As indicated on the Drawings.
 - 11) 700 to 3,000 VA units: One of the following or equal:
 - a) Liebert Micropod 2U.
 - b) Powerware Powerpass 9125.
 - 12) Above 3,000 VA units: By manufacturer of UPS, with connections matched for operation with UPS.
- g. UPS chassis:
 - 1) Electrically isolate from AC output neutral.
 - 2) Include an equipment ground terminal.
- h. Cooling:
 - 1) Forced air cooled.
- i. Locally displayed system indicators:
 - 1) Audible alarms during abnormal conditions:
 - a) UPS fault or overload condition.
 - b) Battery on.
 - c) Low battery.
 - d) Automatic bypass on/off.
 - e) Input power on.
 - f) Battery testing mode.
- j. Controls:
 - 1) Front-panel pushbuttons:
 - a) UPS start-up, shutdown, and manual bypass (for automatic bypass).
 - b) Testing.
 - c) Visual/audible alarms reset.
 - 2) Applicable controls as specified in Communications Requirements.
- k. Alarm contacts:
 - 1) Provide relay interface card and required interposing relays for 120 VAC discrete input status signals:
 - a) Low battery.
 - b) UPS alarm.
 - c) On UPS power.

- I. Communications requirements:
 - 1) RS-232.
 - 2) Ethernet via SNMP - allow remote indication of all alarms and status signals present in the UPS:
 - a) Provide manufacturer's software as required.
 - 3) USB - allow remote indication of all alarms and status signals present in the UPS:
 - a) Provide manufacturer's software as required.

- B. Line-interactive UPS requirements:
 - 1. Provide rack-mount or free-standing UPS as specified and as indicated on the Drawings.
 - 2. The minimum VA rating of the UPS shall be greater than or equal to the safety factor (as indicated in the UPS schedule) times the connected load or 700 VA, whichever is greater.
 - 3. Battery runtime at full load and site ambient temperature as indicated in the UPS schedule.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Install equipment in accordance with manufacturer's instructions.
- B. Do not utilize extension cords, adapters, or other electrical connectors for UPS input.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIRS/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. Perform inspections and test procedures before UPS startup:
1. Inspect equipment for signs of damage.
 2. Verify installation as indicated on the Drawings and specified in the Specifications.
 3. Inspect cabinets for foreign objects.
 4. Verify neutral and ground conductors are properly sized and terminated.
 5. Inspect battery cases.
 6. Inspect batteries for proper polarity.
 7. Check power and control wiring for tightness.
 8. Check terminal connectors for tightness.
 9. Assure connection and voltage of the battery string(s).

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

- A. As specified in Section 17050.

3.10 DEMONSTRATION AND TRAINING (NOT USED)

3.11 PROTECTION

- A. As specified in Section 17050.

3.12 SCHEDULES

TAG	MINIMUM RUNTIME	INPUT VOLTAGE / CONNECTION	SAFETY FACTOR	NOTES
MBR-UPS-001	30 MIN	120 VAC	1.5	
MBR-UPS-002	30 MIN	120 VAC	1.5	
MBR-UPS-003	30 MIN	120 VAC	1.5	
MBR-UPS-004	30 MIN	120 VAC	1.5	

END OF SECTION

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SECTION 17720

CONTROL SYSTEMS – PROGRAMMABLE LOGIC CONTROLLERS HARDWARE

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Programmable logic controller (PLC) based control systems hardware.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the Contractor's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of Contractor's Work.
 - 3. The following Sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - c. Section 17710 - Control System - Panels, Enclosures, and Panel Components.
 - d. Section 17733 - Control Systems - Network Materials and Equipment.
 - e. Section 17761 - Control Systems - PLC Programming Software.
 - f. Section 17762 - Control Systems - SCADA Software.

1.02 REFERENCES

- A. As specified in Section 17050.
- B. Institute of Electrical and Electronics Engineers (IEEE).

1.03 DEFINITIONS

- A. As specified in Section 17050.
- B. Specific definitions:
 - 1. CPU: Central processing unit.
 - 2. I/O: Input/Output.

1.04 SYSTEM DESCRIPTION

- A. Provide all PLC hardware as indicated on the Drawings and as specified in this Section.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 17050.
- B. Product data:
 - 1. CPU:
 - a. Processor type.
 - b. Processor speed.
 - c. Memory.
 - d. Internal processor battery back-up time.
 - 2. I/O modules:
 - a. Type.
 - b. Standard wiring diagram.
- C. Calculations:
 - 1. Submit calculations or documented estimate to verify that memory requirements of this Section are met, including spare requirements. If possible, use PLC manufacturer's calculation or estimating worksheet.
 - 2. Submit calculations to verify that spare I/O requirements of this Section are met.
 - 3. Submit calculations to verify that PLC power supply requirements of this Section are met.

1.06 QUALITY ASSURANCE

- A. Provide PLC hardware manufactured at facilities certified to the quality standards of ISO 9001.
- B. Additional requirements:
 - 1. Provide PLC system components by a single manufacturer:
 - a. Third-party communication modules may be used only for communication or network media functions not provided by the PLC manufacturer.
 - 2. Use PLC manufacturer approved hardware, such as cable, mounting hardware, connectors, enclosures, racks, communication cable, splitters, terminators, and taps.
 - 3. All PLC hardware, CPUs, I/O devices, and communication devices shall be new, free from defects and produced by manufacturers regularly engaged in the manufacture of these products.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050.

1.08 PROJECT OR SITE CONDITIONS

- A. As specified in Section 17050.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 17050.

1.12 SYSTEM STARTUP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

- A. As specified in Section 17050.
- B. In addition to the spare parts requirements specified in Section 17050
 1. CPU: 1 spare for each type of CPU in the system.
 2. I/O cards: 3 spare for each type of I/O card in the system.
 3. Power supplies; 2 spare for every power supply in the system.
 4. Network/communications cards: 1 spare for every network or communications card in the system.
 5. Remote adapter: 1 spare for every remote adaptor in the system.
 6. Chassis: 1 spare for each chassis size in the system.
- C. Installed spare requirements:
 1. I/O points:
 - a. Provide total of 25 percent spare I/O capacity for each type of I/O signal at every PLC and RIO.
 - b. Wire all spare I/O points to field terminal blocks in the PCM.
 2. PLC backplane capacity:
 - a. Provide 25 percent or 3 spare backplane slots, whichever is greater.
 3. PLC memory:
 - a. Provide 50 percent spare program volatile memory.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Acceptable manufacturers:
 1. Allen-Bradley ControlLogix.
 2. Allen-Bradley CompactLogix.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

- A. Programmable logic controller:
 1. Construction:
 - a. Furnish plug-in modular system.
 - b. Chassis wired logic is not acceptable.

- c. Provide PLCs capable of operating in a hostile industrial environment without fans, air conditioning, or electrical filtering:
 - 1) Temperature: 0 - 55 degrees Celsius.
 - 2) RFI: 80 to 1,000 MHz.
 - 3) Vibration: 10 to 500 Hertz.
 - 4) Humidity: 0 to 95 percent.
- d. Provide internal power supplies designed to protect against over voltage and frequency distortion characteristics frequently encountered with the local power utility.
- e. Design the PLC system to function as a stand-alone unit that performs all of the control functions described herein completely independent from the functions of the SCADA system PC-based operator interfaces:
 - 1) Failure of the SCADA system shall not impact data acquisition, control, scaling, alarm checking, or communication functions of the PLC.
- 2. Components general:
 - a. Provide each PLC with the functionality required to implement the control strategies and database shown and specified in the Contract Documents.
 - b. Furnish each PLC with floating point math and PID controller modulating algorithms.
 - c. Provide each CPU with internal fault analysis incorporating a fail-safe mode and a dry contact output for remote location alarming, as well as a local indicator on the PLC frame in the event of a fault in the PLC.
- 3. Central processing unit:
 - a. Configure each central processor unit so that it contains all the software relays, timers, counters, number storage registers, shift registers, sequencers, arithmetic capability, and comparators necessary to perform the specified control functions.
 - b. Capable of interfacing with all discrete inputs, analog inputs, discrete outputs, and analog outputs to meet the specified requirements including the spare and expansion requirements
 - c. Capable of supporting and implementing closed loop floating-point math and PID control that is directly integrated into the CPU control program.
 - d. Design the power supply to contain capacitors to provide for orderly shutdown in the event the incoming power does not meet specifications:
 - 1) Cease operation under this condition and force all outputs off.
- 4. Memory:
 - a. CPU program memory: 2 Mbytes minimum.
 - b. Non-volatile memory: On-board complementary metal oxide semiconductor (CMOS), electrically erasable programmable read only memory (EEPROM), PCMCIA, compact flash card, or SD card.
 - c. Supply with an internal lithium battery to retain non-volatile memory during power outages of up to 30 days.
 - 1) Battery to retain charge for minimum 1 year during normal operations.
 - 2) Furnish with an indicator showing the status of the batteries on the OIS graphic screen to alarm the operator that the batteries should be changed.
 - d. Supply with sufficient memory to implement the specified control functions plus a reserve capacity as specified with the requirements of this Section:
 - 1) This reserve capacity:
 - a) Totally free from any system use.

- 2) Programmed in a multi-mode configuration with multiple series or parallel contacts, counters, timers, and arithmetic functions.
5. Programming:
 - a. Provide a system where processors are programmed by:
 - 1) Portable laptop computer both locally and via the PLC data network.
6. PLC power supply:
 - a. Input: 120 VAC.
 - b. Output current: 10 Amps.
 - c. Mounted in the PLC housing.
 - d. Sized to power all modules mounted in that housing including an average module load for any empty housing slots plus 50 percent above that total.
7. PLC input/output, I/O modules:
 - a. General:
 - 1) Compatible with all of the PLCs being furnished under the contract and by the same manufacturer as the PLCs.
 - 2) Provide I/O modules that:
 - a) Isolated in accordance with IEEE Surge Withstand Standards and NEMA Noise Immunity Standards.
 - b) Provide A/D and D/A converters with optically or galvanically isolated inputs and outputs.
 - c) Accept dual ended inputs.
 - 3) The commoning of grounds between I/O points is not acceptable.
 - 4) Modules that are removable without having to disconnect wiring from the module's terminals:
 - a) Utilize a swing-arm or plug-in wiring connector.
 - 5) Provide at each PLC location the I/O modules required to provide the I/O points, including designated future I/O points, contained in the I/O Lists and/or shown on the P&IDs, control schematics, or described in the control strategies:
 - a) Provide at each PLC location an installed spare capacity in accordance with the requirements of this Section.
 - b) Wire all spares provided to the field terminal strip.
 - 6) Condition, filter, and check input signals for instrument limit conditions.
 - 7) Filter, scale, and linearize the raw signal into an engineering units based measurement.
 - 8) Alarm measurements for high, low, rate-of-change limits, and alarm trends.
 - 9) Provide external fuses mounted on the field connection terminal block for all discrete input, discrete output, and analog input I/O points.
 - 10) When multiple cards of the same I/O type are provided and parallel equipment, instrumentation, or redundant processes exist, distribute I/O among cards to ensure that a single card failure will not render an entire process unavailable.
 - b. Discrete input modules:
 - 1) Defined as contact closure inputs from devices external to the input module.
 - 2) Provide inputs that are optically isolated from low energy common mode transients to 1,500 volts peak from users wiring or other I/O modules.
 - 3) Individually isolated inputs.

- 4) With LED's to indicate status of each discrete input.
- 5) Input signal level: 120 VAC.
- 6) Provide input module points that are individually fused with blown fuse indicator lights, mounted external of the module on the output terminal strip:
 - a) Coordinate external fuse size with the protection located on the module, so that the external fuse opens first under a fault condition.
- c. Discrete output modules:
 - 1) Defined as contact closure outputs for ON/OFF operation of devices external to the output module:
 - a) Triac outputs may be used, with the permission of the Engineer, care must be used in applying this type of modules to ensure that the leakage current through the output device does not falsely signal or indicate an output condition.
 - 2) Optically isolated from inductively generated, normal mode and low energy, common mode transients to 1,500 volts peak.
 - 3) LEDs to indicate status of each output point.
 - 4) Each output point: Individually isolated.
- d. Analog input modules:
 - 1) Signal type: 4 to 20 mA DC.
 - 2) Analog to digital conversion: Minimum 12-bit precision with the digital result entered into the processor.
 - 3) The analog to digital conversion updated with each scan of the processor. Individually isolated each input. Provide individually fused analog input module points with blown fuse indicator lights, mounted external of the module on the output terminal strip:
 - a) Coordinate the size of the external fuse with the protection located on the module, so that the external fuse opens first under a fault condition.
- e. Analog output modules:
 - 1) Signal type: 4 to 20 mA DC.
 - 2) Individual isolated output points each rated for loads of up to 1,200 ohms.
8. Communications modules:
 - a. Remote I/O adapter module:
 - 1) For any PLC location requiring more than 1 housing to mount all of the I/O modules, or is identified as an RIO, provide the appropriate remote I/O adapter module for communication with the secondary housing(s).
 - 2) Install the RIO adapter module in the PLC backplane and the RIO backplane.
 - 3) Provide adapter modules that supports all available types of I/O modules required.
 - 4) Provide all network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.
 - 5) Complete diagnostic LEDs.
 - b. Network communications modules:
 - 1) General:
 - a) Install communications modules in the PLC backplane.
 - 2) Ethernet:
 - a) Ports: 1 RJ-45.

- b) Communication rate: 100 Mbit/s.
 - 3) Provide all network taps, connectors, termination resistors, drop cables, and trunk cables necessary for remote I/O communications.
- 9. PLC Housing:
 - a. Mount the PLC power supply, CPU, rack, and I/O modules in a suitable standard PLC backplane or housing.
 - b. Provide spare slots in each PLC and RIO location in accordance with the requirements of this Section.
 - c. Provide blank slot filler module for each spare slot.
- B. Factory communication:
 - 1. Provide a modem with auto answer capability to be used by the Instrumentation and Controls Subcontractor (ICSC) for on-line factory access and system interaction:
 - a. Provide on-line concurrent interaction between the factory and the operator.
 - b. Data transmission: Minimum 56k baud.
- C. SCADA system interface:
 - 1. As specified in Section 17733 and Section 17762.
- D. Programming:
 - 1. As specified in Section 17761.
- E. Remote inputs and outputs (RIOs):
 - 1. Compatible with all of the PLCs being furnished under this Contract and shall be by the same manufacturer as the PLCs and as a minimum includes:
 - a. Power supply.
 - b. Rack.
 - c. Backplane.
 - d. Communications module.
 - e. I/O modules.
 - f. Enclosure.
 - 2. Provide all cables and software needed for a complete and operational RIO system as specified in the Contract Documents.
 - 3. House the RIO system in enclosures as specified in Section 17710 and consistent with the area classifications as specified in the Electrical Specifications.
 - 4. Power to the RIO modules shall be provided by the enclosure's power supplies, which shall be powered from its associated PCM.
 - 5. The RIO communications modules for each RIO system shall have diagnostic LEDs.
 - 6. Provide a group of pre-assigned diagnostic registers to report RIO system faults to the driver PLC.
 - 7. The control system must continue operation should a fault occur on a single RIO drop:
 - a. Upon clearing the fault, restart communications to that drop automatically.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. As specified in Section 17050.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050.
- B. Utilize personnel to accomplish, or supervise the physical installation of all elements, components, accessories, or assemblies:
 - 1. Employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies.
- C. All components of the control system including all data network cables are the installation responsibility of the ICSC unless specifically noted otherwise.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. As specified in Section 17050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

- A. As specified in Section 17050.

3.10 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050.
- B. Tailor training specifically for this Project that reflects the entire control system installation and configuration.

- C. Perform training by pre-approved and qualified representatives of the ICSC and or manufacturer of the PLC hardware:
 - 1. A representative of the ICSC may perform the training only if the representative has completed the Manufacturer's training course for the PLC hardware.

3.11 PROTECTION

- A. As specified in Section 17050.

3.12 SCHEDULES (NOT USED)

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SECTION 17721

CONTROL SYSTEMS – HUMAN MACHINE INTERFACE HARDWARE

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Human machine interface (HMI) control systems hardware.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - c. Section 17712 - Control Systems - Uninterruptible Power Supplies 10 KVA and Below.
 - d. Section 17765 - Control Systems - Human Machine Interface Software.

1.02 REFERENCES

- A. As specified in Section 17050.
- B. International Organization for Standardization (ISO):
 - 1. 9001 - Quality Management Systems - Requirements.
- C. National Electrical Manufacturers Association (NEMA):
 - 1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

1.03 DEFINITIONS

- A. As specified in Section 17050.
- B. NEMA:
 - 1. Type 4 enclosure in accordance with NEMA 250.
 - 2. Type 4X enclosure in accordance with NEMA 250.
 - 3. Type 12 enclosure in accordance with NEMA 250.

1.04 SYSTEM DESCRIPTION

- A. Provide all HMI hardware identified in the Contract Documents.

1.05 SUBMITTALS

- A. Furnish submittals in accordance with Sections 01330 and 17050.
- B. Product data:
 - 1. Complete manufacturer's brochures for each item of equipment.
 - 2. Manufacturer's operation and installation instructions.
 - 3. Additional requirements:
 - a. Display type and size.
 - b. Operator input.
 - c. Processor type and speed.
 - d. Memory size.
 - e. Programming protocols.
 - f. Communication protocols.
 - g. Power requirements.
 - h. Operating temperature and humidity ranges. NEMA ratings.
- C. Shop drawings:
 - 1. At a minimum, furnish the following:
 - a. System block diagram showing relationship and connections between devices provided. Include manufacturer and model information, and address settings.
 - b. Mounting drawings with dimensions and elevations for each equipment location, including identification of all components, preparation and finish data, and nameplates.
 - c. Electrical connection diagrams.
 - d. Complete grounding requirements.
 - 2. Furnish data sheets for each component together with a technical product brochure or bulletin:
 - a. Manufacturer's model number.
 - b. Project equipment tag.
 - 3. Complete and detailed bills of materials identified by each cabinet. Include with each bill of material item the following:
 - a. Quantity.
 - b. Description.
 - c. Manufacturer.
 - d. Part numbers.
- D. Operation and maintenance manuals:
 - 1. Complete installation, operations, calibration, and testing manuals as described in Section 17050.
- E. Record documents:
 - 1. Electrical connection diagrams revised to reflect any changes made in the field and submitted as record Drawings.

1.06 QUALITY ASSURANCE

- A. As specified in Section 17050.
- B. Examine the complete set of Contract Documents and verify that the HMI equipment is compatible with the installed conditions.

- C. Notify the ENGINEER if any installation condition does not meet the manufacturer's recommendations or specifications.
- D. Provide HMI hardware manufactured at facilities certified to the quality standards of ISO Standard 9001 - Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation, and Servicing.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050.

1.08 PROJECT OR SITE CONDITIONS

- A. Project environmental conditions as specified in Section 17050.
 - 1. Provide HMI equipment suitable for the installed site conditions including, but not limited to, site altitude, site seismic conditions, humidity, and ambient temperatures.

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 17050.

1.12 SYSTEM STARTUP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. One of the following or equal:
 - 1. Allen-Bradley: PanelView Plus 6.
 - 2. Telemecanique: Magelis.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

- A. Human machine interface:
 - 1. General:
 - a. Provide human machine interfaces located on the face of the PCM as indicated on the Drawings.

- b. NEMA 4X rated.
 - c. Human machine interface consists of graphical display screen with operator input capabilities.
 - d. Capable of stand-alone operation in conjunction with 1 PLC.
 - e. Equipped with data network communication capabilities.
- 2. Display:
 - a. Type: TFT LCD screen.
 - b. Resolution: 1024 by 768 pixels.
 - c. Size: 15-inches.
 - d. Easy display viewing at any angle in various ambient light conditions.
 - e. Operator input: Configurable touch screen.
 - f. Screen update speed: The screen update speed and screen change speed less than 1 second.
- 3. Graphic configuration:
 - a. Easily configured graphics by:
 - 1) Portable laptop computer both locally and via the PLC data network.
 - 2) SCADA Engineer's console via the PLC data network.
 - b. As specified in Section 17765.
- 4. Memory:
 - a. Application: 32 Mb Flash EPROM.
- 5. CPU: Minimum 100 MHz.
- 6. Communications:
 - a. RS232.
 - b. Ethernet.
- 7. Environment:
 - a. Temperature: 0 to 50 degrees Celsius.
 - b. Relative humidity: 10 to 90 percent.
- 8. Electrical:
 - a. Power supply:
 - 1) 24 VDC.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES

- A. Human machine interface programming software:
 - 1. As specified in Section 17765.
- B. Uninterruptible power supply (UPS):
 - 1. As specified in Section 17712.
 - 2. Power the HMI from the UPS at the associated PCM.

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. As specified in Section 17050.

PART 3 EXECUTION

3.01 EXAMINATION

- A. As specified in Section 17050.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050.
- B. All components of the control system including all data network cables are the installation responsibility of the ICSC unless specifically noted otherwise.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

- A. As specified in Section 17050.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING

- A. As specified in Section 17050.

3.10 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050.

3.11 PROTECTION

- A. As specified in Section 17050.

3.12 SCHEDULES (NOT USED)

END OF SECTION

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SECTION 17761

CONTROL SYSTEMS - PLC PROGRAMMING SOFTWARE

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Development software to be used with the specified PLC hardware.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - c. Section 17720 - Control Systems - Programmable Logic Controllers Hardware.

1.02 REFERENCES

- A. As specified in Section 17050.

1.03 DEFINITIONS

- A. As specified in Section 17050.
- B. Specific definitions:
 - 1. Development operating software: The software provided by the PLC manufacturer for use in programming the PLC.
 - 2. Application software: The software that is programmed specifically for the Project.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 17050.
- B. Product data:
 - 1. Programming languages.
 - 2. Operating system requirements.

- C. Control logic:
 - 1. Fully annotated copy of programmed PLC logic.
 - 2. Cross-referenced index of all PLC registers or points.
- D. Provide application software for the specific Project process requirements.
 - 1. Fully annotated copy of programmed PLC logic in its native format.
 - 2. Cross-referenced index of all PLC registers or points.

1.06 QUALITY ASSURANCE

- A. As specified in Section 17050.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 17050.

1.12 SYSTEM STARTUP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

- A. As specified in Section 17050.
- B. Provide system upgrades and maintenance fixes for a period of 3 years from Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. The PLC programming software system shall be manufactured by PLC hardware manufacturer.
- B. One of the following or equal:
 - 1. Rockwell Software RSLogix 5000.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

- A. PLC programming software:
 - 1. Furnish operating software capable of monitoring and/or control of the PLCs via the PLC data network:
 - a. Contain diagnostics to collect troubleshooting and performance data and display it in easy to understand graphs and tables.
 - b. Monitor devices at each drop on the PLC data network for proper communications.
 - c. Provide the ability to program all PLCs on the PLC data network from the engineer's console.
 - 2. Operating system:
 - a. Microsoft Windows XP.
 - 3. The PLC programming software shall be suitable for the PLCs specified under Section 17720.
 - 4. PLC programming software for all programming, monitoring, searching, and editing:
 - a. Usable both on-line, while connected to the PLC, and off-line.
 - b. The operating software shall display multiple series and parallel contacts, coils, timers, counters, and mathematical function blocks.
 - c. Capable of disabling/forcing all inputs, outputs, and coils to simulate the elements of the ladder logic, forced elements shall be identifiable by means of color change.
 - d. Include a search capability to locate any address or element and its program location.
 - e. Display at the EC, PLC status information, such as faults and communication errors and amount of memory remaining.
 - 5. The PLC programming software shall support the following programming languages:
 - a. Ladder Diagram.
 - 6. Generate a PLC program printout, which is fully documented, through the PLC programming software:
 - a. Fully documented program listings include, as a minimum, appropriate rungs, address, and coils shown with comments to clarify to a reader what that segment of the program accomplishes on an individual line by line basis.
 - b. Include a sufficient embedded comment for every rung of the program explaining the control function accomplished in said rung.
 - c. Use a mnemonic associated with each contact, coil, etc, that describes its function.
 - d. Utilize the tag and loop identification as contained in the P&IDs:
 - 1) If additional internal coils, timers, etc. are used for a loop they shall contain the loop number.
 - e. Provide a cross-reference report of program addresses.
 - 7. Software functions automatically without operator intervention, except as required to establish file names and similar information:
 - a. Furnish the operating system software that is the standard uncorrupted product of the PLC manufacturer with the following minimum functions:
 - 1) Respond to demands from a program request.
 - 2) Dynamic allocation of the resources available in the PLC. These resources include main memory usage, computation time, peripheral usage, and I/O channel usage.

- 3) Allotment of system resources based on task priority levels such that a logical allocation of resources and suitable response times are assured.
- 4) Queuing of requests in order of priority if one or more requested resources are unavailable.
- 5) Resolution of contending requests for the same resource in accordance with priority.
- 6) Service requests for execution of one program by another.
- 7) Transfer data between programs as requested.
- 8) Management of all information transfers to and from peripheral devices.
- 9) Control and recovery from all program fault conditions.
- 10) Diagnose and report real-time hardware device errors.
8. Program execution:
 - a. Application software - program execution scheduled on a priority basis:
 - 1) A multilevel priority interrupt structure is required.
 - 2) Enter into a list of pending programs a program interrupted by a higher priority program:
 - a) Resume its execution once it becomes the currently highest priority program.
 - 3) Schedule periodic programs.
 - 4) Base the allocation of resources to a time-scheduled program on its relative priority and the availability of resources.
9. Start-up and restart:
 - a. Provide software that initializes and brings a PLC or any microprocessor based hardware unit from an inactive condition to a state of operational readiness.
 - b. Initialization:
 - 1) Determination of system status before start-up of initializing operating system software and initializing application software.
 - 2) Loading of all memory resident software, initializing timers, counters, and queues, and initialization of all dynamic database values.
10. Shutdown:
 - a. Where possible provide orderly shutdown capability for shutdowns resulting from equipment failure, including other PLC processor failures, primary power failure, or a manually entered shutdown command.
 - b. Upon loss of primary power, a high-priority hardware interrupt initiates software for an immediate, orderly shutdown.
 - c. Hardware is quickly and automatically commanded to a secure state in response to shutdown command or malfunction.
 - d. Alarm PLC failure at the operator interface level.
11. Diagnostics:
 - a. Furnish diagnostic programs with the PLC software package to detect and isolate hardware problems and assist maintenance personnel in discovering the causes for system failures.
 - b. Use the manufacturer's standard diagnostic routines as much as possible.
 - c. Furnish diagnostic software and test programs for each significant component in the control system.
 - d. As a minimum, provide diagnostic routines to test for power supply, central processing unit, memory, communications, and I/O bus failures.

12. Calendar/time program:
 - a. The calendar/time program to update the second, minute, hour, day, month, and year and transfer accurate time and date information to all system level and application software.
 - b. Variations in the number of days in each month and in leap years must be handled automatically by the program.
 - c. The operator must be able to set or correct the time and date from any operator interface, only at the highest security level.
13. Algorithms:
 - a. Implementation of algorithms for the determinations of control actions and special calculations involving analog and discrete data.
 - b. Algorithms must be capable of outputting positional or incremental control outputs or providing the product of calculations.
 - c. Algorithms must include alarm checks where appropriate.
 - d. Provide, as a minimum, the following types of algorithms:
 - 1) Performs functions such as summing several variables, raising to a power, roots, dividing, multiplying, and subtracting.
 - 2) A switch algorithm, which reads the current, value from its input address and stores it as the value of its output address. 2 types of switches shall be accommodated, 2 outputs with 1 input and 1 output with 2 inputs.
 - 3) A 3-mode proportional - integral - derivative, PID, controller algorithm, with each of the 3 modes independently adjustable, supporting both direct and reverse acting modes.
 - 4) Lead, lag, dead time, and ratio compensators.
 - 5) Integration and totalization of analog process variables.
14. Furnish a comprehensive database for the analog inputs, calculated values, control modules, and outputs:
 - a. In addition, provide spare database points for future expansion.
15. One integrated database can be utilized for all types of analog points or separate databases for each type, in either case the database for each point must include all specified aspects.
16. All portions of the database must be available for use by the display, report, and other specified software modules.
17. All of the data fields and functions specified below must be part of the point definition database at the operator interface. Provide the capability to define new database points through the point display specified below as well as modifying defined points through these displays. This point definition and modification must include all of the features and functions defined below. The analog database software must support the following functions and attributes:
 - a. Analog input signal types:
 - 1) Provide software at the RTUs and PLCs to read variable voltage/current signals and pulse duration/frequency type analog input signals.
 - b. Input accuracy:
 - 1) Inputs must be read with an accuracy of ± 0.05 percent full scale or better.
 - 2) Data conversion errors must be less than 0.05 percent full scale.
 - 3) Pulse accumulation error less than or equal to 1 count of actual input count at a scan rate of once a minute.
 - 4) Maintain for a minimum of 1 year the system accuracy stated above without adjustments.

- c. Blocking:
 - 1) Provide mechanisms to inhibit or block the scanning and/or processing of any analog input through the operator interface.
 - 2) For any input so blocked, the operator may manually enter a value to be used as the input value.
- d. Filtering:
 - 1) For each analog input provide a first order lag digital filter with an adjustable filter factor.
- e. Linearizing:
 - 1) Where analog inputs require square root extraction or other linearization, provide a mechanism to condition the filtered data before the process of scaling and zero suppression takes place.
- f. Calculated values:
 - 1) Provide means to allow for pseudo-inputs calculated by algebraic and/or Boolean expressions utilizing real inputs, other calculated value, constants, etc.
 - 2) These values must be handled the same as real inputs in terms of record keeping, alarming, etc.
- g. Scaling and zero suppression:
 - 1) Provide a conversion program to convert input values into engineering units in a floating-point format.
- h. Alarms:
 - 1) Provide an alarm program to check all analog variables against high-high, high, low, and low-low alarm limits.
 - 2) When an analog value exceeds a set limit, it must be reported as an alarm based on individually set priority level for each alarm point.
 - 3) Provide an adjustable hysteresis band in order to prevent excessive alarms when a variable is hovering around an alarm limit.
 - 4) Report return to normal shall also be reported.
 - 5) Must be possible to inhibit alarms based on external events, i.e., lock-out low pump flow alarm when the pump is off.
- i. Averages:
 - 1) Provide a program to calculate and store hourly, daily, and monthly averages of analog variables.
 - 2) Continuously compute averages, i.e., the average for the current period to the present point in time must be stored in memory and available for use in displays, etc.
 - 3) Update hourly averages each minute or at the polling interval for the selected variable.
 - 4) Update daily averages at least once each hour and calculate using the results of the hourly averages.
 - 5) Update monthly averages at least once each day and calculate using the results of the daily averages.
 - 6) At the end of each averaging period, store the average values for the period on the hard disk for historical record keeping and reset the present period average register to the present value of the variable.
 - 7) The active database must include the present period average and previous period average for each variable and averaging period.
- j. Totals:
 - 1) Provide a program to calculate and store hourly, daily, and monthly totalization of analog variables.

- 2) Assign a scaling factor to each variable to convert to the appropriate units based on a 1-minute totalizing interval.
- 3) Assign a separate factor for each totalizing interval.
- 4) Variables for which totalization is inappropriate must have scaling factors of zero.
- 5) At the end of each totalizing period, store the totalized values for the period on the hard disk for historical record keeping and reset the present period totalization register to zero.
- 6) The active database must include the present period total and previous period total for each variable and totalizing period.
- k. Engineering units:
 - 1) Provide software to allow the system and the operator to convert all the measured analog variables to any desired engineering units.
 - 2) The operator must be able to view displays and generate reports of any measured variable in one or more engineering units such as flow in gpm, mgd, cfs, and acre-feet per day.
 - 3) Pre-program the conversion of the engineering units, and if not pre-programmed, the operator must be able to program new engineering unit conversions by using simple methods, i.e., multiplication of the database attributes by a constant.
 - 4) The programming method must be at a level and compatible with the specified training of the operator and the OWNER's personnel.
 - 5) New conversions must not require the services of a special programmer and/or special, high-level, programming training.
- l. Control modules:
 - 1) For each control function configured, whether processed at the RTU, PLC, or operator interface, maintain a file of necessary data including input values, setpoints, constants, intermediate calculated values, output value and limit clamps, etc.
 - 2) Input and output assignments, setpoints, and constants must be adjustable by the operator through the operator interface.
 - 3) Provide control algorithms for manual control with output values adjustable by the operator.
- m. Analog outputs:
 - 1) Analog outputs must be maintained as part of the database.
 - 2) These outputs must be adjustable manually by the operator through the operator interface or through automatic control algorithms.
18. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.

B. General control functions:

1. Analog control functions:
 - a. PID, lead/lag, signal select, alarm, limit, delay, and time base.
 - b. Furnish the control system complete with a library of mathematical/calculation software to support averaging, weighted average, addition, subtraction, multiplication, division, square root extraction, exponential, AND, OR, NAND, NOR, XOR and NXOR functions.
 - c. All math utilities must be linkable to process data points or manual inputs via control block configuration.

- d. By linking control blocks to data points, the math library must support system unit conversion and calculation requirements.
 - 2. Discrete control functions:
 - a. AND, OR, NOT, EXCLUSIVE OR, comparators, delays and time base.
 - 3. Software support:
 - a. Retain in firmware all control and logic functions at each RTU and PLC and in RAM at the operator interface.
 - b. Call each function as required by the configured controls to perform the intended function.
 - 4. Control and status discrepancies:
 - a. Generate a discrepancy/fail alarm for any pump, valve, or final control element if a discrepancy exists between a system or operator command and the device status.
 - b. For example, the system commands to start (call), and the pump fails to start (run status report back), within predetermined operator programmable time delay (time disagree), and then a discrepancy (fail) alarm shall be generated.
 - c. Involuntary change in the device's status must also generate an alarm:
 - 1) For example, a pump starts when not commanded to do so, or a pump shuts down while running even though it still has a command to run.
 - d. Each command, status, and alarm must cause the color of the symbol to change.
 - e. Because many discrete final control elements have a cycle time in excess of the scan interval, provide each control output with an associated delay period selected to be longer than the operating period of the control element:
 - 1) Delay periods for each final control element must be adjustable at the operator interface.
 - 2) List all time delays in the final documentation.
 - 5. Some of the above functions may be better accomplished in the data acquisition and graphic display software package; it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.
- C. Control configuration:
- 1. Provide software to allow control strategies to be developed and their operation initiated through the operator interface.
 - 2. Provide standardized control point displays for defining the control functions including the function type, input/output addresses, setpoints and tuning constants, etc.
 - 3. Provide a mechanism to link separate control functions together into an integrated control strategy.
 - 4. Provide a mechanism to download operational/control setpoints developed at any operator interface to any PLC or RTU for operational implementation.
 - 5. Provide a mechanism to define and implement operational/control setpoints locally at the PLC or RTU and to upload them to the operator interface for operational record keeping.
 - 6. Perform control configurations on-line at the operator interface, the PLC or RTU may be taken off-line when being configured or downloaded.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. As specified in Section 17050.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050.
- B. General:
 - 1. The control system logic program shall reside at the PLC level.
- C. Use the tag and loop identifications found on the P&IDs for all tags used and/or assigned as part of the application software work provided by the ICSC.
- D. Program the PLC logic using Ladder Diagram programming language.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION

- A. Provide a minimum of 4 CD/DVD copies of the following:
 - 1. Application software:
 - a. Finalized fully annotated copy of programmed PLC logic in its native format.
 - b. Cross-referenced index of all PLC registers or points.

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050.
- B. Training:
 - 1. Performed by pre-approved and qualified representatives of the ICSC and/or manufacturer of the local operator interface software. A representative of the ICSC may perform the training only if the representative has completed the manufacturer's training course for the PLC programming software.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17765

CONTROL SYSTEMS - HUMAN MACHINE INTERFACE SOFTWARE

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Application software to be used in conjunction with the specified human machine interface (HMI) hardware.
- B. Related sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
 - 3. The following sections are related to the Work described in this Section. This list of related sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 17050 - Common Work Results for Process Control and Instrumentation Systems.
 - c. Section 17100 - Control Strategies.
- C. General requirements:
 - 1. Software provided under this Contract represent a complete and operating control software system. Achieve the functionality specified in this and other sections through a combination of standard control system software and application software developed specifically for this Project.
 - 2. The standard control software listed in this Section does not represent a comprehensive list of software necessary to implement the functional requirements specified in the Contract Documents. Provide all necessary supplemental drivers, utility software and application software, as required, to meet the functional requirements specified in the Contract Documents.
 - 3. Applications software requirements are specified in Section 17100.
 - 4. License all software for proper operation as specified in the Contract Documents.
 - 5. License all software provided under this Contract to the OWNER.

1.02 REFERENCES

- A. As specified in Section 17050.

1.03 DEFINITIONS

- A. As specified in Section 17050.

1.04 SYSTEM DESCRIPTION

- A. Provide all HMI hardware as specified in the Contract Documents.

1.05 SUBMITTALS

- A. Furnish submittals as specified in Sections 01330 and 17050.
- B. Product data:
 - 1. Complete manufacturer's brochures that identify HMI software and options. Mark up to clearly show options and components to be provided, and cross out any options or components that will not be provided.
 - 2. Manufacturer's installation instructions.
- C. Graphic screens:
 - 1. Color printouts of each graphic screen and control pop-ups.
- D. Operation and maintenance manuals:
 - 1. Complete installation, operation, and testing manuals.
 - 2. Complete color printouts of each graphic screen and control pop-ups.

1.06 QUALITY ASSURANCE

- A. As specified in Section 17050.
- B. System compatibility:
 - 1. The software must be the standard operating software system designed specifically for use with the HMI hardware.
 - 2. The software must be furnished and developed by the manufacturer of the HMI hardware.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. As specified in Section 17050.

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING (NOT USED)

1.11 WARRANTY

- A. As specified in Section 17050.

1.12 SYSTEM STARTUP (NOT USED)

1.13 OWNER'S INSTRUCTIONS (NOT USED)

1.14 COMMISSIONING (NOT USED)

1.15 MAINTENANCE

- A. As specified in Section 17050.
- B. Provide system upgrades and maintenance fixes for a period of 3 years from substantial completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Provide the HMI graphic software system manufactured by the HMI hardware manufacturer.
- B. One of the following or equal:
 - 1. Rockwell Software FactoryTalk View Machine Edition.
 - 2. Modicon Vijeo Designer.

2.02 EXISTING PRODUCTS (NOT USED)

2.03 MATERIALS (NOT USED)

2.04 MANUFACTURED UNITS

- A. Human machine interface software:
 - 1. Provide a complete software package to be used for programming the necessary screens and operator interaction with the HMIs.
 - 2. Operating system:
 - a. Microsoft Windows XP.
 - 3. Furnish software with preconfigured symbols, objects, graphics, and imported bitmaps for the generation of the displays.
 - 4. Software must allow bitmaps to be imported or exported to or from other applications.
 - 5. Capable of generating custom reports, complete with screen prints.
 - 6. Capable of working with multiple screens concurrently.
 - 7. Provide dialog boxes for defining object attributes.
 - 8. Configure objects using fill in dialog boxes.
 - 9. Furnish graphic and text editor that allows custom formatting in order to customize and change the appearance of objects and text:
 - a. Allow selection of different fill patterns to define object status.
 - 10. As a minimum, provide the following object capabilities:
 - a. Operator inputs:
 - 1) Momentary pushbutton.
 - 2) Maintained pushbutton.
 - 3) Latched pushbutton.
 - 4) Multistate pushbutton.
 - 5) Keypad enable button.
 - 6) Cursor point.
 - b. Control list selectors:
 - 1) Standard control list.
 - 2) Piloted control list.
 - c. Global objects.

- d. Display objects:
 - 1) Bar graph.
 - 2) Scale.
 - 3) Message display.
 - 4) Multistate indicator.
 - 5) List indicator.
 - 6) Numeric data display.
- e. Screen selector objects:
 - 1) Go to.
 - 2) Return.
 - 3) Screen list selector.
- f. Embedded variables:
 - 1) Time.
 - 2) Date.
 - 3) Numeric variable.
- g. Graphics:
 - 1) Lines.
 - 2) Shapes.
 - 3) Freeform drawings.
 - 4) Imported graphics.
 - 5) Background text.
 - 6) Selection table for standard ISA symbols.
 - 7) PID controller faceplate.
- h. Alarm screens.
- 11. Documentation:
 - a. Provide complete user documentation, including examples of how to operate the various modules within the system.
 - b. Provide the documentation in electronic format, HTML based with the ability to search for topics by keyword or search or specific text.
- 12. On-line Help:
 - a. Provide an on-line "help" facility, based upon Windows standard Hypertext:
 - 1) Useful, context-sensitive information on the operation of the package:
 - a) That can be invoked on-line through a point-and-click operation.
 - b) The "help" facility must also support the ability to perform full text word search, add custom comments, bookmark topics, copy and pasting into another application, printing, and use of system fonts and colors.

2.05 EQUIPMENT (NOT USED)

2.06 COMPONENTS (NOT USED)

2.07 ACCESSORIES (NOT USED)

2.08 MIXES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

- A. As specified in Section 17050.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. As specified in Section 17050.
- B. All tags used and/or assigned as part of the application programming work are to use the tag and loop identifications found on the P&IDs.
- C. Station graphics:
 - 1. Configure the graphic display for each device both in the treatment plant, and/or process area, including but not limited to:
 - a. Symbols for:
 - 1) Pumps.
 - 2) Valves.
 - 3) Major instruments.
 - 4) Flowmeters.
 - 5) Pressure transmitter.
 - b. Alarm symbols including intrusion alarm.
 - c. Relevant test and operational data.
 - d. Status for each controller or controlled device:
 - 1) Hand.
 - 2) Off.
 - 3) Automatic.
 - 4) Local.
 - 5) Remote.
 - 6) Run.
 - 7) Call.
 - 8) Fail.
 - 9) Open.
 - 10) Close.
 - 11) Hold.
 - 12) Modulate.
 - e. Depict a change of state of pumps and valves by a change in color.
 - 2. Production and usage bar graph:
 - a. Depict the production for each site and/or piece of equipment, as determined during the requisite graphics meeting, within the treatment plant, summarized to type, and total usage, with a bar graph and numeric value for each analog value.
 - 3. System level summary:
 - a. Show the level for the plant influent and effluent production, etc, via a display using bar graphs and numbers, as determined during the requisite graphics meeting.

4. Furnish a minimum of 30 screens, to be directed by the ENGINEER and OWNER, during construction for each HMI.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL (NOT USED)

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

- A. As specified in Section 17050.
- B. Perform the training using pre-approved and qualified representatives of the ICSC and or manufacturer of the HMI software:
 1. A representative of the ICSC may perform the training only if the representative has completed the manufacturer's training course for the HMI software.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES (NOT USED)

END OF SECTION

SECTION 17950

TESTING, CALIBRATION, AND COMMISSIONING

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Testing requirements that apply to all process control and instrumentation systems for the entire project.
- B. Related Sections:
 - 1. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.
 - 2. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.
 - 3. The following Sections are related to the Work described in this Section. This list of Related Sections is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the CONTRACTOR to see that the completed Work complies accurately with the Contract Documents.
 - a. Section 01330 - Submittal Procedures.
 - b. Section 01756 - Testing, Training, and Facility Start-Up.
 - c. Section 17050 - Process Control and Instrumentation Systems General Requirements.
 - d. Section 17100 - Control Strategies.

1.02 REFERENCES

- A. Refer to Section 17050.

1.03 DEFINITIONS

- A. Refer to Section 17050.
- B. Specific Definitions:
 - 1. PTO: Profibus Trade Organization.

1.04 SYSTEM DESCRIPTION (NOT USED)

1.05 SUBMITTALS

- A. Furnish submittals in accordance with Section 01330.
- B. General:
 - 1. Reference additional detailed test submittal scheduling and prerequisite requirements in Section 17050, Article 1.09.
 - 2. For each test described in Parts 2 and 3, herein, and described in other sections of Division 17, prepare and submit complete Test Plans, Test

Procedures, Test Forms, Test Binders, and Test Reports, and other submittals, as specified below.

3. Submit Manufacturer's Certifications and Manufacturer's Field Reports where required.
 4. Submit Test Plans, Procedures, Forms, and Binders for approval by the ENGINEER before scheduling or performing tests.
 5. Develop the PCIS system test submittals in consultation and cooperation with all applicable subcontractors.
 6. Additional Test Form and Test Procedure requirements are specified with individual test requirements.
- C. Overall Test Plan:
1. Develop and submit an overall testing plan for the PCIS. The Overall Test Plan to be reviewed and approved by the ENGINEER before detailed test plans, procedures, and forms will be reviewed.
 2. Describe the test phases, as they apply specifically to this project and each process system.
 3. Provide a preliminary testing schedule to show the sequence of tests and commissioning as they apply to each process system and each PLC.
 4. Provide a description of factory tests. Describe what equipment will be included, what testing equipment will be used, and the simulator that will be used.
 5. Provide examples of proposed forms and checklists.
- D. Test Procedures:
1. Develop and submit detailed test procedures to show that the integrated SCADA system hardware and software is fully operational and in compliance with the requirements of the Contract Documents.
 2. Provide a statement of test objectives for each test.
 3. Prepare specific procedures for each process system.
 4. Describe sequentially the steps to be followed in verifying the correct operation of each process system, including all features described in the loop descriptions, control strategies, and shown in the P&IDs. Implied or generic test procedures are not acceptable.
 5. Specify who will perform the tests, specifically what testing equipment will be used (including serial numbers and NIST-traceable calibration), how the testing equipment will be used.
 6. Describe the expected role of the ENGINEER, as well as any requirements for assistance from OWNER's staff.
 7. Provide the forms and checklists to be used.
- E. Test Forms:
1. Provide test and calibration forms and checklists for each of the following:
 - a. Calibration.
 - b. Factory Acceptance Tests.
 - c. Loop Validation Tests.
 - d. Pre-commissioning Test.
 - e. Performance Test.
 2. Test forms shall include the detailed test procedures, or shall include clear references to separate pages containing the complete test procedure applicable to each form. If references to procedures are used, the complete procedure shall be included with each test binder.

3. Every page of each test form shall include project name, date, time, name of person conducting the test, signature of person conducting the test, and for witnessed tests, place for signature of person (ENGINEER and OWNER) witnessing the test.
4. Some sample test forms are included at the end of this Section. These test forms show the minimum required test form content. They are not complete, and have not been customized for this project. The CONTRACTOR is to develop and submit test forms customized for the project and meeting all of the specified test and submittal requirements.

F. Testing Binders:

1. Sub-system to be tested, provide and submit a Test Binder containing all test procedures and individual test forms for the test. References to other documents for test procedures and requirements are not acceptable.
2. Fill out in advance headings and all other information known before the test.
3. Include applicable test plan information, as well as a list of all test prerequisites, test personnel, and equipment.
4. Include or list reference material and provide separately at the time of the test.
5. Record test results and verify that all test requirements and conditions have been met.

G. Factory Acceptance Test Procedure additional minimal requirements:

1. Prepare and submit a factory acceptance test procedure which includes:
 - a. Control system testing block diagram.
 - b. Estimated test duration.
 - c. Details on the simulator construction, components, and operation.

H. Test Reports:

1. At the conclusion of each test, submit a complete Test Report, including all test results and certifications.
2. Include all completed test binders, forms, and checklists.
3. Submission, review, and acceptance of each Test Report is generally required before the start of the sub-system.

1.06 QUALITY ASSURANCE

A. Test Personnel:

1. Furnish qualified technical personnel to perform all calibration, testing, and verification. The test personnel are required to be familiar with this project and the equipment, software, and systems before being assigned to the test program.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS (NOT USED)

1.09 SEQUENCING (NOT USED)

1.10 SCHEDULING

- A. Refer to Section 17050.

1.11 WARRANTY (NOT USED)

- 1.12 SYSTEM STARTUP (NOT USED)**
- 1.13 OWNERS INSTRUCTIONS (NOT USED)**
- 1.14 COMMISSIONING (NOT USED)**
- 1.15 MAINTENANCE (NOT USED)**

PART 2 PRODUCTS

- 2.01 MANUFACTURERS (NOT USED)**
- 2.02 EXISTING PRODUCTS (NOT USED)**
- 2.03 MATERIALS (NOT USED)**
- 2.04 MANUFACTURED UNITS (NOT USED)**
- 2.05 EQUIPMENT (NOT USED)**
- 2.06 COMPONENTS (NOT USED)**
- 2.07 ACCESSORIES (NOT USED)**
- 2.08 MIXES (NOT USED)**
- 2.09 FABRICATION (NOT USED)**
- 2.10 FINISHES (NOT USED)**
- 2.11 SOURCE QUALITY CONTROL**

A. Factory Acceptance Test - General:

1. Before shipment to the project site, the complete PCIS system including all operator stations, servers, network equipment, printers, PCMs, PLCs, RTUs, LCPs, CCS, peripherals, communications equipment, and other SCADA equipment, shall be assembled, connected, and all software loaded for a full functional Factory Acceptance Test (FAT) of the integrated system.
2. Perform tests to show that the integrated system hardware and software is fully operational and in compliance with the requirements of the Contract Documents.
3. Additional factory tests are specified in other sections of Division 17.
4. The CONTRACTOR's test personnel shall be responsible for performing tests and recording results.
5. The Factory Acceptance Test (FAT) will be witnessed by the ENGINEER and/or other representatives of the OWNER.
6. Right of Observation: The OWNER retains the right to observe all factory test activities including any and all subsystem preparation, pretests, troubleshooting, retests, warm-up, and software modification and/or update.
7. The OWNER reserves the right to test any specified function, whether or not explicitly stated in the test submittal.

8. Costs for Repeating Testing: The CONTRACTOR shall pay for ENGINEER's and other OWNER's representatives' travel, subsistence, **[and labor costs]** for witnessing the repetition of failed tests.
9. Correction of Deficiencies: Any deficiencies observed during the test shall be corrected and retested before completion of the test.
10. Any changes and/or corrections shall be noted on the test forms. ENGINEER shall witness the revisions and/or corrections prior to leaving the test site.
11. If the corrections and/or revisions are too extensive to be made while the ENGINEER is scheduled to be at the FAT test site, the FAT shall be, at the ENGINEER's sole discretion, considered failed, and the test shall be restarted at a later date. All costs for the re-test shall be borne by the CONTRACTOR.

B. Testing Simulation:

1. The FAT shall make use of hardware simulators that contain switches, pilot lights, variable analog signal generators, and analog signal level displays, which shall be connected to the I/O points within the SCADA System. All inputs and outputs shall be simulated and proper control and system operation shall be validated. Each switch, pilot light, display, etc. shall be labeled in accordance with the P&IDs so that a timely and thorough test of the complete system can be conducted.
2. The use of jumper wires, terminal block mounted pilot lights, and loose meters to act as or supply the functionality of a simulator shall not be allowed.
3. The hardware simulator may consist of a PLC, operating under a SCADA software package, or other approved software that has its I/O points wired to PLCs I/O points. Software operating on a PC may then act as the switches, pilot lights, variable analog signal generators, and analog signal level displays.

C. Preliminary Factory Acceptance Test:

1. A complete Preliminary Factory Acceptance Test (Pre-FAT) shall be conducted utilizing test procedures approved by the ENGINEER. The Pre-FAT test procedure shall be a subset of the full FAT.
2. The purpose of the Pre-FAT is to provide assurance to the ENGINEER that the SCADA System is ready for the full, witnessed Factory Acceptance Test, in terms of both stability and functionality. Debugging of software and troubleshooting of hardware shall occur during, and before, the Pre-FAT, not during the FAT. The CONTRACTOR shall fully test the SCADA System and fix all deficiencies found before the full FAT.
3. The OWNER shall have the right to witness any or all of the Pre-FAT testing and shall be notified in writing, 20 days before the start of the Pre-FAT.
4. The Pre-FAT test results submittal shall include a letter, signed by the CONTRACTOR's project manager or company officer, certifying that the system is complete, has been tested successfully, and is fully ready for the full, witnessed FAT. The submittal shall include completed Pre-FAT test forms, signed by the CONTRACTOR's staff, and shall be submitted for review before the start of the FAT.

D. Panel Inspections:

1. The ENGINEER will inspect each control panel for completeness, workmanship, fit and finish, and compliance with the Contract Documents and the approved shop drawings.
2. Provide panel inspection forms as part of the Factory Acceptance Test procedures submittal.

3. Inspection to include, as a minimum: layout, mounting, wire and data cable routing, wire tags, power supply, components and wiring, I/O components layout (including terminals, wiring and relays), device layout on doors and front panels, and proper ventilation operation.
- E. I/O Test:
1. Verify that I/O is properly wired to field terminals and is properly mapped into the PLC and the rest of the SCADA system, including all operator interface devices.
 2. Test Methodology:
 - a. Use the submitted and approved system simulator for this test.
 - b. Discrete inputs: Apply appropriate input at panel terminal, observe input card indicator, observe data value at each indicated data address, observe data received on all operator interface displays (SCADA workstations and local operator interface (LOI) displays).
 - c. Discrete outputs: Issue commands from operator interface screen verify output card indicator light and measure response at field wiring terminals.
 - d. Analog inputs: Apply appropriate analog input signal at panel terminals, observe data value at each indicated data address, and observe data properly received at each operator screen. Check each point at 0 percent, 50 percent, and 100 percent of scale.
 - e. Analog outputs: Enter scaled values in the output buffer file, observe the output data file value, and measure appropriate response at panel wiring terminals.
 3. Test forms to include, but not be limited to:
 - a. PLC and panel number.
 - b. I/O Type.
 - c. I/O tag name.
 - d. Panel terminal block numbers.
 - e. Rack/slot/number of I/O point.
 - f. Check-off for correct response for each I/O point.
 - g. Space for comments.
 - h. Initials of individual performing test.
 - i. Date test was performed.
 - j. Witness' signature lines.
- F. System Configuration Test:
1. Demonstrate and test the setup and configuration of all operator stations, servers, development stations, and peripherals.
 2. Demonstrate all utility software and functions, such as virus protection, backup, optical drive burning, network monitoring, etc.
 3. Demonstrate the proper operation of all peripheral hardware.
 4. Demonstrate all general SCADA functions.
 5. Demonstrate proper operation of log-on and other access security functions.
 6. Demonstrate the proper operation of all historical data storage, trend, display, backup, and report functions.
 7. Test automatic fail over of redundant equipment.
 8. Demonstrate the proper operation of the alarm display and acknowledgement functions.
 9. Test Forms:
 - a. For each test, list the specification page and paragraph of the function demonstrated, and provide a description of the function.

- b. List the specific tests and steps to be conducted.
- c. For each function, list all of the different sub-functions or ways the function can be used, and provide a test check-off for each:
 - 1) Include signature and date lines.

G. Control Logic Test:

- 1. The purpose of this test is to verify that all software functions and logic work as specified, along with any hardwired logic or functions in the tested control panels.
- 2. Testing Requirements:
 - a. Demonstrate each function described in Section 17100. Demonstrate in detail how each function operates under a variety of operating scenarios. Test to verify the application of each General Control Strategy function to each specific Control Strategy or Loop Description.
 - b. Demonstrate the proper operation of the programming and configuration for each Control Strategy or Loop Description. Test each Strategy or Loop Description on a sentence by sentence and function by function basis. Loops with similar or identical logic must each be tested individually.
 - c. Demonstrate the proper operation of all digital communication links and networks. Verify each digital communication I/O point.
 - d. Failure Testing: In addition to demonstrating correct operation of all specified features, special effort shall be made to demonstrate how the system responds to and recovers from abnormal conditions including, but not limited to: equipment failure, operator error, communications subsystem error, communications failures, simulated/forced software lockups, power failure (both utility power and power to SCADA hardware), process equipment failure, and high system loading conditions.
- 3. Test Forms:
 - a. Include the fully revised and approved Loop Description or Control Strategy for the loop being tested.
 - b. Identify the Cause and Effect as each I/O point is toggled through the simulator. Check boxes shall be provided to track proper and/or improper operation of the loop.
 - c. Any deficiencies or operational changes shall be noted on the forms for correction and documentation:
 - 1) Include signature and date lines.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

- A. Refer to Section 17050.
- B. Installation Supervision:
 - 1. Provide in accordance with Section 17050.

3.04 ERECTION, INSTALLATION, APPLICATION, CONSTRUCTION (NOT USED)

3.05 REPAIR/RESTORATION (NOT USED)

3.06 RE-INSTALLATION (NOT USED)

3.07 FIELD QUALITY CONTROL

A. General:

1. The OWNER reserves the right to test any specified function, whether or not explicitly stated in the test submittals.
2. Failure Testing:
 - a. In addition to demonstrating correct operation of all specified features, demonstrate how the system reacts and recovers from abnormal conditions including, but not limited to:
 - 1) Equipment failure.
 - 2) Operator error.
 - 3) Communications sub-system error.
 - 4) Power failure.
 - 5) Process equipment failure.
 - 6) High system loading conditions.
3. Conduct testing Monday through Friday during normal working hours for no more than 8 hours per day. Testing at other times requires approval of the ENGINEER.

B. Manufacturer Services:

1. Provide in accordance with Section 17050.

C. Sequencing:

1. See additional requirements in Section 17050, Article 1.09, Sequencing.

D. Calibration:

1. After installation but before starting other tests, calibrate and adjust all instruments, devices, valves, and system, in conformance with the component Manufacturer's instructions and in accordance with these Specifications.
2. Components having adjustable features are to be set carefully for the specific conditions and applications of this installation. Test and verify that components and/or systems are within the specified limits of accuracy.
3. Replace either individually or within a system, defective elements that cannot achieve proper calibration or accuracy.
4. Calibration Points:
 - a. Calibrate each analog instrument at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span, using test instruments with accuracies traceable to National Institute of Testing Standards.
5. Field verify calibration of instruments that have been factory-calibrated to determine whether any of the calibrations are in need of adjustment.
6. Analyzer Calibration:
 - a. Calibrate and test each analyzer system as a workable system after installation. Follow the testing procedures directed by the Manufacturers' technical representatives.
7. Complete instrument calibration sheets for every field instrument and analyzer.
8. Calibration Tags:
 - a. Attach a calibration and testing tag to each instrument, piece of equipment, or system.

- b. Sign the tag when calibration is complete.

E. LAN Cable Post-testing:

1. After installing the cable and connectors, test all cables using the LAN certification to confirm the installation meets the requirements of the specification.
2. Provide test documentation that includes the cable number, total length of cable, a permanent hard copy, as well as an ASCII-formatted diskette copy of all traces.
3. After installing connectors:
 - a. Perform cable end-to-end testing on all installed cables from both ends of the cable. Test shall include cable system performance tests and confirm the absence of wiring errors.
 - b. Submit a signed test report presenting the results of the cable testing.
 - c. Repair or replace any portions of the system not meeting TIA standards for a Category 5e installation. Repaired sections shall be retested.
4. Submit 3 copies of all final documentation (including traces), using the approved test form, to the ENGINEER upon successful completion of the testing.

F. Industrial Network Testing:

1. Test Procedures:
 - a. Provide qualified personnel and test equipment required to conduct the inspection and test procedures as specified herein.
 - b. The scope of qualification and testing services is based on the network representation as indicated on the Drawings.
 - c. Network Qualification and Testing Activities:
 - 1) Network Installation Qualification, Testing, and Documentation:
 - a) This qualification and testing activity focuses on the physical media and its installation.
 - b) Conduct a physical inspection to establish the network configuration:
 - (1) Validate the node type and quantity.
 - (2) Identify improper installation and damaged components.
 - (3) Validate integrity of cables and connectors via a physical media test to confirm the signal propagation capabilities of the network media.
 - (4) Corrective measures shall be recommended based on the results of the inspections and testing.
 - 2) Network Operations Qualification, Testing, and Documentation:
 - a) This qualification and testing activity takes place after the network is commissioned and is under normal operating conditions.
 - b) The network performance is monitored and measured using non-intrusive test equipment and procedures.
 - c) The test results are analyzed and corrective measures recommended.
 - 3) Report:
 - a) Prepare a report that documents the results of the qualification and testing activities.

- b) Document the installed condition of the network and provide baseline values for future network maintenance and testing activities.
 - c) The report to include, but not limited to, the following:
 - (1) Executive summary for each network.
 - (2) Inspection and test results for each network.
 - (3) Calculated network parameters.
 - (4) Recommendations.
 - (5) Description of test procedures and required test equipment.
- 4) Network Agency Specifications:
 - a) The testing and qualifications services will adhere to the recommended standards and practices of the referenced standards bodies and agencies:
- 5) Manufacturer's Specifications and Guidelines:
 - a) Include all applicable manufacturer's specifications and guidelines.
 - b) Manufacturer's specifications and guidelines may supersede the specifications of the applicable governing body for the associated network.
- 6) Test Sequence and Responsibilities:
 - a) All qualification and testing activities will be conducted by the CONTRACTOR. Figure 1, Network Test Sequence and Responsibilities, defines the general test sequence:
 - (1) Before commencing any network inspection or testing activities, verify that all network segments and nodes are in their final installed condition.
 - (2) The installer to provide all necessary components and labor required to address changes required to bring the network into compliance. The installer shall be available at the time of network inspection and testing to address network deficiencies.
 - (3) Before commencing any network inspection or testing activities, inspect all network components and all deficiencies addressed.
- 7) Test Procedure:
 - a) The following prerequisite conditions must be completed before commencing the qualification and testing activities:
 - (1) Installation Qualification and Testing:
 - (a) All cabling installed, terminated, and labeled.
 - (b) All network node devices installed.
 - (c) All node devices physically disconnected from the network.
 - (2) Manufacturer's data and specifications for all installed network components, available on-site for use by the network testing firm.
 - (3) A complete set of construction drawings and specifications with all addenda and change orders are available on-site for use by the network testing firm.
- 8) Operations Qualification and Testing:
 - a) Network installation qualification and testing successfully completed.

- b) Network is commissioned and is operating under normal conditions.
 - c) Process and process equipment is not dependent on operation of the network:
 - (1) Network operation may be interrupted for inspection and testing.
 - d. Test Equipment: The following test equipment will be utilized in the execution of the described qualification and testing procedures.
 - 1) Network Line Analyzer, ProfiTrace v1.6.
 - 2) Oscilloscope, Fluke Scopemeter Series 190 or equivalent.
 - 3) Digital VOM, Fluke 87 Multimeter or equivalent.
 - 4) Network Bus Monitor, ProfiTrace v1.6.
- 2. Installation Qualification and Test Procedures:
 - a. Visual and Mechanical Inspection:
 - 1) Compare network devices nameplate data with drawings and specifications.
 - 2) Confirm network components are PTO compliant.
 - 3) Verify labeling of all trunk cables.
 - 4) Confirm minimum cable distance between nodes.
 - 5) Verify the presence/absence of stub lines.
 - 6) Verify network terminators are in place.
 - 7) Verify power supply source and connections for active terminations.
 - 8) Verify total network node count.
 - 9) Verify power supply specifications including quantity, ratings, locations, and configuration. Verify power supply source of supply location, conductor size, and rating.
 - 10) Inspect accessible network cabling for adherence to specified installation practices:
 - a) Cable installed in conduit or protective raceway.
 - b) Cable proximity to high voltage wiring.
 - c) Exposure to extreme temperatures, shock, vibration, chemicals, or moisture.
 - d) Bend radius.
 - 11) Inspect cable and conductor terminations for adherence to specified installation practices.
 - 12) Check all accessible components for evidence of physical damage.
 - 13) Check grounding techniques including ground conductor sizes and termination points.
 - 14) Non-permissible cable length.
 - 15) Wrong cable type.
 - 16) Signal reflections.
- 3. Electrical Tests:
 - a. Measure network resistance.
 - b. Measure network cable length.
 - c. Line analysis for the following conditions:
 - 1) Short circuit between signal lines A and B.
 - 2) Short circuit between signal lines A and B and the cable shield.
 - d. Shield continuity.
 - e. Cross-wired signals lines.
 - f. Terminator installed in wrong position.
 - g. Poor transmission or reception levels.
 - h. Non-permissible stub line.

4. Generate slave list.
 5. Measure power supply voltage at active terminations.
 6. Evaluation:
 - a. Confirm the network cable topology (length and configuration) does not exceed data rate limitations.
 - b. Confirm total stub length (if required by design) does not exceed data rate limitations.
 - c. Calculate spare trunk length for the specified data rate.
 7. Operations Qualifications and Test Procedures:
 - a. Electrical Tests:
 - 1) Examine the data traffic between the master and each slave device.
 - 2) Verify baud rate.
 - 3) Confirm signal level.
 - 4) Verify network cycle time.
 - 5) Generate "live" slave list.
 - 6) Verify and record scanner diagnostic data including node status and error codes.
 - 7) Monitor and capture network waveform.
 8. Evaluation:
 - a. Confirm all specified slave devices appear on the live list.
 - b. Evaluate data traffic between master and each slave to confirm proper slave configuration and performance.
 - c. Inspect waveform capture for evidence of excessive noise.
 - d. Evaluate and report any failed or questionable network tests.
 - e. Evaluate and report network error codes and related symptoms.
- G. Loop Check/Validation:
1. Check all control loops under simulated operating conditions by causing a range of input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the graphic displays associated with the SCADA System. Issue commands from the SCADA system and verify proper responses of field devices. Use actual process inputs wherever available.
 2. Provide "End-to-End" tests:
 - a. Test SCADA System inputs from field device to SCADA system operator workstations.
 - b. Test SCADA System outputs from SCADA operator workstations to field devices and equipment.
 - c. Observe and record responses at all intermediate devices.
 - d. Test and record operator commands and signal readouts to each operator device where there is more than one operator interface point.
 - e. For each signal, perform separate tests for SCADA computer screens, local operator interface (LOI) screens, and local control panels.
 3. Retest any loop following any necessary corrections.
 4. Specified accuracy tolerances for each analog network are defined as the square-root of the sum of the squares of individual component accuracy.
 5. Apply simulated sensor inputs corresponding to 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span for networks that incorporate analog elements, and monitor the resulting outputs to verify compliance to accuracy tolerance requirements.
 6. Apply continuously variable up and down analog inputs to verify the proper operation and setting of discrete devices (signal trips, etc.).

7. Apply provisional settings on controllers and alarm set points.
8. Record all analog loop test data on test forms.
9. Exercise each field device requiring an analog command signal, through the SCADA System. Vary, during the validation process, the output from the PLC SCADA System and measure the end device position, speed, etc. to confirm the proper operation of the device for the supplied analog signal. Manually set the output from the SCADA screen at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent and measure the response at the final device and at any intermediate devices.
10. Exercise each field device providing a discrete input to the SCADA System in the field and observe the proper operation shall be observed at the operator workstation:
 - a. Test limit switches, set limits mechanically, and observe proper operation at the operator workstation.
 - b. Exercise starters, relay contacts, switch contacts, and observe proper operation.
 - c. Calibrate and test instruments supplying discrete inputs, and observe proper operation.
11. Test each device accepting a discrete output signal from the SCADA. Perform the appropriate operator action at the SCADA operator stations (including LOIs, if present) and confirm the proper operation of the field device:
 - a. Stroke valves through outputs from the SCADA System, and confirm proper directional operation. Confirm travel limits and any feedback signals to the SCADA System.
 - b. Exercise motors starters from the SCADA System and verify proper operation through direct field observation.
 - c. Exercise solenoids and other field devices from the SCADA System and verify proper operation through direct field observation.
12. Include in the test forms:
 - a. Analog input devices:
 - 1) Calibration range.
 - 2) Calibration data: Input, output, and error at each test value.
 - 3) Analog input associated PLC register address.
 - 4) Value in PLC register at each test point.
 - 5) Value displayed at each operator interface station (local operator interface displays and SCADA workstations).
 - b. Analog output devices:
 - 1) Calibration range.
 - 2) Test value at each test point.
 - 3) Analog output associated PLC register address.
 - 4) Control variable value at field device at each test point.
 - 5) Physical device response at each test point:
 - a) Response to be actual valve position, or motor speed, etc.
 - c. Discrete instrument input devices:
 - 1) Switch setting, contact action, and dead band.
 - 2) Valve position switches:
 - a) Response in the PLC as the valve is stroked from the PLC.
 - b) Field observed actual valve position, and valve indicator position as the valve is stroked from the PLC.
 - 3) Operator interface switches (control stations and other pilot devices) and associated response.
 - 4) Starter and drive auxiliary device contact response.

- 5) Response of all other discrete inputs to the PLC.
 - d. Discrete output devices:
 - 1) Observed response of field device to the discrete output from the PLC.
 - 2) Observe the proper operation of Open, Close, Start, Stop, On, Off, etc.
 - e. Test equipment used and associated serial numbers.
- H. Pre-commissioning (Functional) Test:
- 1. General:
 - a. Commence pre-commissioning tests after completion of all loop check/validation tests:
 - 1) Reference Section 17050, Article 1.09, Sequencing and Scheduling.
 - b. Pre-commissioning to demonstrate proper operation of all systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.
 - c. Pre-commissioning testing to generally occur in conjunction with Functional Testing specified in Section 01756.
 - d. Additional tests are specified in other Division 17 sections.
 - e. Follow approved detailed test procedures and check lists for all pre-commissioning and test activities.
 - 2. Control Logic Operational Validation:
 - a. The purpose of Control Logic Validation is to field test the operation of the complete control system, including all parts of the SCADA System, all control panels (including vendor control panels), all control circuits, all control stations, all monitored/controlled equipment, and final control elements.
 - b. Demonstrate all control functionality shown on the P&IDs, Control Schematics, and other Drawings, and specified in the Loop Descriptions, Control Strategies, Electrical Specifications, and Mechanical Equipment Specifications.
 - c. Test in detail on a function-by-function and sentence-by-sentence basis.
 - d. Thoroughly test all hardware and software functions:
 - 1) Including all hardwired and software control circuit interlocks and alarms.
 - e. Test final control elements, controlled equipment, control panels, and ancillary equipment under start-up, shut down, and steady-state operating conditions to verify all logic and control is achieved.
 - f. Control Logic Validation tests to include, but not limited to: a repeat of all Control Logic Tests from the Factory Acceptance Tests, modified and expanded to include all field instruments, control panels, circuits, and equipment.
 - 3. Loop Tuning:
 - a. Optimally tune all electronic control stations and software control logic incorporating proportional, integral, or derivative control. Apply control signal disturbances at various process variable levels and adjusting the gain, reset, or rate settings as required to achieve proper response.
 - b. Verify the transient stability of final control elements operating over the full range of operating conditions, by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates. As a minimum, achieve

- 1/4 wave amplitude decay ratio damping (subsidence ratio of 4) under the full range of operating conditions.
- c. If excessive oscillations or system instability occur, as determined by the ENGINEER, continue tuning and parameter adjustments, or develop and implement any additional control algorithms needed to achieve satisfactory control loop operation.
4. Pre-commissioning Validation Sheets:
- a. Document each pre-commissioning test on an approved test form.
 - b. Document loop tuning with a report for each loop, including two-pen chart recordings showing the responses to step disturbance at a minimum of 3 setpoints or process rates approved by the ENGINEER. Show tuning parameters on the charts, along with time, date, and sign-off by CONTRACTOR and ENGINEER.
 - c. Include on the form, functions which can be demonstrated on a loop-by-loop basis:
 - 1) Loop number and P&ID number.
 - 2) Loop description or control strategy, or reference to specification tested.
 - 3) Test Procedures: Where applicable, use the FAT function-by-function, sentence-by-sentence Loop Test Checklist forms modified to meet the requirements of the Pre-commissioning test. Otherwise, create new forms.
 - d. For functions that cannot be demonstrated on a loop-by-loop basis (such as overall Plant power failure), include on the test form a listing of the specific steps and tests to be conducted. Include with each test description the following information:
 - 1) Specification page and paragraph of function demonstrated.
 - 2) Description of function and/or text from specification.
 - 3) Test procedures: use the FAT Loop Test Checklist forms modified to meet the specific testing conditions of the Pre-commissioning Test.
5. Pre-commissioning Certification:
- a. Document via a certified report the completion of all pre-commissioning and test activities:
 - 1) Including all test forms with test data entered, submitted to the ENGINEER with a clear and unequivocal statement that all pre-commissioning test requirements have been satisfied.

3.08 ADJUSTING (NOT USED)

3.09 CLEANING (NOT USED)

3.10 DEMONSTRATION AND TRAINING

- A. Performance/Reliability/Operational Tests:
 - 1. After successful completion of the pre-commissioning test as accepted by the ENGINEER and OWNER, the performance test can proceed.
 - 2. Complete training and instruction of the OWNER's personnel in conformance with paragraph 1.09 Sequencing and Scheduling of Section 17050.
- B. The Performance Test may be performed concurrently with the 7-Day Operational Test noted in Section 01756.

C. General:

1. The performance test is part of the Work that must be completed as a condition of substantial completion for the entire project.
2. The complete PLC control and SCADA system must run continuously for the duration of the performance test. During this period, exercise all system functions, and log for cause of failure, any system interruption and accompanying component, subsystem, or program failure:
 - a. Include time of occurrence and duration of each failure.
3. Provide a competently trained technician or programmer on call for the project site during all normal working days and hours from the start of the performance test until final acceptance of the system. Response time to the project site:
 - a. 24 hours or less, for a major failure.
4. The Performance Test duration:
 - a. 7 days.
5. Test and use; the entire process control system under standard operating conditions.

D. System Testing:

1. Exercise each system function, e.g., status report, alarms, logs, and displays several times at a minimum, and in a manner that approximates "normal" system operation.
2. Failure of the system during testing shall be considered as indicating that the programs and operating system do not meet the requirements of the specifications.
 - a. Corrective action is required before restarting the acceptance test.
3. Only those components, sub-systems, and systems covered in this specification and supplied under this contract shall be considered for this acceptance test. Problems and failures of other systems shall not be considered as part of this test, except as they display the capabilities of this system to detect failures.

E. Failures:

1. Classify failures as either major or minor.
 - a. Minor Failure:
 - 1) A small and non-critical component failure or software problem that can be corrected by the OWNER's operators.
 - 2) Log this occurrence but this is not a reason for stopping the test and is not grounds for non-acceptance.
 - 3) Should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance.
 - 4) Failure of one printer, or operator station is considered a minor failure providing all functions can be provided by backup equipment, i.e. alternate printers and operator station, and repairs can be made and equipment returned to service within 3 working days.
 - b. Major Failure:
 - 1) Considered to have occurred when a component, subsystem, software control, or program fault causes a halt in or improper operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system.
 - 2) Cause termination of the performance test.

- 3) Start a new acceptance test when the causes of a major failure have been corrected.
- 4) A failure is also considered major when failure of any control system that results in an overflow, underflow, overdose, or underdose condition occurs.

F. Technician Report:

1. Each time a technician is required to respond to a system malfunction, he or she must complete a report which includes details concerning the nature of the complaint or malfunction and the resulting repair action required and taken.
2. If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report is required or logged as specified above.
3. If a technician has performed work but no report is written, then a major failure is considered to have occurred.
4. Each report shall be submitted within 24 hours to the ENGINEER and the OWNER, or its representative.

3.11 PROTECTION (NOT USED)

3.12 SCHEDULES

A. Example Test Forms:

1. Example test forms are attached at the end of this Section. They may be used as a starting point for the development of project-specific test forms for this project.
2. The example test forms are not intended to be complete or comprehensive. Edit and supplement the forms to meet the requirements for testing and test forms specified in this Section and other Contract Documents.

		INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

A COPY OF LATEST ISSUE OF THE FOLLOWING DOCUMENTS ARE INCLUDED IN THIS INSTRUMENT INSTALLATION CERTIFICATION FILE:

- ☐ INSTRUMENT SPECIFICATION SHEETS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT INSTALLATION DETAILS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT LOOP WIRING DIAGRAMS
- ☐ INSTRUMENT INSTALLATION CERTIFICATION CHECKLIST
- ☐ SIZING CALCULATIONS
- ☐ INSTRUMENT INSTALLATION SCHEDULE (APPLICABLE PART)
- ☐ NAMEPLATE SCHEDULE (APPLICABLE PART)
- ☐ VENDOR LITERATURE CALIBRATION INFORMATION

☐ ☐

INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS? No Yes

REMARKS: _____

CHECKED BY (COMPANY) _____	ACCEPTED BY (COMPANY) _____
SIGNATURE _____	SIGNATURE _____
DATE _____	DATE _____

		SWITCHES INSTALLATION AND CALIBRATION CHECKLIST	

INSTRUMENT LOOP NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, WHEN COMPLETED:

- ☐ BENCH CALIBRATED PER SPEC SHEET
- ☐ VERIFIED PER P&ID NO
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO.
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO.
- ☐ INSTALLATION CORRECT PER DETAIL NO.
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

☐ ☐

INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS?

No Yes

<u>FIELD CALIBRATION CHECK</u>						
CONTACT NO.	FUNCTION	FOR SIGNAL	CONTACT IS TO	AT SPECIFIED VALUE FOR	ACTUAL TRIP POINT WAS...	
1	<input type="checkbox"/> ALARM	<input type="checkbox"/> INCR	<input type="checkbox"/> OPEN	SET PT = _____	SET PT = _____	_____
	<input type="checkbox"/> S/D PERM	<input type="checkbox"/> DECR	<input type="checkbox"/> CLOSE	RESET = _____	RESET = _____	_____
2	<input type="checkbox"/> ALARM	<input type="checkbox"/> INCR	<input type="checkbox"/> OPEN	SET PT = _____	SET PT = _____	_____
	<input type="checkbox"/> S/D PERM	<input type="checkbox"/> DECR	<input type="checkbox"/> CLOSE	RESET = _____	RESET = _____	_____
3	<input type="checkbox"/> ALARM	<input type="checkbox"/> INCR	<input type="checkbox"/> OPEN	SET PT = _____	SET PT = _____	_____
	<input type="checkbox"/> S/D PERM	<input type="checkbox"/> DECR	<input type="checkbox"/> CLOSE	RESET = _____	RESET = _____	_____
4	<input type="checkbox"/> ALARM	<input type="checkbox"/> INCR	<input type="checkbox"/> OPEN	SET PT = _____	SET PT = _____	_____
	<input type="checkbox"/> S/D PERM	<input type="checkbox"/> DECR	<input type="checkbox"/> CLOSE	RESET = _____	RESET = _____	_____

NOTE: PERM IS ABBREVIATED FOR PERMISSIVE

		TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST		

☐ ☐

INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS?

No Yes

INSTRUMENT TYPE INDICATOR ☐ TRANSMITTER ☐ CONTROLLER ☐

☐ OTHER DESCRIPTION

INSTRUMENT TAG NO. SERIAL NO.

SERVICE DESCRIPTION

BENCH CALIBRATION CHECK				
INPUT RANGE =		OUTPUT RANGE =		
HEAD CORRECTION =		<input type="checkbox"/> LINEAR		
CALIBRATED SPAN =		<input type="checkbox"/> SQUARE ROOT		
% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

CHECK BELOW, WHEN COMPLETED:

- ☐ BENCH CALIBRATED PER SPEC SHEET
- ☐ VERIFIED PER P&ID NO.
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO.
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO.
- ☐ INSTALLATION CORRECT PER DETAIL NO.
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

FIELD CALIBRATION CHECK				
INPUT RANGE =			OUTPUT RANGE =	
% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

		TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

- ☐ DIRECT ☐ REVERSE
☐ ACTION VERIFIED AT 50% SPAN
☐ ACTION VERIFIED AT _____ SPAN

CONTROLLER SETTINGS

SETTING	GAIN	PB	RESET (INTEGRAL)	DERIV. (RATE)	HIGH LIMIT	LOW LIMIT	ELEV. ZERO	ZERO SUPP
PRE-TUNE								
POST-TUNE								

PRE-TUNE SETTINGS

	GAIN	PB	RESET (REPEAT/MIN)	RESET (MIN/REPEAT)	DERIVATION (MINUTES)
FLOW:	1.0	100	10	0.1	N/A
LEVEL	1.0	100	MIN.	MAX.	N/A
PRESSURE	2.0	50	2.0	0.5	N/A
TEMP.	4.0	25	0.1	10	OFF

REMARKS _____

CHECKED BY (COMPANY) _____ ACCEPTED BY (COMPANY) _____

SIGNATURE _____ SIGNATURE _____

DATE) _____ DATE _____

		ANALYZERS INSTALLATION AND CALIBRATION CHECKLIST	

☐ ☐

INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS?

NO YES

TYPE OF INSTRUMENT _____

INSTRUMENT TAG NO. _____ SERIAL NO. _____

SERVICE DESCRIPTION _____

CHECK BELOW, IF TRUE:

- ☐ BENCH CALIBRATED PER SPEC SHEET
- ☐ VERIFIED PER P&ID NO. _____
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO. _____
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. _____
- ☐ INSTALLATION CORRECT PER DETAIL NO. _____
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

REMARKS _____

CHECKED BY (COMPANY) _____

ACCEPTED BY (COMPANY) _____

SIGNATURE _____

SIGNATURE _____

DATE _____

DATE _____

END OF SECTION

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