

**SECTION 01030**  
**CONSTRUCTION SEQUENCE**

**PART 1 GENERAL**

1.01 SCOPE OF WORK (NOT USED)

1.02 RELATED WORK (NOT USED)

1.03 SUBMITTALS

- A. Provide the following submittals in accordance with section 01300.
1. Shutdown Requests and Plans

1.04 REFERENCE STANDARDS (NOT USED)

1.05 QUALITY ASSURANCE (NOT USED)

1.06 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS (NOT USED)

1.07 DELIVERY, HANDLING AND STORAGE (NOT USED)

1.08 MAINTENANCE/SPARE PARTS (NOT USED)

1.09 WARRANTY/EXTENDED WARRANTY (NOT USED)

1.10 GENERAL REQUIREMENTS

- A. The South Canadian Wastewater Treatment Plant is a critical component of the City of Oklahoma City's wastewater system. Any disruption to the Plant's ability to treat wastewater will have a drastic effect upon the City's wastewater system. It is imperative that this project remain on schedule.
- B. The Owner's operations necessary to meet these requirements are of higher priority than construction activities. Schedules of connections, renovations and modifications shall be submitted to the Owner for approval, and all such items shall be coordinated throughout the entire construction period. These schedules shall permit full and normal treatment of wastewater including necessary delivery of chemicals.
- C. The Contractor shall not operate any valves, gates, or equipment in the plant or yard piping system unless directed to do so by the Owner, and under the Owner's direct supervision. The Contractor shall schedule all valve or gate operations with the Owner. Existing valves and gates should be expected to not seal completely or properly. Contractor shall provide any temporary containment and dewatering equipment, at no additional cost to the Owner, to perform the work.
- D. Contractor shall maintain access to all plant facilities at all times.
- E. Existing plugged pipelines, in which water or wastewater has been standing, may have to be cleaned of debris prior to connecting to a new pipeline or installing protective coatings and linings.

- F. The Contractor shall submit shop drawings to show details of all temporary services, bypasses, tie-ins to existing systems, temporary chemical fill stations, and temporary roads. Shop drawings shall include size and type of all temporary and/or permanent equipment, piping, valving, controls and associated appurtenances.
- G. The Contractor shall coordinate with electric and gas utility providers to relocate services. Contractor is responsible to schedule and coordinate these activities in a manner to maintain existing plant operations as well as maintain the construction schedule. Engineer has performed preliminary coordination with the utilities and will provide technical assistance only.

#### 1.11 COMPLETE AND PARTIAL PLANT SHUTDOWNS

- A. This work at the South Canadian Wastewater Treatment Plant may be concurrent with other work at the plant. Plant outages that may be required by other Contractors at the Treatment Plant will be coordinated by the Owner and Engineer. In case of conflicts in scheduling work requiring shutdowns or partial outages at multiple facilities, the Owner will determine which treatment process shutdowns will be delayed.
- B. The Contractor shall perform the construction activities to accommodate normal plant operations with only minimal process interruptions necessary for process unit isolation, chemical feed application point piping, process piping, electrical connections, and chemical deliveries.
- C. Influent flow to the facility cannot be completely shut down during any portion of the project. Flow Equalization Basins (FEBs) are available to store flow for short periods if a plant shutdown is needed. If the FEBs are used, the Contractor shall be responsible for all temporary pumping and for cleaning of the basins after use. To use the FEBs, the Contractor must comply with the coordination procedures discussed below.
- D. Peak flow to the plant is 50 MGD. Maximum flows to the treatment process are 10 MGD. The Contractor shall have at least 10 MGD of pumping capacity on site during dry weather shutdowns. If a shutdown occurs during wet weather conditions, the Contractor shall have 50 MGD of pumping capacity on the site. The Contractor shall be responsible to pump at a sufficient rate as to prevent upstream sanitary sewer overflows. All peak flow temporary pumping shall be transported to the Flow Equalization Basin using either temporary piping to the basin or using temporary connections to the existing FEB Influent pipe as long as the temporary connection does not interfere with the operation of other facilities.
- E. Regardless of the dates outlined herein, partial or total shutdown of any facility requires special coordination and planning with the Owner. The Contractor shall comply with the operational constraints of the facility during the shutdown periods.
- F. The Contractor shall notify the Owner in writing at least 21 days in advance and again 3 days prior to beginning work on a particular area, and coordinate with the Owner the specific items to be isolated and the duration for each. Contractor shall obtain written approval from the Owner prior to each shutdown. High demand conditions creating the need for increased treatment plant flow may require the rescheduling of an approved shutdown or cancellation of work in progress. Emergency work may be accomplished without obtaining prior permission; however, Contractor shall notify onsite operators, Owner, and Engineer immediately of any emergencies.

- G. At least twenty-one (21) calendar days prior to partially or totally shutting down any facility, the Contractor shall submit to the Owner for review in accordance with Section 01650:
    - 1. A detailed description of the work to be performed.
    - 2. A schedule outlining the duration of each scheduled task and total duration of the shutdown.
    - 3. A list of all equipment and materials required to complete each task.
    - 4. Documentation that all manpower, equipment and materials necessary to complete each task are available on site.
  - H. A minimum of two working days prior to shutdowns, a special coordination meeting will be held with the Contractor, Owner, Engineer, and other parties (Subcontractor) as requested by Owner to review procedures.
  - I. Prior to beginning work, the Contractor shall have on-site all materials, equipment, and personnel necessary to complete the work in the time scheduled. The Contractor shall also perform all possible tasks to the most complete state possible prior to shutdowns. All exposed bolts and nuts on valves or fittings that are to be disassembled shall be removed and replaced one at a time prior to shutdown to assure timely progress.
  - J. The Owner's plant manager and/or his designee shall be responsible for directing shutdown operations. The Contractor shall provide any labor assistance necessary to complete shutdown operations including but not limited to:
    - 1. Operating gates and valves (under direction and supervision of the Owner's plant operating staff).
    - 2. Removing water, scale, mud and debris from pipelines and containing, pumping and conveying water, which will leak through existing gates and valves.
  - K. The Contractor shall work whatever hours are necessary to maintain schedules during shutdowns, at no additional cost to the Owner. While a facility is partially or totally shut down, the Contractor shall work 24 hours/day to minimize the shutdown period.
  - L. Failure of the Contractor to properly plan and perform the Work in the prescribed manner may result in discharge of inadequately treated wastewater. In this case, the Contractor may be liable for payment of fines, fees or other charges imposed upon the Owner by state or federal regulatory agencies, and all other costs associated with the inadequately treated discharge.
- 1.12 CONSTRUCTION SEQUENCE
- A. The following sequence is mandatory.
    - 1. Place fill and compact soils to preload the areas shown in the C-drawings. Place and compact initial fill in the areas shown on the Drawings to allow for pre-loading of to occur. The fill material will need to remain in place for a minimum of 120 days. Only the installation of piers and ground improvements are allowed in the pre-loading area for the 120-day duration.
    - 2. The following facilities must be fully operational, tested and accepted by the Owner prior demolishing the existing degritting building, SBRs, filters, and disinfection facilities.
      - a. Influent Pump Station

- b. Degritting Facility
  - c. Aeration Basin
  - d. Final Clarifiers
  - e. RAS and Scum Pump Stations
  - f. Filters
  - g. Chlorine Contact Basins
  - h. Reaeration System
  - i. Effluent Pipeline
  - j. Monitoring and Sampling Stations.
  - k. Electrical Buildings and Systems
  - l. All other related equipment, piping, electrical components, controls, and systems necessary for the plant to treat the wastewater to a quality stipulated in the NPDES permit.
- B. The following sequence is for information only and is intended to represent a general sequence of construction of major activities in which the Work can proceed. The following items are not necessarily in the order that construction will proceed. The sample sequence provided below is not intended to represent a complete work plan.
- 1. Establish storm water controls.
  - 2. Relocate existing/temporary outfall with associated piping within 45 days of NTP.
  - 3. Contractor shall locate existing utilities and piping. If located utilities are found to differ from the Drawings and may create a conflict with proposed improvements, the Contractor shall notify the Engineer within 24-hours.
  - 4. Grade the site and construct temporary roads.
  - 5. Construct the Degritting Facility, Aeration Basin, RAS Pump Station, Final Clarifiers, Filters, Reaeration Blower Building, and Disinfection Facility with associated piping, electrical and controls.
  - 6. Construct the Chlorine Contact Basin with Reaeration Basin and Effluent Pump Station.
    - a. The piping connections from the Filters and the proposed Chlorine Contact Basin to the existing Chlorine Contact Basin may be delayed until after Substantial Completion. The Contractor may choose to construct the connections earlier if the Contractor can maintain adequate treatment through the existing Chlorine Contact basins during the construction activities.
  - 7. Construct the Effluent Pipeline and associated outfall structure.
    - a. The United States Army Corp of Engineers (USACE)- Tulsa District has issued a Nationwide Permit (NWP) for the effluent pipeline construction (NWP-12 for Utility Lines Activities) and the outfall and associated riprap construction (NWP-13 for Bank Stabilization).
    - b. A NWP-13 condition requires the outfall structure and the associated streambank stabilization be constructed after September 1<sup>st</sup> and before April 1<sup>st</sup>. Placement of topsoil and seed shall be delayed until after April 1<sup>st</sup>.
  - 8. Construct the Medium Voltage Ductbanks
    - a. Contractor to construct the majority of the ductbank prior to Substantial Completion.

- b. The portion of the ductbank that is in conflict with the existing SBR influent piping may be delayed until the SBR is demolished.
- 9. Construct the proposed Administration Building
  - a. The proposed Administration Building and all related equipment for the SCADA system, control room, and laboratory shall be complete, operational, and accepted for occupancy, as well as accepted by the Owner prior to demolishing the existing Administration Building.
  - b. The Administration Building shall be complete for Substantial Completion.
- 10. Construct the Diversion Structure and Headworks.
  - a. Construct the Diversion Structure around the existing piping and hydrostatically test the basin and gates prior to demolishing the existing pipes. After receiving acceptance from Owner, demolish the existing piping and cover the openings in the interior wall.
  - b. Provide all temporary pumping around the Diversion Structure and Headworks as necessary to perform the work.
- 11. Conversion of the Existing Flow Equalization Basin Pump Station to the Influent Pump Station.
  - a. After the Existing Flow Equalization Basin Pump Station is converted to the Influent Pump Station, the Contractor shall be responsible for temporary pumping required to pump peak flows to the Flow Equalization Basins that are in excess of the capacity of the peak flow pumps remaining in the Influent Pump Station.
  - b. The Existing Influent Pump Station shall remain fully operational until the converted Influent Pump Station is fully operational and accepted by the Owner.
- 12. Convert the Existing Influent Pump Station to the Flow Equalization Pump Station.
  - a. Conversion of the pump station will occur after Substantial Completion. Prior to converting the pump station, the Existing Grit Building requires demolition.
- 13. Construct the Digester Blower Building
  - a. Construction of the Digester Blower and associated air piping to the Digesters shall occur after the Existing Backwash Basin is demolished and the excavation is filled.
- 14. Demolition of the Existing Buildings, Basins and Processes
  - a. Demolition of existing treatment processes, piping, electrical and controls will not occur until after Substantial Completion unless noted in the Drawings or stipulated in this Specification Section.
  - b. If demolition and/or outages of portions of the existing system are required to construct the proposed systems, the Contractor shall coordinate with the Owner and provide temporary pumping, power and other services as needed to maintain operation of the treatment processes.
- C. Construction Activities Requiring Coordination Shutdowns
  - 1. Some of the Work will require shutdowns of treatment processes. Shutdowns should be scheduled during dry weather periods to minimize the potential for peak flows. At no additional cost to the Owner, the Contractor shall provide all temporary

pumping and fuel, as well as all temporary electrical and controls necessary to maintain operation of the treatment facility.

2. All partial and total shutdowns shall be scheduled with the Owner.

#### 1.13 MILESTONES

- A. Critical beneficial use milestones have been assigned to the Project to ensure that the flow of work is progressing in a timely manner. The following dates define the time limitations of the Work. The Contractor shall plan and execute his work to comply with these limitations.
  1. Substantial Completion of all work under this Contract less demolition of the existing buildings and basin NTP + 1,278 calendar days
  2. Final Completion of all work under this Contract NTP + 1,645 calendar days
- B. Substantial Completion includes the following.
  1. Completion and Owner Acceptance of all work associated with the Administration Building, Headworks, Influent Pump Station, Degritting Facilities, Aeration Basins, Final Clarifiers, RAS Pump Station, Thickener Building, Electrical Buildings, Generators, Splitter Boxes, Filters, Chlorine Contact Basins, Reaeration Blowers, Effluent Pumps, Effluent Pipeline and Outfall, as well as all other related equipment, piping, electrical components, controls, and systems necessary for the plant to treat the wastewater to a quality stipulated in the NPDES permit.
  2. Completion and Owner acceptance of all O&M Manuals associated with the above listed equipment and facilities.
  3. Construction and/or rehabilitation of the following facilities may be completed after Substantial Completion.
    - a. Flow Equalization Pump Station improvements
    - b. Digester Blower Building and associated air piping improvements
    - c. Paving and Entrance
    - d. Site Lighting
- C. Final Completion includes the following.
  1. Completion and Owner Acceptance of all work included in this Contract
  2. Completion and Acceptance by the Owner of all items included in punch lists
  3. Submittal and Acceptance by the Engineer of all record drawings
  4. Submittal and Acceptance by the Owner of all required close-out documents
- D. Liquidated damages for uncompleted work that is required to meet the milestones set out above shall be \$2,250 per Calendar Day. Liquidated damages will be concurrent and additive if more than one date is missed.

#### 1.14 CONSTRUCTION CONSTRAINTS

- A. The treatment plant must be capable of treating wastewater to sufficient quality to comply with the discharge permit. Prior to demolition or decommissioning of existing treatment facilities, the proposed improvements for the main treatment process must be completed and accepted by the Owner.



- B. At no additional cost to the Owner, the Contractor shall provide all temporary pumping and associated fuel necessary to temporarily bypass existing facilities as needed to construct proposed improvements.
- C. At no additional cost to the Owner, the Contractor shall provide all temporary electrical and controls necessary to temporarily operate existing and proposed facilities as needed to construct improvements.
- D. Demolition
  - 1. Contractor has the right to salvage demolished materials and equipment, except for the generator near the existing Administration Building and the generator near the existing Chlorine Building. Contractor to transport the two generators to a site selected by the City that is within the City limits.
  - 2. When demolishing buildings and basins, the Contractor shall remove all concrete, piping and equipment. Removal of structures shall include removal of the slab. Contractor shall demolish piers that are within 8 feet of the ground surface. The Contractor is not required to remove piers below 8 feet deep.
  - 3. Contractor is responsible for final dewatering of the basins.
    - a. Grit, rags, biosolids and other residuals remaining in the basins being demolished shall be removed prior to demolition. These materials shall be disposed in accordance with applicable regulations.
    - b. Wastewater from the basins may be returned to the head of the plant through the Flow Equalization Basins. The Contractor shall closely coordinate basin dewatering activities with the Operators to ensure the dewatering the basins will not adversely impact operations of the treatment plant. The Contractor is responsible for cleaning the Flow Equalization Basins within 24-hours of the FEBs being drained.
- E. Roads and Entrance
  - 1. During construction of the roads and entrance, Contractor shall maintain alternate routes and construct temporary roads to allow for operation of the plant and chemical deliveries.
  - 2. Prior to constructing any paving, all underground piping, culverts, and ductbanks shall be installed. Once paving is placed, no partial paving repairs are allowed. If Contractor must cut paving, the complete paving section between joints shall be replaced.
  - 3. During construction of the entrance, the Contractor shall maintain plant security in the area at all times.
- F. Partial shutdowns for Electrical Tie-Ins shall not exceed 4-hours. Planning and approvals for partial shutdowns shall comply with subsection 1.11 of this Specification. Contractor is responsible to provide bypass pumping during the shutdowns.
- G. Dewatering of structures, dewatering of piping connection points, and removal of obstructions shall be the full responsibility of the Contractor. The Contractor shall provide any additional bulkheads, dewatering equipment, or other protection as needed to allow installation of the improvements under proper conditions. Existing valves and gates may leak considerably or not hold at all. Pumping equipment, piping and valving and associated costs shall be borne by the Contractor at no additional cost to the Owner. The Contractor shall coordinate with the Owner on approved discharge locations,

discharge quantity, discharge times and discharge durations. All dewatering operations required for construction are part of the overall "down time" for any of the recommended sequence steps in this Specification. No additional time will be given for the dewatering operations.

- H. For all construction activities removal and replacement of equipment or appurtenances, the replacement equipment and appurtenances must be on site prior to any demolition activities.
- I. For all construction activities in the plant, vehicular access shall be maintained for Plant Staff to perform all daily operation and maintenance activities. All hauling routes shall be maintained at all times. Construction activities shall not interfere with routine hauling activities at the plant. If the Contractor determines that a roadway should be temporarily shut down, the Contractor must request and receive approval from the Owner in writing five (5) days prior to the closure of the road. The Contractor shall cover all the excavated pipe trenches with cover plates when not performing any construction activity in the pipe trenches. In addition, the Contractor shall also provide traffic rated closure plates at all times on the construction site to cover the excavated roads at the end of every construction day or within one (1) hour at Owner's request at any time during the work day to allow for movement of traffic over the excavated roads.
- J. Contractor shall coordinate with the Owner on any other concurrent construction projects before any shutdown of any facilities or utilities.
- K. Startup of all equipment and systems shall conform to Section 01650 – Testing, Adjusting, Balancing, Demonstration, and Startup of Systems. Unless noted otherwise in the Contract Documents or in writing by the Owner, existing equipment and systems shall remain in place and operational until new equipment and systems are fully functional for at least 30 days and are accepted by the Owner.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION



Shutdown Request No. \_\_\_\_\_

**SOUTH CANADIAN WASTEWATER TREATMENT IMPROVEMENTS  
PROJECT NO. ST-0138**

To: PLANT OPERATOR/ENGINEER/CITY PROJECT MANAGER

Date/Time Received: \_\_\_\_\_/\_\_\_\_\_

From: \_\_\_\_\_  
                     Contractor Superintendent/Cell Phone                      Subcontractor Representative/Cell Phone

Work Depicted on Contract Drawing(s): \_\_\_\_\_

Work Described in Specification Section(s): \_\_\_\_\_

Planned shutdown of process:                      Date: \_\_\_\_\_                      Time: \_\_\_\_\_

Planned restart of process:                      Date: \_\_\_\_\_                      Time: \_\_\_\_\_

Equipment to be shut down by Plant: \_\_\_\_\_

Verify all required equipment/tools are on site: \_\_\_\_\_

Request Approved: \_\_\_\_\_

Remarks: \_\_\_\_\_

Request Denied: \_\_\_\_\_

Remarks: \_\_\_\_\_

\_\_\_\_\_  
Engineer                      Date\_\_\_\_\_  
Plant Operator/                      Date\_\_\_\_\_  
Water Quality                      Date\_\_\_\_\_  
City Project Manager                      Date

Date/Time Request Returned to Contractor: \_\_\_\_\_/\_\_\_\_\_

Emergency Contacts:                      Plant Operator – 405.821.7579  
    Engineer/Inspector – 405.596.2342  
    City Project Manager – 405.326.7016

Attachments: \_\_\_\_\_

Page 1 of \_\_\_\_

**SECTION 01150**  
**MEASUREMENT AND PAYMENT**

**PART 1 GENERAL**

**1.01 SCOPE OF WORK**

- A. Work includes the furnishing of all labor, materials, equipment, tools, and related items for performing all operations required to complete the project satisfactorily in place, as specified by the Contract Documents.
- B. Required items of work and incidentals necessary for the satisfactory completion of the project shall be considered incidental to the specified work required under this Contract and shall be considered as included in the unit prices for the various bid items. The Contractor shall prepare his bid accordingly to allow for such items:
  - 1. Not specifically listed in the Bid Form.
  - 2. Not specified in this section to be measured or to be included in one of the items listed in the Bid Form.
  - 3. To include Contractor's overhead and profit.

**1.02 RELATED WORK**

- A. 01300 – Submittals.
- B. 01310 – Construction Schedules.
- C. 01370 – Schedule of Values.

**1.03 SUBMITTALS (NOT USED)**

**1.04 REFERENCE STANDARDS (NOT USED)**

**1.05 QUALITY ASSURANCE (NOT USED)**

**1.06 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS (NOT USED)**

**1.07 DELIVERY, HANDLING AND STORAGE (NOT USED)**

**1.08 MAINTENANCE/SPARE PARTS (NOT USED)**

**1.09 WARRANTY/EXTENDED WARRANTY (NOT USED)**

**1.10 MEASUREMENT AND PAYMENT**

- A. Lump sum bids shall cover the costs of all the work shown and/or specified in the Plans and Specifications and be required to complete that particular portion of the work. Payment of the full lump sum price shall be paid for the work.
- B. Unit price bids shall cover all costs associated in providing a single unit (linear foot, each, cubic yard, square foot, etc.) as called for on the Plans and/or Specifications and as required to provide a complete unit. Payment shall only be made for the actual quantity of units provided as determined by the Engineer.

- C. Payment shall constitute full compensation to the Contractor for furnishing all labor, equipment, tools, and materials, and for performing all operations required to furnish to the Owner the entire project, complete in place, as specified and as indicated on the drawings.

1.11 INDEXATION CLAUSE FOR ADJUSTING PRICING BASED ON COMMODITY INDICES

- A. The total contract price will be reduced or increased relative to the terms of this Section and the specific commodity indices prescribed in paragraph E below. If provided documentation is not sufficient, OCWUT reserves the right to request additional documentation from Contractor.
- B. Documentation
1. For each vendor bid, the Contractor wants considered for pricing adjustment, the Contractor shall provide certified bids from vendors that specifically state the items in paragraph F below at the Date of Bid. Vendor bids that are incomplete may be disallowed from consideration. The Contractor may submit the vendor bid items for consideration shown in Table 1.

*Table 1. Vendor Bid Items Considered for Indexation*

<b>Vendor Bids</b>	<b>Allowed Materials for Pricing Adjustment</b>
Headworks screens and compactor	Stainless Steel
Odor Control Units and piping	Fiberglass Products
Degritting Equipment	Stainless Steel
Final Clarifiers	Stainless Steel
Launder Cover System	Fiberglass Products
Chlorine Contact Basin baffles	Fiberglass Products
Oxygenation System	Stainless Steel
Piping	Ductile Iron Pipe, PVC, Fiberglass Products
Electrical Wiring	Copper Wire and Cable
Aluminum Handrail	Aluminum Handrail
Reinforcing Steel	Reinforcement
Stainless tubing	Stainless Steel
Fuel used at the site	Diesel
Sludge Thickener System (Price Proposal from Huber)	Stainless Steel
Onsite Hypochlorite Generation System (Price Proposal from UGSI)	Stainless Steel, Fiberglass Products, Copper Wire and Cable, PVC, Titanium, Precious Metals

2. The certified documents shall be provided with Contract, insurance, bonds and all applicable project documentation within 10 calendar days of the bid opening by the apparent low Contractor. The certified documents shall become part of the Contract and no additions will be considered unless approved by OCWUT.
3. The Contractor shall provide a certified purchase order for each vendor bid being considered for price adjustment. Purchase orders shall be used to verify the information in the certified vendor bids, and the order shall include the items in

paragraph F below. If discrepancies in materials, price, and quantities exist between the certified vendor bids and the certified purchase order, OCWUT reserves the right to use the materials, price, and quantities from either document to develop a new baseline for determining the total contract price adjustment.

4. The end of the indexing adjustment period for each vendor bid shall be the date the Contractor releases the product for the vendor. The Contractor shall provide certified emails and/or letters documenting the release date and the quantity of material released. Partial releases of materials from a vendor are acceptable; however, separate release certifications are required.
5. For fuel used at the site, the Contractor shall provide all delivery tickets that include date of delivery and total fuel delivered. Adjustments to the contract price will be evaluated for each delivery ticket.
6. For delivery of aggregate and concrete, the Contractor shall provide all delivery tickets that include date of delivery and fuel surcharges. Adjustment to the contract will be evaluated for each delivery ticket. OCWUT will pay fuel surcharges for delivery of aggregate and concrete. Vendors shall provide certified contracts from 3 similar projects in the region to show fuel surcharges are consistently applied to this project. If fuel charges are applied at a higher rate on this project than commonly used in the region, OCWUT may select to pay a lower fuel surcharge rate that is more commonly used in the region. OCWUT may also have other parties research typical fuel surcharges in the region and use the findings from the other party to calculate fuel surcharges.

C. Calculation Method

1. The following calculation will be used in adjusting the vendor bid prices and total contract price. No increases or adjustment will be made to the vendor prices until the percent adjustment changes by more than 5%. No additional Contractor overhead and profit shall be allowed in the adjustment of total contract price.

$$VBP1_i = \left( VBP0_i \times \left( 1 - \sum_{j=0}^n PVBP_j \right) \right) + \left( VBP0_i \times \sum_{j=0}^n \left( \frac{I1_j}{I0_j} \times PVBP_j \right) \right)$$

$$TCP1 = TCP0 + \sum_{i=0}^n ((VBP1_i - VBP0_i) \times ST)$$

Where:

- a. i = Certified Vendor Bid Item
- b. j = Commodity
- c. I0 = Index value at Bid Date
- d. I1 = Index value at end of adjustment period
- e. VBP0 = Vendor bid pricing at bid date
- f. VBP1 = Vendor bid pricing AFTER pricing adjustment
- g. PVBP = Percent of the vendor bid pricing associated with the index
- h. ST = Sales Tax
- i. TCP0 = Total Contract Price PRIOR TO adjustment
- j. TCP1 = Total Contract Price AFTER adjustment

2. The calculation above is demonstrated by Figure 1.

Vendor 1						
<i>j</i>	Commodity	PVBP*	Index at Bid Date ( <i>I</i> <sub>0</sub> )	Index After Adjustment Period ( <i>I</i> <sub>1</sub> )	( <i>I</i> <sub>1</sub> / <i>I</i> <sub>0</sub> )	$\sum_{j=0}^n \left( \frac{I_{1j}}{I_{0j}} \times PVBP_j \right)$
1	Reinforcement	5%	212.200	331.980	1.56	0.08
2	Diesel	2%	2.592	3.477	1.34	0.03
3	Copper	1%	342.400	401.700	1.17	0.01
4	Stainless Steel	5%	103.100	143.610	1.39	0.07
5	PVC	1%	325.000	410.000	1.26	0.01
6	Iron	5%	341.700	374.808	1.10	0.05
7	Reinforced and fiberglass products	5%	180.000	208.045	1.16	0.06
8	Aluminum	4%	156.000	162.000	1.04	0.04
		$\sum_{j=0}^n PVBP_j =$	28%	*PVBP is a set percentage dependent on		0.35322
		VBPO <sub>1</sub> = \$	50,000.00			
		VBPI <sub>1</sub> = \$	53,660.93			

Figure 1 – Example Spreadsheet Calculation

D. Frequency of Contract Adjustment

1. Every 4 months, the Contractor shall submit a certified report with line item values for each increase or reduction associated with the terms of this Indexation Clause. The certified report shall contain at least the following information.
  - a. Spreadsheet tracking list of all increases and reductions to date.
  - b. Release of materials documents
  - c. Supporting documents justifying increases and reductions in accordance with the terms of this clause. This will include delivery tickets.
  - d. Certification from the Contractor stating "All information in this report accurately represents actual project information. No dates or pricing have been altered in the supporting documents."
2. After submitting the information, the Contractor shall meet with OCWUT's representative to review the materials and make appropriate adjustments. At OCWUT's discretion, OCWUT may also have other parties review the report.
3. Potential cost increases and reductions associated with the Indexation Clause shall be approved by the Director. Once approved by the Director, the Contractor shall amend the schedule of values for the Indexation Clause Allowance to reflect the changes. At the end of the project, a change order to the Contract shall be developed to adjust the final total contract price to reflect the Director approved increases and decreases.

E. Commodity Indices Allowed for Adjusting Pricing

1. The following indices shall be used when determining total contract price adjustment.
  - a. Reinforcement:
 

U.S. Bureau of Labor Statistics, Producer Price Index by Industry:  
Fabricated Structural Metal Manufacturing: Fabricated Structural Metal

Bar Joists and Concrete Reinforcing Bars [PCU3323123323121], retrieved from FRED, Federal Reserve Bank of St. Louis; April 12, 2022. Producer Price Index by Industry: Fabricated Structural Metal Manufacturing: Fabricated Structural Metal Bar Joists and Concrete Reinforcing Bars (PCU3323123323121) | FRED | St. Louis Fed (stlouisfed.org)

b. Diesel:

U.S. Energy Information Administration, PADD II (Midwest District) Diesel Sales Price [GASDESMWW], retrieved from FRED, Federal Reserve Bank of St. Louis, April 12, 2022. PADD II (Midwest District) Diesel Sales Price (GASDESMWW) | FRED | St. Louis Fed (stlouisfed.org)

c. Copper Wire and Cable:

U.S. Bureau of Labor Statistics, Producer Price Index by Commodity: Metals and Metal Products: Copper Wire and Cable [WPU10260314], retrieved from FRED, Federal Reserve Bank of St. Louis; April 12, 2022. Producer Price Index by Commodity: Metals and Metal Products: Copper Wire and Cable (WPU10260314) | FRED | St. Louis Fed (stlouisfed.org)

d. Stainless Steel:

U.S. Bureau of Labor Statistics, Producer Price Index by Commodity: Metals and Metal Products: Steel Pipe and Tube, Stainless Steel [WPU10170674], retrieved from FRED, Federal Reserve Bank of St. Louis; April 11, 2022. Producer Price Index by Commodity: Metals and Metal Products: Steel Pipe and Tube, Stainless Steel (WPU10170674) | FRED | St. Louis Fed (stlouisfed.org)

e. PVC:

U.S. Bureau of Labor Statistics, Producer Price Index by Commodity: Rubber and Plastic Products: Plastics Pipe [WPU07210603], retrieved from FRED, Federal Reserve Bank of St. Louis; April 12, 2022. Producer Price Index by Commodity: Rubber and Plastic Products: Plastics Pipe (WPU07210603) | FRED | St. Louis Fed (stlouisfed.org)

f. Ductile Iron Pipe

U.S. Bureau of Labor Statistics, Producer Price Index by Industry: Iron Foundries: Ductile Iron Pressure Pipe and Fittings [PCU3315113315111], retrieved from FRED, Federal Reserve Bank of St. Louis; April 12, 2022. Producer Price Index by Industry: Iron Foundries: Ductile Iron Pressure Pipe and Fittings (PCU3315113315111) | FRED | St. Louis Fed (stlouisfed.org)

g. Reinforced and Fiberglass Plastic Products:

U.S. Bureau of Labor Statistics, Producer Price Index by Commodity: Rubber and Plastic Products: All Other Reinforced and Fiberglass Plastics Products [WPU07290197], retrieved from FRED, Federal Reserve Bank of St. Louis; April 12, 2022. Producer Price Index by Commodity: Rubber and Plastic Products: All Other Reinforced and Fiberglass Plastics Products (WPU07290197) | FRED | St. Louis Fed (stlouisfed.org)

h. Aluminum Handrail

U.S. Bureau of Labor Statistics, Producer Price Index by Commodity: Metals and Metal Products: Extruded Aluminum Rod, Bar, and Other

Extruded Shapes [WPU10250162], retrieved from FRED, Federal Reserve Bank of St. Louis; April 12, 2022. Producer Price Index by Commodity: Metals and Metal Products: Extruded Aluminum Rod, Bar, and Other Extruded Shapes (WPU10250162) | FRED | St. Louis Fed (stlouisfed.org)

i. Titanium

U.S. Bureau of Labor Statistics, Producer Price Index by Commodity: Metals and Metal Products: Titanium and Titanium-Base Alloy Extruded Shapes [WPU102505], retrieved from FRED, Federal Reserve Bank of St. Louis; March 18, 2022. Producer Price Index by Commodity: Titanium and Titanium-Base Alloy Extruded Shapes [IP28] | FRED | St. Louis Fed (stlouisfed.org)

j. Precious Metals related to coating of Titanium components.

U.S. Bureau of Labor Statistics, Import Price Index: Inorganic Chemical: Organic or Inorganic Compounds of Precious Metals, Of Rare Earth Metals, of Radio Active Elements or of Isotopes [IP28]: retrieved from FRED, Federal Reserve Bank of St. Louis; March 18, 2022. Import Price Index: Inorganic Chemical: Organic or Inorganic Compounds of Precious Metals, Of Rare Earth Metals, of Radio Active Elements or of Isotopes [IP28]: | FRED | St. Louis Fed (stlouisfed.org)

F. Vendor Bid Items

1. For each vendor bid item the Contractor requests consideration for pricing adjustment, the following information shall be provided.
  - a. Date of price
  - b. Duration of manufacture
  - c. Delivery period after release
  - d. Applicable commodity Index from Subitem E
  - e. Quantity of Material being considered
  - f. Percent of the Vendor Bid Total affected by the commodity (PBVB in Calculation Method)
  - g. Bid Total
  - h. Fuel surcharges and basis of charge
  - i. Certification from the Vendor and Contractor
2. For equipment (except for the Onsite Hypochlorite Generation System), multiple commodity indices may be considered; however, the summation of the percent of the vendor bid total affected by all commodities shall be less than 40%.
3. For the Onsite Hypochlorite Generation System, multiple commodity indices may be considered; however, the summation of the percent of the vendor bid total affected by all commodities shall be less than 78%.

## 1.12 BID ITEMS' DESCRIPTIONS

- A. The Bid Items and their descriptions are listed in the Table below. Each Item corresponds to the Bid Form.

Item No.	Estimated Quantity	Unit	Item Description
1	1	LS	<b>MOBILIZATION</b> Payment shall be made for mobilization on lump sum basis at the amount identified in the Proposal based on the progress of the Work. No direct measurement will be made for mobilization; payment will be determined based upon the estimated percentage of the overall mobilization effort up to 75% of the total pay item amount. The mobilization cost shall not exceed 3.5% of the total project cost. The final 25% of the pay item total will be paid upon final completion of the Work. Mobilization shall include all costs for construction staking, insurance, bonds, and permits; as well as the furnishing of all labor, materials, equipment, and services to perform those operations necessary for the movement of personnel, equipment, supplies, and incidentals to and from the project site and for establishing temporary facilities as specified and otherwise.
2	1	LS	<b>HEADWORKS FACILITY</b> Furnish, Install, and Place into Service Headworks Facility and All Related Equipment, Civil, Structural, Electrical, Instrumentation, and Appurtenances.
3	1	LS	<b>INFLUENT PUMP STATION</b> Furnish, Install, and Place into Service Influent Pump Station, Influent Meter Vault, and All Related Equipment, Civil, Structural, Electrical, Instrumentation, and Appurtenances.
4	1	LS	<b>FEB PUMP STATION IMPROVEMENTS</b> Furnish, Install, and Place into Service FEB Pump Station Improvements and All Related Equipment, Civil, Structural, Electrical, Instrumentation, and Appurtenances.





5	1	LS	VORTEX GRIT CHAMBERS AND GRIT WASHER FACILITY Furnish, Install, and Place into Service Vortex Grit Chambers, Grit Washer Facility, and Grit Washer Facility Lift Station and All Related Equipment, Civil, Structural, Electrical, Instrumentation, and Appurtenances.
6	1	LS	AERATION BASIN TANKS Construct Aeration Basin Tanks Including All Civil, Structural, and Appurtenances.
7	1	LS	FOUNDATION IMPROVEMENTS FOR AERATION BASIN TANKS Construct Foundation Improvements for the Aeration Basin Tanks per Section 02450.
8	1	LS	AERATION BASIN EQUIPMENT AND PIPING Furnish, Install, and Place into Service Aeration Basin Equipment and Piping and All Related Equipment, Electrical, Instrumentation, and Appurtenances.
9	1	LS	FINAL CLARIFIER TANKS Construct Final Clarifier Tanks Including All Civil, Structural, Deep Foundation Systems in Accordance with Geotechnical Report, and Appurtenances. Deep Foundation Systems for Final Clarifier Tanks are Separate from Bid Line Items 43, 44, and 45.
10	1	LS	FINAL CLARIFIERS EQUIPMENT AND PIPING Furnish, Install, and Place into Service Final Clarifiers Equipment, Piping, Scum Pump Stations 1 and 2 and All Related Equipment, Electrical, Instrumentation, and Appurtenances.
11	1	LS	CLARIFIERS SPLITTER BOX Furnish, Install, and Place into Service Clarifiers Splitter Box and All Related Equipment, Civil, Structural, Electrical, Instrumentation, and Appurtenances.
12	1	LS	FOUNDATION IMPROVEMENTS FOR CLARIFIERS SPLITTER BOX Construct Foundation Improvements for the Clarifiers Splitter Box per Section 02450.
13	1	LS	RAS PUMPING Furnish, Install, and Place into Service RAS Pumping and All Related Equipment, Civil, Structural, Electrical, Instrumentation, and

			Appurtenances.
14	1	LS	RAS SPLITTER BOX Furnish, Install, and Place into Service RAS Splitter Box and All Related Equipment, Civil, Structural, Electrical, Instrumentation, and Appurtenances.
15	1	LS	FOUNDATION IMPROVEMENTS FOR RAS SPLITTER BOX Construct Foundation Improvements for the RAS Splitter Box per Section 02450.
16	1	LS	FILTERS Furnish, Install, and Place into Service Filters and All Related Equipment, Civil, Structural, Electrical, Instrumentation, and Appurtenances.
17	1	LS	FOUNDATION IMPROVEMENTS FOR FILTERS Construct Foundation Improvements for the Filters per Section 02450.
18	1	LS	DISINFECTION AND BRINE STORAGE EXCLUDING EQUIPMENT IN FOLLOWING LINE ITEM Furnish, Install, and Place into Service Disinfection and Brine Storage Building and Associate Equipment (Less Equipment in Bid Item 19), and All Related Civil, Structural, Electrical, Instrumentation, and Appurtenances.
19	1	EA	DISINFECTION AND BRINE STORAGE EQUIPMENT (PRICE PROPOSAL COST IS \$4,274,000) Furnish Disinfection and Brine Storage Equipment and All Related Electrical, Instrumentation, and Appurtenances in Accordance with Attached Price Proposal.
20	1	LS	CHLORINE CONTACT BASIN AND EFFLUENT PUMP STATION Furnish, Install, and Place into Service Chlorine Contact Basin and Effluent Pump Station and All Related Equipment, Civil, Structural, Electrical, Instrumentation, and Appurtenances.
21	1	LS	FOUNDATION IMPROVEMENTS FOR CHLORINE CONTACT BASIN Construct Foundation Improvements for the Chlorine Contact Basin per Section 02450.
22	1	LS	REAERATION BUILDING AND LOX STORAGE Furnish, Install, and Place into Service Reaeration Building and LOX Storage and All Related

			Equipment, Civil, Structural, Electrical, Instrumentation, and Appurtenances.
23	1	LS	EFFLUENT PUMP STATION AND DISCHARGE PIPELINE Furnish, Install, and Place into Service Effluent Pump Station, 54-inch Effluent Pipeline, and All Related Equipment, Civil, Structural, Electrical, Instrumentation, and Appurtenances.
24	1	LS	THICKENING AREA EXCLUDING EQUIPMENT IN FOLLOWING LINE ITEM Furnish Thickening Building and Associated Equipment (Less Equipment in Bid Item 25), and All Related Civil, Structural, Electrical, Instrumentation, and Appurtenances.
25	1	EA	THICKENING EQUIPMENT (PRICE PROPOSAL COST IS \$479,590) Furnish Thickening Equipment and All Related Electrical, Instrumentation, and Appurtenances in Accordance with Attached Price Proposal.
26	1	LS	DIGESTER BLOWER BUILDING AND AIR PIPING Furnish, Install, and Place into Service Digester Blower Building and Air Piping and All Related Equipment, Civil, Structural, Electrical, Instrumentation, and Appurtenances.
27	1	LS	PLANT WATER SUPPLY Furnish, Install, and Place into Service Plant Water Supply and All Related Equipment, Civil, Structural, Electrical, Instrumentation, and Appurtenances.
28	1	LS	INSTRUMENTATION Furnish, Install, and Place into Service All Instrumentation and Controls that are not Included in Other Bid Items.
29	1	LS	MAIN ELECTRICAL BUILDING Furnish, Install, and Place into Service Main Electrical Building and All Related Equipment, Civil, Structural, Electrical, Instrumentation, and Appurtenances.
30	1	LS	STANDBY DIESEL GENERATORS Furnish, Install, and Place into Service Standby Diesel Generators and All Related Appurtenances.
31	1	LS	INFLUENT ELECTRICAL BUILDING Furnish, Install, and Place into Service Influent Electrical Building and All Related Equipment,

			Civil, Structural, Electrical, Instrumentation, and Appurtenances.
32	1	LS	<p>MV LOOP AND MV TRANSFORMERS</p> <p>Furnish, Install, and Place into Service MV Loop and MV Transformers and All Related Equipment, Civil, Structural, Electrical, Instrumentation, and Appurtenances.</p>
33	1	LS	<p>OG&amp;E FLOW METER AND MODULATING VALVE VAULTS</p> <p>Furnish, Install, and Place into Service OG&amp;E Flow Meter and Modulating Valve Vaults and All Related Equipment, Civil, Structural, Electrical, Instrumentation, and Appurtenances.</p>
34	1	LS	<p>MONITORING AND SAMPLING POINT MANHOLES</p> <p>Furnish and Install Monitoring and Sampling Point Manholes.</p>
35	1	LS	<p>ODOR CONTROL UNITS</p> <p>Furnish, Install, and Place into Service all Odor Control Units including for the Influent Pump Station, Headworks, Grit Washer Facility, Grit Chamber, and Disinfection Building, and all Related Equipment, Civil, Structural, Electrical, Instrumentation, and Appurtenances.</p>
36	1	LS	<p>ROADWAY LIGHTING</p> <p>Furnish, Install, and Place into Service Roadway Lighting and All Related Equipment, Civil, Structural, Electrical, Instrumentation, and Appurtenances.</p>
37	1	LS	<p>DEMOLITION OF EXISTING FACILITIES, PAVING, AND PIPING</p> <p>Provide all Labor, Materials, and Equipment Required for Demolition of Existing Facilities, Paving, and Piping.</p>
38	1	LS	<p>SITE CIVIL</p> <p>Provide all Labor, Materials, and Equipment Required for Site Civil and Grading.</p>
39	1	LS	<p>PAVING</p> <p>Provide all Labor, Materials, and Equipment Required for Site Paving.</p>
40	1	LS	<p>ADMINISTRATIVE BUILDING</p> <p>Furnish, Install, and Place into Service Administrative Building and All Related Equipment, Civil, Structural, Electrical, Instrumentation, and Appurtenances.</p>

41	1	LS	MAINTENANCE BUILDING MODIFICATIONS Furnish, Install, and Place into Service Maintenance Building Modifications and All Related Equipment, Civil, Structural, Electrical, Instrumentation, and Appurtenances.	
42	1	LS	DEWATERING AND SHORING Provide all Labor, Materials, and Equipment Required for Dewatering and Shoring.	
43	11,000	LF	24" DRILLED PIERS 24-inch Drilled Shaft Pier Installation. Quantities for Bid Item 43 are not to be used for Bid Line Item 9: Final Clarifier Tanks.	
44	4,626	LF	30" DRILLED PIERS 30-inch Drilled Shaft Pier Installation. Quantities for Bid Item 44 are not to be used for Bid Line Item 9: Final Clarifier Tanks.	
45	5	EA	ADDITIONAL PERFORMANCE TESTS FOR RIGID INCLUSION IMPROVEMENTS Additional Rigid Inclusion Performance Tests as Required by Engineer per Test.	
46	1	LS	TRENCH SAFETY SYSTEMS Provide all Labor, Materials, and Equipment Required for Installing Trench Safety Systems.	
47	1	LS	EROSION CONTROL AND STORMWATER POLLUTION CONTROL Provide all Labor, Materials, and Equipment Required for Erosion and Stormwater Pollution Control.	
48	1	LS	SODDING AND LANDSCAPING Provide all Labor, Materials, and Equipment Required for Fencing, Sodding and Landscaping.	
49	10	EA	DOCUMENTATION SOFTWARE LICENSES FOR CITY AND CONTRACTOR (\$5,250 EACH) Purchase Licenses for Autodesk Construction Cloud with Autodesk Build Module Add-on for Contractor's Internal Use and Licenses to be Assigned to the Owner's Personnel, Per Section 01010.	
50	1	LS	MISCELLANEOUS WORK ITEMS Payment is a Lump Sum Basis Based on the Progress of the Work. This Includes Payment for all Work Required Under the Contract Except for Work Specifically Being Provided Under Other Bid Items Listed on the Proposal and Described in this	

Section. It Includes Completion of all Required Project Closeout Activities Specified in Section 01700 – Contract Closeout and Submission of Contractor Field Drawings Indicating the Location and Limits of each Repair Type and Limits of New Concrete Interior Lining System Including the Elevation of the Keyway in each Tank. This Item Shall Constitute Full Compensation for All Such Work Required per the Contract Documents.

51	1	LS	PRE-PURCHASED SCREEN FOR INFLUENT PUMP STATION Install and Place in Service Pre-Purchased Bar Screen in Influent Pump Station and All Related Equipment, Electrical, Instrumentation, and Appurtenances
52	1	LS	INDEXATION CLAUSE ALLOWANCE (Bid Allowance of \$2,500,000) Allowance item to be used in accordance with Section 01150, 1.11.



PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

## **SECTION 01500**

### **TEMPORARY FACILITIES AND CONTROLS**

#### **PART 1 GENERAL**

##### **1.01 SCOPE OF WORK**

- A. The facilities and controls specified in this Section are considered minimum for the project. The Contractor may provide additional facilities and controls which he considers necessary for the proper execution of the Work and to meet his responsibilities for protection of persons, property and the environment.

##### **1.02 RELATED WORK (NOT USED)**

##### **1.03 SUBMITTALS**

- A. Submit plan of temporary facilities noting location of all storage areas, including areas where hazardous or dangerous materials will be stored.

##### **1.04 REFERENCE STANDARDS (NOT USED)**

##### **1.05 QUALITY ASSURANCE (NOT USED)**

##### **1.06 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS (NOT USED)**

##### **1.07 DELIVERY, HANDLING AND STORAGE (NOT USED)**

##### **1.08 MAINTENANCE/SPARE PARTS (NOT USED)**

##### **1.09 WARRANTY/EXTENDED WARRANTY (NOT USED)**

##### **1.10 PERMITS**

- A. Contractor is responsible for obtaining all City or other regulatory permits required for the temporary facilities.

#### **PART 2 PRODUCTS**

##### **2.01 BUILDINGS**

- A. Field Office, General: Prefabricated or mobile units with serviceable finishes, temperature controls, foundations adequate for normal loading, having insulated double walls, ceiling and floors. All field offices shall have at least the following items.
  1. ADA Compliant Toilet and wash facilities. Provide sewage disposal service for the toilet and drain in accordance applicable codes.
  2. Storage room with door and cylinder lock, keyed differently than the exterior door locks. Provide 2 set of keys.
  3. Provide 3 sets of exterior door keys
  4. Fire extinguishers and smoke detectors
  5. Minimum features shall include the following

- a. 110-volt lighting and wall plugs
  - b. Ceiling lights
  - c. Electric heating and self-contained air-conditioning units properly sized for the project location and conditions.
  - d. Railed stairways and landings at entrances
  - e. Windows at least every 15 feet
- B. Contractor's Field Office: The Contractor's Field Office shall be at least 1200 square feet with a conference area capable of seating at least 15 people. A 65-inch monitor with video connections shall be provided for the conference area.
- C. Engineer's Field Office: The Contractor shall provide the Engineer a separate Field Office that is at least 1440 square feet.
- 1. Provide separate field office on project site for the exclusive use of the ENGINEER, as follows:
    - a. Size: Approximately 24 feet by 60 feet, including 1 ADA toilet room, with 8-foot minimum ceiling height.
    - b. Construction: Weathertight building constructed at the site, pre-manufactured building, or trailer, with 2 toilet rooms containing a water closet and lavatory, partitioned off from the working area.
    - c. Walls and Ceiling: Insulated with finished interior surfaces.
    - d. Openings: At least 8 windows and 2 entrance doors, each with cylinder lock and 4 keys.
    - e. Exterior lighting over entrance doors.
    - f. Twenty 110 volts AC duplex receptacles with at least 2 in each office.
    - g. Six 10' by 10' offices shall be configured within the structure.
    - h. HVAC shall be designed for ambient temperatures for actual site. Air conditioning shall assume maximum summer time temperature of 115 degrees Fahrenheit.
    - i. HVAC shall have duplex air conditioners that can provide adequate redundancy during peak summertime and cold weather conditions.
    - j. Provide metal underpinning for entire perimeter of field office, with access doors at both opposing longitudinal ends of office.
    - k. At entrance doors, provide concrete entrance pads a minimum 8 feet by 8 feet, with metal access stairs with handrail, that are anchored to the entrance pads.
    - l. One Entrance to be ADA Compliant with one ADA Compliant Concrete Parking spot near the ADA entrance.
  - 2. Arrange and Pay For:
    - a. Janitorial service, including weekly dusting, floor cleaning, and trash removal, and monthly comprehensive cleaning, including windows.
    - b. Heating, ventilating, and air conditioning equipment in operating condition.
    - c. Electric wiring, power, and lighting fixtures capable of providing at least 75 foot candles of light on work surfaces.
    - d. A continuous supply of toilet paper, paper hand towels and hand soap for each restroom.





- e. Bottled drinking water and service with dispenser.
  - f. Coffee service with coffee maker
  - g. Suitable restroom facilities with sinks with hot and cold water.
  - h. Data Service
3. Provide Following Furnishing and Equipment:
- a. All furnishings and equipment shall be new.
  - b. Eight office desks with 6 drawers (2 with locks) and padded, upholstered swivel chairs.
  - c. Two 30" by 96" conference table with eight swivel chairs.
  - d. Three 30" by 72" folding tables.
  - e. One drafting table not less than 36 inches by 60 inches.
  - f. Twelve straight chairs.
  - g. Eight swivel chairs.
  - h. Four metal filing cabinets, 18 inches by 30 inches by 52 inches, 4 drawers with locks.
  - i. One supply cabinet with not less than 15 square feet of shelves.
  - j. Six bookcases with not less than 12 linear feet of shelves for each bookcase.
  - k. Six wastebaskets.
  - l. Two Dry erase board 96 by 48 inches, magnetic, with markers and erasers.
  - m. Kitchenette with sink and two base cabinets and two upper cabinets.
  - n. Refrigerator, 20 cubic feet capacity.
  - o. Microwave oven, 1.0 cubic feet.
  - p. First aid kit
  - q. High speed internet with at least 30 Mbps download speed
  - r. At least 12 ethernet connection ports and one Wi-Fi Router
  - s. Two – 65" TV's mounted in the conference room for Video Conferencing.
  - t. Provide one Barco ClickShare System, complete with 1 Hub and 4 ClickShare Buttons.
  - u. Field Office Printer:
    - (i) Provide a multifunctional printer with the capability of printing, copying, and scanning. The CONTRACTOR is responsible for all maintenance of equipment and related hardware and software. The printer shall consist of, as a minimum:
      - (a) Double-sided printing capability.
      - (b) Copy speed: 33 copies per minute.
      - (c) Print speed: 30 prints per minute.
      - (d) Up to 600 x 600 dpi resolution.
      - (e) Original scan/copy paper size: up to 11" x 17".
      - (f) Printer paper size: up to 11" x 17"
      - (g) Dry, dual component toner.
      - (h) Scan-to-FiIe/ Folder/URL/FTP/Email functionality.
      - (i) Full-Color VGA Touch Screen Control Panel.
      - (j) 1.5 GB RAM + 250 GB HDD

- (k) Paper, toner, and other supplies for duration of project.
- 4. Locate field office adjacent to Contractor's Field Office.
- 5. Have field office ready for occupancy within 2 weeks after start of sitework.
- 6. Provide two utility vehicles; one (1) capable of carrying 2 passengers, and one (1) capable of carrying at least 4 passengers.
  - a. Vehicle shall be new, with less than 10 hours operation time upon delivery, fully functional, have a rated towing capacity of no less than 1,200 lb., have a rated payload capacity of no less than 800 lb.
  - b. Manufacturer and Model:
    - (i) Seat Capacity: 2 – CAB ENCLOSED
      - (a) Yamaha Viking EPS
      - (b) Polaris Ranger 1000
      - (c) Can Am Defender DPS-HD9
    - (ii) Seat Capacity: 4
      - (a) Yamaha Viking VI EPS
      - (b) Polaris Ranger 1000 Crew
      - (c) Can Am Defender Max DPS-HD10

Include Storage Facility and Maintenance for Vehicles.

B. Storage Facilities:

- 1. Provide watertight storage facilities as required with floor above ground level for materials susceptible to weather damage. Storage of other materials on blocks off the ground is acceptable. Place materials to permit easy access for inspection and identification. Location of storage facilities and areas shall be approved by the Owner.
- 2. Provide separate storage areas for hazardous, dangerous or volatile materials.

### PART 3 EXECUTION

#### 3.01 SAFETY

- A. Prior to all regularly scheduled meetings, the Contractor shall clean and disinfect the meeting area. The Contractor shall provide hand sanitizer at all times in both the Contractor's and Engineer's Field Office.

#### 3.02 UTILITIES

- A. Contractor's Job Telephone: The Contractor is to provide telephone service for the Contractor's field office at the South Canadian Wastewater Treatment Plant at all times for the duration of the construction period. Existing phone in treatment facility shall not be used by the Contractor's personnel.
- B. Wastewater Facilities: The Contractor shall provide and maintain toilets and other wastewater facilities for his employees and his subcontractor's employees that will comply with the regulations of the State and local health departments and as directed by the Owner. Chemical toilets, if used, shall be of watertight construction. A minimum of one (1) toilet per 20 employees shall be provided by the Contractor. Chemical toilets shall be maintained by the Contractor until the completion of construction or as directed by the Owner. Upon completion of the Work, all wastewater facilities shall be

removed and the area restored to its original condition. Contractor's personnel shall not be permitted to use Owner's wastewater facilities and shall be required to use Contractor provided facilities.

- C. Water for Construction: The Contractor shall arrange for the necessary temporary water service, including the securing of any necessary permits.
  - 1. The Contractor shall make the necessary arrangement to supply water required for the project. This includes providing water for temporary facilities, general cleaning and maintenance, dust control, testing and verification of the Work prior to acceptance of the Work.
  - 2. Cost of water usage shall be borne by the City.
  - 3. Contractor shall implement dust control measures to minimize the creation and dispersion of dust. Dust control will include application of water to control dust from roadways and other activities. Contractor shall apply clean water to gravel and unsurfaced roads. Contractor must use a flush hydrant meter to obtain water from the plant. The City shall bear the cost of water used for dust control.
- D. Electric Power for Construction: The Contractor shall determine the type and amount required and make arrangements for providing temporary electric power. The Contractor shall pay all costs related to obtaining temporary electrical services.
  - 1. The Contractor shall maintain the temporary electric power system during the Contract period at his expense.
  - 2. The electrical service shall be of adequate capacity for all construction tools and equipment without overloading the temporary facilities. The temporary systems and their components shall be furnished and installed in conformance with the requirements of the National Electrical Code (NEC) and all local authorities having jurisdiction.
  - 3. Temporary electric power installation shall meet the construction safety requirements of NEC, Federal (OSHA), State and other governing agencies.
  - 4. Cost of electrical power usage for the Contractor's and his subcontractor's construction trailers and associated equipment shall be paid for by the Contractor.



### 3.03 ACCESS AND PARKING

- A. Access to the plant site for construction personnel shall be through the construction entrance as shown on the drawings. Signs shall be installed to divert all traffic to that gate, including signs inside the plant site if needed. Location of job sign will be as directed by Owner. Contractor and Subcontractor parking areas shall be as shown on the drawings or coordinated with Owner.

### 3.04 SECURITY AND TEMPORARY PROTECTION

- A. Furnish, install and maintain suitable barriers and protections to prevent public entry, and to protect the Work, existing facilities and existing roads from construction operations. Damage to existing roads caused by the Contractors' vehicles shall be repaired by the Contractor at no cost to the Owner.
- B. The Contractor shall take all necessary measures and be solely responsible for the protection of temporary facilities, finished construction areas, equipment, and materials at the site until the project has been completed and accepted by the Owner.

### 3.05 PERMIT-REQUIRED CONFINED SPACE

- A. The Contractor shall evaluate the project's work area(s) to determine if any spaces are permit-required confined spaces per the requirements of Federal Regulations Standards 29CFR 1910.146. If the work area(s) contains permit spaces, the Contractor shall inform all employees and subcontractor(s), by posting danger signs or by any other equally effective means, of the existence and location of, and the danger posed by, the permit spaces.

NOTE: Provide a sign reading DANGER – PERMIT-REQUIRED CONFINED SPACE, DO NOT ENTER or using other similar language to satisfy the requirement for a sign.

- B. If the Contractor decides that its employees and/or subcontractor(s) will not enter permit spaces, the Contractor shall take effective measures to prevent its employees and/or subcontractor(s) from entering the permit spaces and shall comply with paragraphs (c)(1), (c)(2), (c)(6) and (c)(8), of Federal Regulation Standards 29CFR 1910.146.
- C. If the Contractor decides that its employees and/or subcontractor(s) will enter permit spaces, the Contractor shall develop and implement a written permit space program that complies with Federal Regulation Standards 29CFR 1910.146. The written program shall be available for review by employees and subcontractor(s). The written program shall also be available to the Owner's authorized representatives for information only.
- D. The Contractor may use the alternate procedures specified in paragraph (c)(5)(ii) of the Federal Regulation Standards 29CFR 1910.146 for entering a permit space under the conditions set forth in paragraph (c)(5)(i) of the Federal Regulation Standards 29CFR 1910.146.

### 3.06 CONTROLS

- A. Protect equipment, newly finished areas and connected finished areas from dust and moisture. Use temporary walls, dust curtains or other enclosures, as necessary, to prevent damage.

### 3.07 CONSTRUCTION AIDS

- A. Furnish, install and maintain required construction aids:
  1. Provide construction aids required by personnel and to facilitate the execution of the Work: scaffolds, staging, ladders, stairs, ramps, runways, platforms, railings, hoists, cranes, chutes, and other such facilities and equipment.
  2. When permanent stair framing is in place, provide temporary treads, platforms and railings for use by construction personnel.

### 3.08 SITE MAINTENANCE

- A. The Contractor shall limit his on-site operations and storage of equipment and materials to the area designated on the Plans and Specifications and as directed by the Owner.

- B. Except as provided herein, no sidewalk, private property, or other areas adjacent to the plant site shall be used for storage of the Contractor's equipment and materials unless prior written approval is obtained from the Owner.
- C. The Contractor shall maintain the area during construction in a manner that will not obstruct operations on street areas. Contractor shall proceed with his work in an orderly manner, maintaining the construction site free of debris and unnecessary equipment or materials.
- D. At all times, the Contractor shall maintain areas covered by the Contract and public properties free from accumulations of waste, debris, and rubbish caused by construction operations. All trash and waste materials shall be cleaned up and disposed in an approved waste receptacle each day.
- E. Excavated materials shall be removed from the site in a manner that will cause the least damage to adjacent lawns, grassed areas, trees, gardens, shrubbery, or fences regardless of whether these are on private property or on public right-of-ways.
- F. At least weekly, brush sweep entry drive and roadways, and all other streets and walkways affected by the Work and where adjacent to the Work.

### 3.09 FIRST AID FACILITIES

- A. Maintain at a well-known location at the job site all articles for giving first aid to the injured. Make standing arrangements for the immediate removal of persons, including employees, who may be injured on the job site to a hospital or a doctor's care. In no case shall employees be permitted to work at a job site before the employer has made standing arrangements for removal of injured persons to a hospital or a doctor's care.

### 3.10 PROJECT SIGNS

- A. Furnish and install a standard sign at the plant entrance road during the duration of the Work at that facility. The project sign shall be constructed and installed according to the City standard. A mockup of the project sign shall be submitted for approval prior to installation.
- B. Install in locations approved by Owner.
- C. Signs not listed in this Specification and/or drawings permitted only upon approval of Engineer.

### 3.11 REMOVAL OF TEMPORARY FACILITIES AND CONTROLS

- A. Prior to final inspection, remove all temporary buildings, wastewater conveniences, signs and other items. Remove or restore, as required, all temporary roads and parking areas. Clean up all construction areas at the site.

### 3.12 ENVIRONMENTAL CONTROLS

- A. The Contractor shall, without additional expense to the Owner, be responsible for complying with any applicable Federal, State and Municipal laws, codes and regulations, in connection with the prosecution of the Work. He shall take proper safety and health precautions to protect the Work, the workers, the public and the

property of others. He shall also be responsible for all materials delivered and work performed.

### 3.13 STORM WATER POLLUTION CONTROLS

- A. Prior to commencing excavation and construction, submit detailed plan showing procedures intended to handle and dispose of stormwater, groundwater, and dewatering pump discharges. Contractor shall be responsible for installing, maintaining, and removing appropriate erosion control devices such as silt fences, hay bales, etc. in accordance with Storm Water Quality Best Management Practices for Construction Activities (BMP Manual).

### 3.14 ENGINEER'S FIELD OFFICE

- A. Make available for Engineer's use prior to start of the Work at Site and to remain on the Site for minimum of 15 days after final acceptance of the Work.
- B. Locate where directed by Engineer; level, block, tie down, skirt, provide stairways, and relocate when necessary and approved. Construct on proper foundations, and provide proper surface drainage and connections for utility services.
- C. Provide minimum 100 ft<sup>2</sup> of gravel or crushed rock base, minimum depth of 4", at each entrance.
- D. Raise grade under field office, as necessary, to elevation adequate to avoid flooding.
- E. Provide sanitary facilities in compliance with state and local health authorities.
- F. Exterior Door Keys: Furnish two sets of keys.
- G. Arrange and provide for telecommunication service for use during construction. Pay costs of installation, maintenance, and monthly service of internet connection.
- H. Maintain in good repair and appearance, and provide weekly cleaning service and first-aid kit supplies, and bottled water.

### 3.15 TEMPORARY RESIDENCE.

- A. Travel trailers, recreational vehicles, mobile homes, or similar means to provide overnight accommodations will not be allowed at the site of the work. Workmen will not be allowed to remain on the site before or after work hours. Overnight use of the site will only be allowed when construction scheduling may require 24-hour shifts or when otherwise approved by the Owner.

### 3.16 DAMAGE TO EXISTING PROPERTY.

- A. Contractor will be held responsible for any damage to existing structures, work, materials, or equipment because of his operations and shall repair or replace any damaged structures, work, materials, or equipment to the satisfaction of, and at no additional cost to the Owner. Contractor shall protect all existing structures and property from damage and shall provide bracing, shoring, or other work necessary for such protection. Contractor shall be responsible for all damage to streets, roads, curbs, sidewalks, highways, shoulders, ditches, embankments, culverts, bridges, or other public or private property, which may be caused by transporting equipment, materials, or workers to or from the Work. Contractor shall make satisfactory and

acceptable arrangements with the agency having jurisdiction over the damaged property concerning its repair or replacement.

PART 4 PRODUCTS (NOT USED)

PART 5 EXECUTION (NOT USED)

END OF SECTION

**SECTION 01520****SECURITY****PART 1 GENERAL****1.01 SCOPE OF WORK**

- A. Furnish security services as required to protect Work, existing premises and Owner's operations from theft, vandalism and unauthorized entry.
- B. The Contractor shall be responsible for security aspects only as related to this Contract such as and including work areas, construction entrance gate, etc.

**1.02 RELATED WORK (NOT USED)****1.03 SUBMITTALS (NOT USED)****1.04 REFERENCE STANDARDS (NOT USED)****1.05 QUALITY ASSURANCE (NOT USED)****1.06 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS (NOT USED)****1.07 DELIVERY, HANDLING AND STORAGE (NOT USED)****1.08 MAINTENANCE/SPARE PARTS (NOT USED)****1.09 WARRANTY/EXTENDED WARRANTY (NOT USED)****1.10 CONTRACTOR SECURITY PLAN**

- A. Prior to the performance of any work the Contractor shall submit a security plan commensurate with the needs of the project. The security plan shall be approved and signed by an officer of the Contractor. The security plan shall be submitted to the Owner for approval before construction begins. Adequacy of the security plan is the responsibility of the Contractor. The security plan shall:
  1. Include security measures to control access to the Owner's property via the construction entrance.
  2. Include security measures to protect Contractor employees and other persons from injury.
  3. Include an employee site security orientation program.
  4. Maintain the security plan throughout the construction period until Owner's acceptance and removal of construction access gate(s).

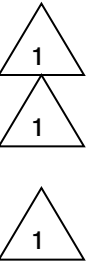
**1.11 ENTRY CONTROL**

- A. The Contractor shall:
  1. Restrict entry of unauthorized personnel and vehicles onto the Project or Work site(s). The entry gate shall be secured by an electronic gate operator with authorized personnel provided remotes.





2. Operators shall be provided two remotes and the Engineer shall be provided two remotes.
3. Post a sign indicating who visitors shall contact for entry.
4. Allow entry only to authorized persons with proper identification.
5. Maintain a log of workmen that have gate remotes and any visitors that enter the site. Provide the log to Owner upon request.
6. Provide and maintain temporary security fencing equal to existing fencing in the event that existing fencing or barriers are breached or removed for purposes of construction.



#### 1.12 SECURITY SERVICE

- A. The Contractor may, at the Contractor's discretion and cost, employ uniformed guard service to provide watchmen at Site.

#### 1.13 USE OF PREMISES

- A. Contractor personnel are prohibited from building interiors except as required to execute specific work as indicated in the Contract Documents.
- B. The Contractor is prohibited from utilizing Owner's computers, phones and internet services unless specifically allowed by Owner.
- C. Owner's toilet facilities and service sinks are not to be used by the Contractor, Subcontractors or their personnel.
- D. Building keys will not be made available to the Contractor. Access to secured areas shall be arranged through the Owner.
- E. Construction activities, equipment or materials shall not impede emergency evacuation or emergency vehicles.

#### 1.14 RESTRICTIONS

- A. The Contractor shall not allow cameras on site or photographs taken except by the Owner or Engineer or by written approval of Owner.

#### PART 2 PRODUCTS (NOT USED)

#### PART 3 EXECUTION (NOT USED)

END OF SECTION

**SECTION 01650****TESTING, ADJUSTING, BALANCING, DEMONSTRATION, AND STARTUP OF SYSTEMS****PART 1 GENERAL****1.01 SCOPE OF WORK**

- A. Provide all materials, equipment, and personnel required to test, adjust, balance, and start the various mechanical systems installed as a part of the Work.
- B. The startup, testing, and commissioning services referenced or specified herein include the following:
  - 1. Startup and Testing.
  - 2. Startup checks.
  - 3. Functional testing.
  - 4. Functional acceptance testing.
  - 5. Operation acceptance testing.
- C. Provide procedures for demonstration of equipment operation and instruction of Owner's personnel.
- D. Provide procedures for starting of mechanical, electrical, and instrumentation systems.
- E. The Owner will supply all water and/or chemicals required for testing, adjusting, and balancing, demonstration, and startup of the systems. Any water used shall be potable or utility water as required by the process or equipment being testing. Any chemicals used shall be provided by the Owner. Contractor shall give at least 90-days notice prior to needing any chemicals for testing and startup.
  - 1. The Owner will provide potable water.
  - 2. The Contractor may use treated chlorinated water, if it is available, for testing and startup of systems that do not require potable quality water. If the Contractor chooses to use treated chlorinated water, the Contractor shall be responsible for temporary pumping and piping required to transport the water to the system being tested. If sufficient treated chlorinated water is not available, the Contractor shall use potable water.
  - 3. Potable water is required for the following systems.
    - a. Any system where the water used for testing may be discharged to the environment.
    - b. Testing of all systems associated with the onsite chlorine generation system including connected tanks, piping, softeners and appurtenances.
    - c. Testing of all systems associated with chemical storage, pumping, and piping.
- F. The Contractor shall pay for all electrical power used for testing, adjusting, and balancing, demonstration, and startup of the system. When the power is provided through the Owner's electrical system, the Contractor shall be responsible to provide a sub-electrical meter to measure electrical usage for the system, equipment or process drawing power from the Owner's system. Reimbursement shall be at the rate the Owner pays the electric provider.
- G. The Owner shall provide fuel for startup and testing of the generators.



## 1.02 RELATED WORK

- A. Section 01640 – Manufacturers’ Services.

## 1.03 DEFINITIONS.

- A. Startup and Testing is the transitional phase between completion of construction and start of commissioning and includes the following:
  1. Pre-Startup Activities and Checks - Inspections, tests and other activities necessary to determine that equipment, systems and subsystems have been properly manufactured and installed. Pre-startup activities shall include an audit of all factory testing of equipment and compiling the results for comparison to startup and commissioning testing.
  2. Functional Testing – Initial limited operation of equipment, to demonstrate capability of installed components to perform their intended functions, respond to controls, and safely interface with external systems, followed by operation of individual systems in manual and automatic mode to test full functionality of individual systems.
  3. Operational acceptance testing - Continuous testing of the complete treatment processes under specified operating conditions in accordance with the technical Specifications and applicable regulations to demonstrate proper performance of the facility.

## 1.04 SUBMITTALS

- A. Startup manager’s qualifications and past project experience including contact names, addresses and current telephone numbers of owner representatives that can be used to verify the accuracy of the information. Submittal shall be made at the preconstruction conference.
- B. Manufacturers’ field services representative’s qualifications and past project experience including contact names, addresses and current telephone numbers that can be used to verify the accuracy of the information.
- C. Qualification submittals shall be made 3 weeks before the manufacturer’s representative is scheduled to be on Site.
- D. Manufacturer’s certification of proper installation of all equipment as specified in the equipment sections.
- E. Equipment and system startup, testing, and commissioning plans and schedule in accordance with the requirements of this section. Startup manager shall coordinate with Subcontractors and include their information in the startup and testing plan.
- F. Daily logs with reports and photographs of all testing, startup and commissioning activities.
- G. No later than fourteen (14) days prior to testing, adjusting, and balancing of the first mechanical system, submit to the Owner and/or Engineer a complete schedule indicating when and by whom testing, adjusting, and balancing will be completed.
- H. Submit to the Owner and/or Engineer a final schedule of testing, adjusting and balancing listing times and dates for each system two (2) weeks prior to proposed dates.

- I. Prior to start of testing, adjusting, and balancing work, submit to Owner and/or Engineer the name of organization proposed to perform services. Designate Contractor's managerial responsibilities for coordination of entire testing, adjusting, and balancing.
- J. Submit to the Owner and/or Engineer documentation to confirm organization qualifications for testing, adjusting, balancing and start-up work.
- K. Submit to the Owner and/or Engineer three (3) preliminary specimen copies of each of the report forms proposed for use.
- L. Fourteen (14) days prior to either the Owner's Beneficial Use of the System or Substantial Completion, submit to Owner and/or Engineer three (3) copies of final testing, adjusting, and balancing reports.
  - 1. The Contractor shall prepare the overall report.
  - 2. Each Form shall bear signature of recorder, and that of supervisor of reporting organization.
  - 3. Identify each instrument used, and latest date of calibration of each.
  - 4. Report any defects or deficiencies noted during performance of services.
- M. Submit to the Owner and/or Engineer Representative reports of testing, adjusting and balancing which is postponed due to seasonal, climatic, occupancy, or other reasons beyond Contractor's control, promptly after execution of those services.
- N. Submit to the Owner and/or Engineer startup reports within one week after completion of demonstrations certifying that demonstrations and instructions have been satisfactorily completed. Give time and date of each demonstration, and hours devoted to demonstration, with a list of persons present.

#### 1.05 CONSTRAINTS

- A. Constraints. Startup and testing shall be conducted in a manner that does not compromise operation of the existing facilities or the quality of treated products released from the facility. Any startup and testing activities affecting operation of the existing facilities shall be coordinated with the Owner and shall be shown on the Progress Schedule. The Owner will cooperate with the Contractor to the extent possible, but will have sole authority in decisions affecting existing operations. Refer to Specification Section 01310 – Construction Progress Schedule for Project Parameters affected start-up scheduling and sequencing.

#### 1.06 REFERENCE STANDARDS (NOT USED)

#### 1.07 QUALITY ASSURANCE (NOT USED)

#### 1.08 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS (NOT USED)

#### 1.09 DELIVERY, HANDLING AND STORAGE (NOT USED)

#### 1.10 MAINTENANCE/SPARE PARTS (NOT USED)

#### 1.11 WARRANTY/EXTENDED WARRANTY (NOT USED)



#### 1.12 CONTRACTOR RESPONSIBILITIES

- A. The Contractor shall be responsible for and furnish all labor, materials, instruments, incidentals, and equipment required for startup, testing, and commissioning. The Owner will provide chemicals, fuel for generators, and water. Temporary facilities required to carry out the specified testing, including temporary pipe, pumps, and other appurtenances, shall be furnished and installed, and removed when no longer required for startup, testing, and commissioning. Refer to the Temporary Facilities section for requirements concerning water and power for startup and testing. Contractor shall provide the Owner at least 90-days notice prior to needing any fuel for generators or chemicals for startup or testing.
- B. Wastewater, including treated or test water that cannot be delivered to the system for any reason, shall be disposed of at the expense of the Contractor, in a manner acceptable to the Owner, and in accordance with all laws, regulations, and permits.
- C. Startup and testing shall be conducted during normal working hours during the workweek of Monday through Thursday only, unless otherwise approved by the Owner. Where continuous long-term testing is required, testing may continue over the weekends and holidays with prior approval from the Owner.
- D. Prepare each system for testing, adjusting, balancing, startup, and demonstration.
- E. Coordinate with testing organization or Manufacturer's Representative and provide access to equipment and systems. Operate systems at designated times, and under conditions required for proper testing, adjusting, balancing, demonstration and start-up.
- F. Notify testing organization, the Owner and/or Engineer seven (7) days prior to time, system will be ready for testing, adjusting and balancing.
- G. Prepare overall reports.

#### 1.13 TESTING ORGANIZATION'S RESPONSIBILITIES

- A. Comply with procedural standards of certifying association under whose standards service will be performed.
- B. Notify Owner in writing seven (7) days prior to beginning of operations.
- C. Accurately record data for each step during performance of services.
- D. Prepare the final testing, adjusting, and balancing reports for inclusion in Contractor's overall report.

#### 1.14 MANUFACTURERS' RESPONSIBILITIES

- A. The manufacturers shall provide a technically qualified field-service representative for the installation, startup, and testing of equipment furnished, as specified in the equipment sections. The manufacturer shall submit qualifications and experience records for all key personnel to be involved in startup activities.
- B. The manufacturer's field services representative shall be employed full-time in installation, startup, and testing of similar equipment and facilities and work directly for the manufacturer. The representative shall have conducted startup activities similar to those required herein on at least two other projects of similar complexity. The

Owner or Engineer shall have the right to reject the manufacturer's field services representative at any time, for immediate replacement by the manufacturer, if the accepted qualifications are not representative of the actual experience or abilities of the representative, as determined by the Owner or Engineer.

- C. Provide field services and authorized Manufacturer's representative as specified in Section 01640 or as required in the individual Sections.
- D. Demonstrate operation of equipment and systems, instruct Owner's personnel, and provide written report that demonstrations and instructions have been completed.
- E. Be present at site to inspect, verify, and approve equipment installation prior to startup.
- F. Supervise placing equipment in operation during startup.
- G. Provide a written report that equipment has been properly stored, installed and lubricated, is in accurate alignment, is free from any undue stress imposed by connecting lines or anchor bolts, and has been satisfactorily operated under full load conditions.
- H. Submit the Manufacturer's Certificate of Proper Installation form in Section 01640.

#### 1.15 OWNER'S RESPONSIBILITIES

- A. Chemicals, fuel for generators, and water required for startup and testing will be provided by the Owner.
- B. Owner will coordinate attendance of Owner's personnel at agreed-upon times for testing, adjusting, and balancing of systems, as needed.
- C. Owner will coordinate attendance of Owner's personnel at agreed-upon times for start-up and demonstration.



#### PART 2 PRODUCTS (NOT USED)

#### PART 3 EXECUTION

##### 3.01 STARTUP TEAM

- A. The Contractor shall maintain a dedicated startup team led by a startup manager. The individual to be designated as startup manager shall be identified within 45 days of the Notice to Proceed and will be reviewed by Owner and Engineer. Once accepted, the Contractor shall not change the startup manager throughout the full period of performance of the Work without written permission of the Owner. Once engaged in the Project, the startup manager shall attend regular construction progress meetings. No startup activities shall begin until the startup manager has arrived at the jobsite.
- B. The startup team shall include the startup manager and all staff deemed necessary for successful completion of startup, testing, and commissioning. This will typically include engineers, major equipment vendors, operators, and representatives from the Instrumentation and Control System Supplier. Additional trade representatives may be included as project requirements dictate.

### 3.02 STARTUP MANAGER

- A. The startup manager shall be on Site full time at least 30 days prior to any field startup and testing activities and shall remain on site until all startup, testing, and commissioning activities are complete.
- B. The Startup Manager shall have at least a Class D Wastewater Operators license issued by ODEQ.
- C. The startup manager shall be a project manager employed by the Contractor dedicated to the startup, testing, and commissioning activities, and be capable of starting up equipment and systems of similar type, size, capacity, and complexity to the equipment and systems included in this Project. The startup manager shall have the necessary experience to fully understand all startup requirements, to manage the Contractor's resources providing the startup services, and to prepare all startup documentation, as specified. The startup manager's assigned duties and responsibilities are those specifically related to planning, supervising, and executing startup activities and shall include, but shall not be limited to the following:
  - 1. Coordinating all testing and startup activities.
  - 2. Preparing all startup and field testing plans, documentation, and forms.
  - 3. Liaising between the Contractor, Engineer, and Owner for all startup and testing activities.
  - 4. Developing a comprehensive schedule for all startup activities and providing regular schedule updates. The startup and testing schedule shall be incorporated into the Progress Schedule.
  - 5. Scheduling and leading startup, testing, and commissioning planning meetings.
  - 6. Conducting coordination meetings during startup, testing, and commissioning at least weekly.
  - 7. Coordinating manufacturers' services and their certification of proper installation and/or operation of equipment as required by the Specifications.
  - 8. Overseeing and administering all startup, testing, and commissioning activities, including either direct participation in the activities and/or oversight and monitoring of activities. It shall be the startup manager's responsibility to assure that all tests have been completed in accordance with accepted testing procedures.
  - 9. Ensuring readiness for and coordinating maintenance, repair, and adjustment of equipment and systems during startup testing, and commissioning.
  - 10. Conducting or overseeing pre-test checks to ensure readiness for testing. Verify all piping hydrostatic testing and flushing has been completed prior to field testing connected equipment.
  - 11. Ensuring all testing equipment is in proper working order and has been calibrated to appropriate standards.
  - 12. Developing safe work policies and procedures including lockout/tagout procedures and personal protective equipment policies, that will be followed during all field startup and testing activities. At a minimum the Contractor shall comply with OSHA and the Owner's established safety guidelines. It shall be the startup manager's responsibility to assure all safety procedures are followed at all times.

13. Reviewing and approving all equipment training sessions prior to submission to Engineer, to assure that the training is compliant with the requirements of the Specifications and includes all applicable operation, maintenance, safety, functional, performance, and startup and testing information.
14. Organizing teams made up of qualified representatives of Suppliers, Subcontractors, and others, as appropriate, to efficiently and expeditiously startup and test the equipment and systems installed and constructed under this Contract. The objective of this program shall be to demonstrate to the Engineer and Owner that the structures, systems, and equipment constructed and installed under this Contract meet all performance requirements and the facility is ready for operation as intended. In addition, the testing program shall produce baseline operating conditions for the Owner to use in a preventive maintenance program.
15. Ensuring the development and maintenance of records documenting all startup, testing, and commissioning activity. The records shall be organized by major process system into organized files/binders and turned over to the Owner prior to applying for final payment. Testing records shall be accessible to the Engineer and Owner at all times to allow monitoring of the progress.
16. Ensuring the startup team is equipped and ready to make emergency repairs and adjustments to equipment installed and modified as part of the Project.
17. Scheduling and conducting a one day workshop with the Owner and Engineer to resolve submittal review comments to the Contractor's startup, testing, and commissioning plan submittal.
18. Notifying the Owner and all respective equipment manufacturers at least 21 days prior to the date when each equipment system is scheduled for pre-startup activities and checks.
19. Organize International Electrical Testing Association (NETA) acceptance testing in accordance with the Electrical Equipment Installation section.

### 3.03 STARTUP SCHEDULE AND COMMISSIONING PLANS.

- A. Plans and schedules shall be developed to facilitate coordinated and efficient startup, testing, and commissioning of the Project equipment and systems.
- B. The Contractor shall submit a startup, testing, and commissioning plan and schedule to the Engineer no later than 90 calendar days prior to the commencement of startup and testing. A minimum of 21 days shall be allowed for review by Engineer and Owner. The schedule and plan must be accepted a minimum of 30 days prior to commencement of startup and testing. The schedule and plan shall include sections for startup checks, functional testing, functional acceptance testing, and operational acceptance testing.
- C. Forms for startup and testing shall include identification of equipment or system, startup/test date, nature of startup/test, startup/test objectives, startup/test prerequisites, startup/test results, instruments employed for the startup/test and signature spaces for the Engineer's witness (where applicable) and the Contractor's startup manager.
- D. Startup Schedule. A startup schedule that provides an overall sequence and duration for all startup, testing and commissioning activities, shall be prepared and maintained. This schedule shall serve as a companion to but shall not be a replacement for the



startup plan. The startup schedule described in this section shall be integrated into the overall Progress Schedule and shall be prepared as specified for the Progress Schedule in the Construction Progress Schedule section. The Startup Schedule shall be updated weekly during the startup, testing, and commissioning period.

- E. Startup Plan. The Startup Plan shall include the following:
1. Introduction with a narrative description of the overall testing and startup program. The description shall include all contractual or regulatory treatment requirements to be demonstrated.
  2. A summary of the objectives and approach for startup checks, functional testing, functional acceptance testing, and operational acceptance testing.
  3. List of the instruments, equipment, and systems that will undergo startup and testing with references to the appropriate PIDs, equipment tags/identification numbers, Specification number and standards for testing procedures.
  4. Schedule for startup and field testing for each instrument, piece of equipment (including redundant equipment), and system.
  5. Safety and emergency response plan including a list of emergency and non-emergency contacts (email and phone).
  6. Organization chart for Contractor's startup and testing personnel with assigned responsibilities for each.
  7. Startup and testing record keeping plan.
  8. Plan for reuse and disposal of water/wastewater from startup, testing, commissioning including information on any required regulatory permits/approvals.
  9. Description of temporary facilities that will be provided. List of chemicals to be provided by the Owner.
  10. Within 7 to 14 days of initial submittal of the startup plan, the Contractor shall schedule a workshop with the Owner and Engineer to present the plan. The Contractor shall submit minutes of the workshop, including action items and a schedule for updating the startup plan, to the Engineer within 3 days of the workshop.
  11. Individual plans for each phase of startup, testing, and commissioning can be assembled as chapters in the startup plan or submitted as individual documents but should be correlated to ensure there is not disagreement between chapters or separate documents.
- F. Startup Checks Plan. The startup checks plan shall be subdivided into plans for each system and major component. Each system/major component plan shall include but not be limited to the following:
1. Identification of information for each component or piece of equipment to be inspected as part of the system. All applicable tag numbers shall be included.
  2. Specific activities to be completed on each component, piece of equipment, or system as required to demonstrate proper installation and connection.
  3. A tracking checklist of prerequisites for the checks and each step of the checking procedure, including any temporary facilities or utility requirements.
  4. Listing of manufacturer's representative(s) to be on site during the check. Sign off forms for the Contractor's startup manager.

- G. Functional Testing and Functional Acceptance Testing Plans. The functional testing plan shall include procedures and reporting for functional testing. The functional testing plan shall be subdivided into testing plans for each system. Each system test plan shall include but not be limited to the following:
1. A narrative description of the purpose and goals of the test for each component, piece of equipment, or system, which should include all activities (including those required by vendors/suppliers) necessary to verify proper equipment and system functionality.
  2. Identification of each component or piece of equipment to be tested as part of the system. All applicable tag numbers shall be included.
  3. Schedule and duration for the tests.
  4. Prerequisites for each test, including any temporary facilities or utility requirements.
  5. Pass/fail criteria for the test.
  6. A checklist for tracking testing progress which includes prerequisites for the test and each step of the testing procedure. The check list shall include specified performance criteria that are to be met.
  7. A description of test apparatus required to conduct the test.
  8. Identification of all temporary facilities and chemicals require during startup. Listing of manufacturer's representative(s) to be on site during the test.
  9. Certificates of proper installation, as applicable to the test.
  10. Step-by-step detailed procedure of the test. The level of detail shall be sufficient for a witness to be able to follow the steps during the test and be confident that the test is being performed as planned. All steps required to proceed through the test in an orderly manner are considered significant and each of these steps shall be included in the procedure.
  11. Copies of the data recording forms that will be used during the test.
  12. Calculation methodologies to be used to evaluate the data and/or test criteria for the test.
  13. Sample computations or analyses for the test with results in the same format as the final report. This item is intended to demonstrate how data collected will be used to generate final results. A sample shall be included for each type of computation required for the test and analysis of results.
  14. Blank sign-off forms for the test acknowledging the startup manager's, Engineer's, Owner's, and equipment manufacturer's acceptance of the test where applicable.
  15. The functional testing plan shall identify constraints for individual systems start up, and shall include the following:
    - a. Headworks,
    - b. Pump stations
    - c. Grit Facility
    - d. Aeration Basin
    - e. RAS Pumping
    - f. Secondary Clarifiers
    - g. Filter Systems
    - h. Reaeration System (Oxygenation System)

- i. Blower Systems
- j. Thickener Systems
- k. Onsite Chlorine Generation and Sodium Bisulfite Systems
- l. Generators
- m. Odor Control Systems

H. REPORTS AND RECORDS.

1. Records of all startup and testing shall be compiled by the Contractor and submitted to the Engineer. Prior to being submitted to the Engineer, the startup manager shall certify that the results recorded and the tested systems comply with the Contract requirements. Records shall include all documentation assembled for each piece of equipment or system involved in the startup and testing, including all certifications, forms, and check lists completed during the startup and test, and sign-off forms.
2. Records of all startup and testing shall be compiled as separate documents for each system tested, and shall be submitted within 48 hours of completion of the startup and testing for each system. Testing samples that require analysis periods greater than 48 hours shall be clearly defined in the startup plan but shall not preclude delivery of the balance of the records within the 48 hour timeframe.
3. The Contractor shall provide formal reporting and documentation of failures, malfunctions or defects, and repairs made during the startup and/or testing activities. A "System Problem Report" form is included at the end of this section, and shall be used by the Contractor to document problems that arise during these tests and their resolution. Records submitted shall include "System Problem Report" forms completed during testing.

3.04 PREPARATION PRIOR TO FUNCTIONAL TESTING AND DEMONSTRATION:

1. Inspect and clean equipment, devices, and connected piping so they are free of foreign material.
2. Lubricate equipment in accordance with manufacturer's instructions. Turn rotating equipment by hand.
3. Open and close valves by hand and operate other devices to check for binding, interference, or improper functioning.
4. Test and commission related electrical and control system components in accordance with the Division 16 and Division 17 sections requirements. All electrical testing shall be completed and approved by Engineer prior to testing of any mechanical equipment.
5. Calibrate all instruments associated with the equipment.
6. Check for proper rotation, adjustment, alignment, balancing, mechanical and electrical connections, and any other conditions that may damage or impair equipment from functioning properly.
7. Inspect and verify proper anchorage.
8. Obtain manufacturer's certification of proper installation where specified in the equipment sections.
9. All equipment shall be confirmed ready to test by the Engineer based on the following:

- a. Acceptance of Contractor's startup and testing plan.
  - b. Notification in writing by the startup manager that each piece of equipment or system is ready for testing.
  - c. Verification by the Engineer and Owner that all lubricants, tools, maintenance equipment, spare parts and approved equipment operation and maintenance manuals have been furnished as specified.
  - d. Cleanliness of equipment, devices, and connected work.
  - e. Adequate completion of work adjacent to or interfacing with equipment to be tested.
  - f. Confirmation of manufacturer's representative's availability to assist with testing, where specified, and satisfactory fulfillment of all other manufacturers' responsibilities as specified.
  - g. Engineer's inspection of all related civil construction, mechanical, and electrical installations.
  - h. Confirmation of completion of acceptable testing of all adjacent piping, duct work and other affected Work.
10. Verify installation of system to be tested is complete and in continuous operation.
  11. Verify ambient conditions and related facilities are in full operation.
  12. The Owner shall supply all water and/or chemicals required for testing, adjusting, balancing, demonstration, and startup of the systems. Any water used shall be potable or utility water, as required by the process or equipment being tested.
  13. Operate each system through the design performance range consistent with available flows. Adjust, balance, calibrate, and in general, check out the equipment, safety devices, controls, and process system within the design conditions.
  14. Submit preparation reports showing above items were addressed.



### 3.05 FUNCTIONAL TESTING AND DEMONSTRATION

#### A. Preparation

1. Verify equipment has been inspected and certified by the Manufacturer and put into operation in accordance with Section 01640 and items in Paragraph 3.04.
2. Verify equipment and systems are fully operational.
3. Have copies of completed operation and maintenance manuals at hand for use in demonstrations and instructions.
4. Submit schedule of systems demonstrations.

#### B. Procedure

1. All startup checks shall be completed prior to functional testing. Functional testing shall be in accordance with relevant standards and in accordance with instructions of the manufacturers.
2. Ancillary and/or temporary facilities necessary to recycle, control, or discharge water, air, chemical, or gas from facilities being tested, shall be operational.
3. Functional testing shall include the functional operation of each piece of equipment. All moving parts of equipment and machinery shall be tested and adjusted so that they move freely and function satisfactorily. Functional testing shall demonstrate correct operation of all hardwired interlocks and controls.

4. Functional testing of power actuated valves shall include at least 4 full open- close operations. Testing shall demonstrate the maximum number of operations per hour as recommended by the actuator manufacturer without overheating.
5. Once functional testing of individual pieces of equipment is completed, individual systems functional testing shall commence. Individual system functional testing shall include startup of the complete system of mechanical, electrical, and instrumentation and control equipment as a functional process system.
6. Check all instrumentation and control systems required to verify readiness for automatic operation of the individual system before commencement of individual system functional testing.
7. Individual system functional testing shall include operation in manual and automatic modes, startup operation, and shutdown in normal and emergency modes. Individual systems shall be tested over their entire operating range and for sufficient time to demonstrate the intended functionality of each piece of equipment and the system. If any part of a system shows evidence of unsatisfactory or improper operation during the test period, correction or repairs shall be made and the functional testing shall be repeated until satisfactory results are obtained.
8. Functional testing of all process and pumping equipment and drive motors, including auxiliary equipment, shall be in accordance with the appropriate and approved test codes, such as those specified by the American Society of Mechanical Engineers, Hydraulic Institute Standards, and IEEE.
9. Qualified personnel from the electrical and mechanical trades responsible for installation of the equipment, shall be available during functional testing involving electrically operated equipment. Where appropriate, a representative of the Control System Supplier shall also be available.
10. Demonstrate operation and maintenance of equipment and systems to Owner's personnel a minimum of two (2) weeks prior to 30-day verification testing.
11. Use operation and maintenance manuals as basis of instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.
12. Demonstrate startup, operation, control, adjustment, troubleshooting, servicing, maintenance, and shutdown of each item of equipment at agreed-upon times, at designated location(s).
13. The amount of time required for instruction on each item of equipment and system is that specified in equipment schedule or in individual sections.
14. Prepare and insert additional data in operations and maintenance manuals when need for additional data become apparent during instructions.
15. Submit system demonstration reports.

### 3.06 FUNCTIONAL ACCEPTANCE TESTING.

- A. Once the Contractor's functional testing is complete and associated documentation has been submitted and accepted by the Engineer, the Contractor shall conduct functional acceptance testing of each complete process system, to demonstrate individual systems meet the specified requirements. Acceptance testing shall include the successful demonstration of all operating functions and conditions that are specified

for the equipment, system, and controls. The manufacturer's representative shall be on Site during acceptance testing when specified in the equipment specifications.

- B. The Functional Acceptance Testing shall include the following submissions prior to commencement:
  1. Prerequisite checklist, to be acknowledged by the Engineer prior to initiating the test, that demonstrates that all testing and other Work required to be completed prior to the test is complete.
  2. Listing of Owner's personnel necessary to operate the system and conduct any related monitoring of performance.
  3. A listing of Contractor's personnel designated to supervise and direct the Owner's operators as required herein.
  4. Listing of standby personnel, equipment, and materials that will be available if needed during the test period.
  5. Step-by-step procedures for operation of the facility showing how local and remote control of equipment will be demonstrated.
  6. Description of all data and other information to be reported in support of the completed test. Include any blank data logs that may be used for recording results.
  7. Descriptions of all necessary calculations that must be completed to verify the specified results are being achieved, including formulas.
  8. Blank sign-off form for the test acknowledging the Contractor's, Engineer's, Owner's, and the equipment manufacturer's acceptance of the test.
- C. Contractor shall provide Owner and Engineer 14 days notice prior to testing of any individual system.
- D. Individual Functional Acceptance Testing shall continue for 80-hours without interruption for each system, and all parts shall operate satisfactorily in all respects under a range of conditions to simulate the full operating range of the equipment or system. If there are multiple parallel components or trains, then the testing duration will be 80-hours for each individual train.
- E. If any part of a system shows evidence of unsatisfactory or improper operation during the testing period, correction or repairs shall be made and the test repeated until the test is successfully completed. Testing interrupted by power failure will not be required to be repeated, but the test shall be continued upon restoration of power and extended to the specified duration at no additional cost to the Owner.
- F. During this testing period the Contractor shall operate all equipment.

### 3.07 EQUIPMENT STARTUP

- A. Inspection by Manufacturer's Representative:
  1. Verify that equipment installation complies with Manufacturer's and Contract requirements.
  2. Verify that status of Work meets requirements for starting of equipment and systems.
  3. Prepare a field inspection report as specified in Paragraph 1.04 and Certification of Proper Installation (CPI) as specified in Section 01640.

## B. Preparation:

1. Coordinate sequence for startup of various items of equipment and systems.
2. Provide confirmation notice to Owner seven (7) days prior to startup of each item of equipment.
3. Have Contract Documents, shop drawings, product data, and operation and maintenance data at hand during entire startup process.
4. Verify that each piece of equipment has been checked for proper lubrication, drive rotation, vibration, belt tension, control sequence, and other conditions which may cause damage.
5. Verify control systems are fully operational in automatic mode.
6. Verify that tests, meter readings, and specific electrical characteristics agree with those specified by electrical equipment Manufacturer.
7. Verify wiring to motors and controls required by mechanical work for operational smoke and fire protection demonstrations is complete.
8. Bearings: Inspect for cleanliness; clean and remove foreign matter. Verify alignment; take corrective measures.
9. Drives: Inspect for tension on belt drives, adjustment of varipitch sheaves and drives, alignment, proper equipment speed, and cleanliness. Take corrective action.
10. Motors: Verify that motor amperage agrees with nameplate value. Inspect for conditions which produce excessive current flow and which exist due to equipment malfunction. Take corrective action.

## C. Procedure:

1. The Contractor shall execute startup under supervision of responsible Manufacturer's Representative.
2. The Contractor shall place equipment in operation in proper sequence as per Manufacturer's recommendations.
3. Submit system startup report.

## 3.08 PROCESS STARTUP

- A. Overview of Process Start-Up Phase: Operating the facility to verify performance meets the Contract Document requirements.

## B. Process Start-Up:

1. Perform process start-up in the presence of the Engineer.
2. Pre-start-up activities:
  - a. Commissioning Documentation and Data Review.
  - b. Start-Up Go/No-Go Decision Criteria.
  - c. Building and Fire Inspection Compliance Check.
  - d. Process Start-Up Sequence Review.
    - (i) Submit a Process Start-Up plan for review by Engineer not less than 90 calendar days prior to planned commencement of process start-up activities.
    - (ii) Include the following:
      - (a) Pre-start-up activities.



- (b) Process Start-Up.
- (c) Process Operational Period.
- (d) Description of Temporary Testing Arrangement, if applicable.
- (e) Final Process Start-Up Forms and Documentations.
- (f) Final Operational Testing Plan.
- (iii) Control loop tuning. Perform control loop tuning during system testing with water to the extent possible.
- (iv) Process area start-ups.
  - (a) Process start-up individual process areas comprised of multiple interdependent systems where possible and beneficial to reduce complexity and risk of complete facility testing.
  - (b) Process area test flows may be limited by upstream and downstream process constraints (i.e., tank and basin volumes) and/or localized recirculation capabilities.
- (v) Facility-wide process start-up.
  - (a) Upon approved completion of pre-start-up activities, perform entire facility process start-up.
    - (1) Complete control loop tuning during this phase of process start-up.
    - (2) Continue process start-up operations until facility meets or exceeds the Contract requirements.
  - (b) Process control systems testing. Test complete system instrumentation, controls and PLC, and HMI programming for the facility.
  - (c) HVAC systems start-up and testing. Test complete HVAC system for the facility.
  - (d) Ancillary systems start-up and testing. Test complete security system, phone system, fire alarm system, etc. for the facility.
  - (e) Remaining equipment/system tests. Conduct remaining specified equipment/system performance tests that could not be performed during the Testing and Training Phase due to inter-system and/or treatment process dependencies.

C. Process Operational Period:

1. Prior to beginning the Process Operational Period:
  - a. Conformance with treatment standards is required prior to Operational Testing, if applicable. Biological processes require time to build up the necessary population of organisms to meet treatment standards
  - b. Correct any outstanding punchlist items prior to the Operational Testing.
  - c. Verification Period Duration: 30 calendar days.
  - d. Contractor to coordinate closely with Owner and Engineer during the process operational period.
  - e. Prove facility conformance with Contract Document requirements.
  - f. Contractor to provide: Specified start-up materials and operating supplies.

END OF SECTION



**SECTION 02515****PVC PRESSURE PIPE FOR TRANSMISSION WATER AND DISTRIBUTION (AWWA C900 AND AWWA C905)****PART 1 GENERAL****1.01 SCOPE OF WORK**

- A. Furnish all labor, materials, equipment, and incidentals required to install Polyvinyl Chloride (PVC) Pressure Pipe in accordance with the Contract Documents.

**1.02 RELATED WORK**

- A. Section 01300 – Submittal Procedures.
- B. Section 02223 – Trench and Excavation Safety Systems.
- C. Section 02225 – Trenching and Backfill.
- D. Section 02514 – Inspection and Testing of Water Utilities.
- E. Section 02530 – Dewatering and Drainage.
- F. Section 02675 – Disinfection of Potable Water Facilities.

**1.03 SUBMITTALS**

- A. Submit shop drawings and product data in accordance with Section 01300 – Submittal Procedures for:
  - 1. Piping layouts and schedules, including dimensioning, fittings, locations of valves, and appurtenances, joint details, and locations of thrust blocks.
  - 2. All data and information required for the complete installation of the piping systems. Dimensions shall be based on the existing field conditions and pipe laying schedule.
- B. Prior to shipment of pipe, submit certified test reports that the pipe for the Contract was manufactured and tested in compliance with ASTM and ANSI/AWWA Standards specified herein.
- C. Verifiable Certificate of Compliance with the NSF 61 Standard for all pipe and fittings.

**1.04 REFERENCE STANDARDS**

- A. American Water Works Association (AWWA):
  - 1. C104 – Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
  - 2. C111 – Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
  - 3. C153 – Ductile-Iron Compact Fittings
  - 4. C800 – Underground Service Line Valves and Fittings.
  - 5. C900 – Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 60 In. for Water Transmission and Distribution.



6. M23 – PVC Pipe–Design and Installation.

- B. American Society for Testing and Materials (ASTM):
1. ASTM B62 – Specification for Composition Bronze or Ounce Metal Castings.
  2. ASTM D1784 – Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
  3. ASTM D3139 – Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
  4. ASTM F477 – Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

1.05 QUALITY ASSURANCE

- A. PVC pipe and fittings shall be from a single Manufacturer. PVC pipe to be installed under this Contract may be inspected at the plant for compliance with these Specifications by an independent testing laboratory selected by the Owner. The Contractor shall require the Manufacturer's cooperation in these inspections. The cost of additional inspections deemed necessary by the Owner because of the failure of the pipe to meet the specification shall be borne by the Contractor.
- B. Inspection of the pipe will also be made by the Owner's Representative after delivery. The pipe shall be subject to rejection on account of failure to meet Specification requirements, even though pipes may have been accepted as satisfactory at the place of manufacture. Pipe rejected after delivery shall be marked for identification and shall immediately be removed from the job.
- C. Materials used in manufacture of the pipe shall be tested in accordance with the requirements of the referenced standards, as applicable.

1.06 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS (NOT USED)

1.07 DELIVERY, HANDLING AND STORAGE

- A. Pipe fittings and accessories shall be carefully inspected before and after installation and those found defective shall be rejected. Pipe and fittings shall be free from fins and burrs. Before being placed in position, pipe, fittings, and accessories shall be cleaned, and shall be maintained in a clean condition. Proper facilities shall be provided for lowering sections of pipe into trenches. Under no circumstances shall pipe, fittings or any other material be dropped or dumped into trenches.
- B. Store pipe, fittings, and accessories at the site in unit packages provided by the manufacturer. Exercise caution to avoid damage or deformation of the pipe. Store pipe in such a way as to prevent sagging or bending and be protected from exposure to direct sunlight by covering with an opaque material while permitting adequate air circulation above and around the pipe. Store gaskets in cool, dark place out of the direct rays of the sun, preferably in original cartons.

## 1.08 MAINTENANCE/SPARE PARTS (NOT USED)

## 1.09 EXTENDED WARRANTY (NOT USED)

## PART 2 PRODUCTS

## 2.01 POLYVINYL CHLORIDE WATER MAIN PIPE

- A. Polyvinyl chloride water main pipe shall comply with the requirements of AWWA C-900 for sizes 4" through 60". PVC pipes 12" and smaller shall have a dimension ratio of 14. PVC pipes larger than 12" shall have a dimension ratio of 18. The pipe shall be fabricated from virgin PVC resin that has been compounded to provide physical and chemical properties that equal or exceed cell Class 12454-B as defined in ASTM D1784. Each pipe length shall be marked with the Manufacturer's name or trademark, size, material code, pressure rating, AWWA designation number and seal of test agency that verified pipe material for potable water service.
- B. The pipe shall be manufactured with integral bell and spigot joints. An elastomeric ring complying with ASTM D3139 and ASTM F477 shall be a Reiber style locked in place gasket in the bell end of the pipe. The wall thickness of the bell shall be at least as great as that of the pipe barrel.
- C. Fittings shall be cast or ductile iron complying with AWWA C153 for mechanical joints. Adaptors, fittings, and transition gaskets necessary to connect cast or ductile iron fittings to PVC pipe shall be furnished.
- D. All fittings shall be lined and coated in accordance with Section 15072 - Ductile Iron Pipe and Fittings. Each fitting shall be clearly labeled to identify its size and pressure class.
- E. Service Saddles: The service saddle shall have a brass body conforming to ASTM B62. Double straps shall be 18-8 Type 304 stainless steel. Nuts and washers shall be 18-8 Type 304 stainless steel coated to prevent galling. Gasket shall be Neoprene rubber. Epoxy coat stainless steel band and bolts. The threads shall have a taper and pitch in accordance with AWWA C800.



## 2.02 DETECTABLE UNDERGROUND WARNING TAPE

- A. The material and ink shall be chemically inert and shall not degrade when exposed to acids, alkalis and other destructive substances likely to be encountered in soil.
- B. Minimum thickness and width of tape shall be 5 mils and 6-inch respectively. Tape shall include a 0.35 mil solid aluminum foil core.
- C. The tape shall be imprinted continuously over entire length with 1-inch high permanent black lettering.
- D. Acceptable Manufacturers:
  - 1. Reef Industries; Terra Tape
  - 2. Presco; Detectable Underground Warning Tape

## PART 3 EXECUTION

### 3.01 INSTALLATION

- A. Trench excavation and backfill shall conform to the requirements of Section 02225 - Trenching and Backfilling.
- B. PVC pipe shall be installed in accordance with the requirements of AWWA Manual M23 and the manufacturer's installation guide. Whenever the provisions of this Section and the requirements of referenced standards are in conflict, the more stringent provision will apply.
- C. Bell and spigot pipe shall be laid with the bell end pointing in the direction of laying. Pipe shall be graded in straight lines, taking care to avoid the formation of any dips or low points. Pipe shall not be laid when the conditions of trench or weather are unsuitable. At the end of each work day, open ends of pipe shall be closed temporarily with wood blocks or bulkheads.
- D. Pipe shall be laid at its designed elevation and grade. Care shall be taken to support the pipe uniformly. The entire length of the pipe and fittings shall rest firmly on the pipe bed, with recessed excavation to accommodate bell joints.
- E. Short lengths of pipe shall be used in and out of each rigid joint or rigid structure.
- F. Pipe shall be cut by means of saws, power driven abrasive wheels, or pipe cutters which will produce a square cut. After cutting, the end of the pipe shall be beveled using a beveling tool, portable sander, or abrasive disc.
- G. Prior to installation, each pipe length shall be carefully inspected, flushed clean of any debris or dust, and straightened, if not true. All pipe fittings shall be equally cleaned before assembly.

### 3.02 PIPE JOINTS

- A. Push-on Joints: Joints shall be made in strict compliance with the manufacturer's instructions. Pipe shall be laid with bell ends looking ahead. The gasket and spigot shall be cleaned and lubricant shall be properly applied. A rubber gasket shall be inserted in the groove of the bell end of the pipe, and the joint surfaces cleaned and lubricated. The plain end of the pipe to be entered shall than be inserted in alignment with the bell of the pipe to which it is to be joined, and pushed home with a come-along or by other means. Check that the reference mark on the spigot end is flush with the end of the bell. Over insertion is not allowed.
- B. Mechanical Joint Fittings: Mechanical joints at valves, fittings, and where designated shall be installed in accordance with the "Notes on Method of Installation" under AWWA C111 and the instructions of the manufacturer. Suitable PVC to cast iron adaptors shall be installed prior to installing fittings. PVC beveled spigot shall be cut flush prior to insertion in mechanical joints. To assemble the joints in the field, the Contractor shall thoroughly clean the joint surfaces and rubber gasket with soapy water before

tightening the bolts. Bolts shall be tightened to the specified torques. Under no condition shall extension wrenches be used to provide greater leverage.

### 3.03 SERVICE CONNECTIONS

- A. Direct tapping will not be allowed for service connections. Double strap bronze service clamps shall be used for all service connections. Service clamps shall have a bearing area of sufficient width along the axis of the pipe, so that the pipe will not be distorted when the saddle is made tight. An internal shell cutter shall be used to drill through the corporation stop to minimize PVC shavings, retain the coupon, and reduce stress. Lubricate the cutting and tapping edges of the tool with cutting lubricant. Make the cuts slowly and use the follower very lightly. Do not force cutter through pipe wall. Shell cutter shall have sufficient throat depth to handle the heavy wall PVC pipe. Maximum outlet size permitted with service clamps or saddle is 2-inch.

### 3.04 THRUST BLOCK

- A. Concrete thrust blocks shall be installed at all fittings and other locations for buried unrestrained pipe. Thrust force shall be calculated using the field test pressure or pressure rating of the pipe whichever is greater. Minimum bearing area shall be calculated in accordance with Manual M23. The soil bearing capacity and safety factor to be used for calculation shall be 1,000 lb/ft<sup>2</sup> and 1.5, respectively. Concrete shall be placed against undisturbed material, and shall not cover joints, bolts or nuts, or interfere with the removal of any joint. Wooden side forms shall be provided for thrust blocks.

### 3.05 CONNECTIONS TO EXISTING PIPELINES

- A. Connections to existing pipes shall be made using suitable joints and fittings for the conditions encountered. Each connection with an existing pipe shall be made at the time and under conditions which will least interfere with normal operation. Connections with buried existing flanges shall require removal of grout from the flanges. Remove concrete thrust block when encountered for connections to the existing pipes.
- B. Facilities shall be provided for proper dewatering and for disposal of all water removed from the dewatering lines and excavations without damage to adjacent property.
- C. Existing valves will leak when in closed position. Contractor shall provide whatever means and equipment necessary to control water during construction.

### 3.06 DETECTABLE UNDERGROUND WARNING TAPE

- A. Detectable underground warning tape shall be installed within the final backfill of the trench at a maximum bury depth of 24-inch. The tape shall be installed in accordance with the manufacturer's instructions.

### 3.07 FIELD TESTING

- A. Field Testing: All piping systems shall be pressure tested as specified in Section 15002 – Field Testing of Piping Systems. Where no pressures are indicated, the pipes shall be

subject to 1-1/2 times the maximum working pressure. The Contractor shall furnish all test equipment, labor, materials, and devices at no extra cost to the Owner.

3.08 CHLORINATION OF PIPELINES

- A. Pipelines designated to carry potable or utility water shall be chlorinated as per Section 02675 – Disinfection of Water Utility Piping System.

END OF SECTION

**SECTION 02535**  
**PVC WASTEWATER PIPE**

**PART 1 GENERAL**

**1.01 SCOPE OF WORK**

- A. The work to be performed under this section of the specifications shall consist of furnishing and installing polyvinyl chloride pipe and fittings for gravity wastewater flow, including all clearing, grubbing, excavation, dewatering, pipe laying, jointing, backfilling, and any other work that is required or necessary to complete the installation as shown on the Contract Drawings and as specified herein.
- B. This section covers gravity wastewater pipe sizes from 4 to 48 inch in diameter.

**1.02 RELATED WORK**

- A. Section 01300 – Submittal Procedures.
- B. Section 02223 – Trench Shielding.
- C. Section 02225 – Trenching and Backfill.
- D. Section 02600 – Temporary Bypass Pumping.

**1.03 SUBMITTALS**

- A. Submittals shall be in accordance with Division 1.
- B. Submit product data on pipe, fittings, gaskets and appurtenances.
- C. Certificates: Pipe manufacturer shall submit a certificate that the pipe is manufactured, sampled, tested, and inspected in accordance with this specification, and has been found to meet the requirements. Certificate shall be signed by an authorized agent of the manufacturer.
- D. Submit Field Test Reports including Television Inspection CDs and run sheets.

**1.04 REFERENCE STANDARDS**

- A. American Water Works Association (AWWA):
  - 1. C104 – Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
  - 2. C111 – Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
  - 3. C153 – Ductile-Iron Compact Fittings.
  - 4. C800 – Underground Service Line Valves and Fittings.
  - 5. C900 – Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 60 In. for Water Transmission and Distribution.
  - 6. M23 – PVC Pipe—Design and Installation.



- B. American Society for Testing and Materials (ASTM):
  - 1. ASTM B62 – Specification for Composition Bronze or Ounce Metal Castings.
  - 2. ASTM D1784 – Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
  - 3. ASTM D3139 – Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
  - 4. ASTM F477 – Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

#### 1.05 QUALITY ASSURANCE

- A. PVC pipe and fittings shall be from a single manufacturer. The quality of all materials, the process of manufacture, and finished pipe shall be subject to the inspection and approval by the Owner's Representative. Such inspection may be made at the place of manufacture, or on the work site after delivery, or at both places, and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements even though some sample pipes may have been accepted as satisfactory at the place of manufacture. Pipe rejected after delivery shall be marked for identification and shall be removed from the site at once.
- B. Contractor shall require the manufacturer to mark the date of extrusion on the pipe. This shall be done in conjunction with records to be held by the manufacturer for 2 years, covering quality control tests, raw material batch number, and other information deemed necessary by the manufacturer.

#### 1.06 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS (NOT USED)

#### 1.07 DELIVERY, HANDLING, AND STORAGE

- A. Care shall be exercised during loading, transporting, and unloading pipe and fittings to prevent damage to these items. Items shall be examined before installation. No piece shall be installed which is found defective. Handling and installation of pipe and fittings shall be in accordance with the Manufacturer's instructions, referenced standards and as specified.
- B. Pipe shall be adequately supported from below at no more than 3 ft. intervals to prevent deformation during storage. Pipe shall not be stacked more than 5 ft. high. Pipe and fittings shall be stored in a manner which will keep them at ambient outdoor temperature and out of sunlight. Provide temporary shading to meet this requirement. Protect pipe and fittings with canvass or other opaque material from sunlight. Clear plastic will not be allowed to protect the pipe and fittings from sunlight. Provide air circulation under the protective cover.



#### 1.08 MAINTENANCE/SPARE PARTS (NOT USED)

#### 1.09 WARRANTY/EXTENDED WARRANTY (NOT USED)



## PART 2 PRODUCTS

### 2.01 PIPE

- A. Polyvinyl chloride pipe shall comply with the requirements of AWWA C-900 for sizes 4" through 60". PVC pipes shall have a dimension ratio of 25. The pipe shall be fabricated from virgin PVC resin that has been compounded to provide physical and chemical properties that equal or exceed cell Class 12454-B as defined in ASTM D1784. Each pipe length shall be marked with the Manufacturer's name or trademark, size, material code, pressure rating, AWWA designation number and seal of test agency that verified pipe material for potable water service. 
- B. The pipe shall be manufactured with integral bell and spigot joints. An elastomeric ring complying with ASTM D3139 and ASTM F477 shall be a Reiber style locked in place gasket in the bell end of the pipe. The wall thickness of the bell shall be at least as great as that of the pipe barrel.
- C. Fittings shall be cast or ductile iron complying with AWWA C153 for mechanical joints. Adaptors, fittings and transition gaskets necessary to connect cast or ductile iron fittings to PVC pipe shall be furnished. 
- D. All fittings shall be lined and coated in accordance with Section 15072 - Ductile Iron Pipe and Fittings. Each fitting shall be clearly labeled to identify its size and pressure class.
- E. For drain pipe under building, pipe shall be Schedule 80 PVC and shall be encased in concrete.

### 2.02 DETECTABLE UNDERGROUND WARNING TAPE

- A. The material and ink shall be chemically inert and shall not degrade when exposed to acids, alkalis and other destructive substances likely to be encountered in soil.
- B. Minimum thickness and width of tape shall be 5 mils and 6-inch respectively. Tape shall include a 0.35 mil solid aluminum foil core.
- C. The tape shall be imprinted continuously over entire length with 1-inch high permanent black lettering.
- D. Acceptable Manufacturers:
  - 1. Reef Industries; Terra Tape
  - 2. Presco; Detectable Underground Warning Tape

## PART 3 EXECUTION

### 3.01 PIPE INSTALLATION

- A. Pipe shall be installed in compliance with current ASTM Designation D2321 and the Manufacturer's installation guide.
- B. Trenching and backfill shall conform to Section 02225 – Trenching and Backfilling.

- C. The laying of pipes shall commence at the lowest point so that the spigot ends point in the direction of flow. All pipes shall be laid with ends abutting and true to line and grade. The pipe shall be matched so that when laid, they will form a sewer with a smooth, uniform invert. Sockets shall be carefully cleaned before pipes are lowered into trenches. Tight fitting stoppers or bulkheads shall be securely placed in the ends of all pipe lines when the work is stopped temporarily, or at the end of each day's work, to prevent trash or dirt entering the pipe.
- D. All pipe lines shall be installed to the lines and grades as indicated on the Contract Drawings.
- E. Manhole connections shall be made using elastomeric gaskets or boot type connectors.
- F. Sanitary sewers shall be located horizontally at least:
  - 1. 50 feet from petroleum product tanks unless constructed of ductile iron pipe which shall be no closer than 10 feet (joint material shall be resistant to petroleum products);
  - 2. 300 feet from a public water supply well;
  - 3. 50 feet from a private water well;
  - 4. 10 feet from any existing or proposed water main; and
  - 5. 5 feet from electrical lines and petroleum lines.
- G. Sanitary sewers shall be located vertically at least:
  - 1. 24 inches above or below water mains, and the crossing section centered so that the joints will be as far as possible from the water mains.

### 3.02 DETECTABLE UNDERGROUND WARNING TAPE

- A. Detectable underground warning tape shall be installed within the final backfill of the trench at a maximum bury depth of 24-inch. The tape shall be installed in accordance with the manufacturer's instructions.

### 3.03 FIELD TESTING

- A. All gravity wastewater pipes and service laterals shall be tested for exfiltration or low-pressure air test. Deflection test shall be performed for all gravity wastewater pipes in addition to the above tests.
- B. Field testing shall be performed in accordance with Section 15002 – Field Testing of Piping System.
- C. Television Inspection
  - 1. All wastewater pipelines shall be subject to television inspection by Contractor.
  - 2. The Contractor shall employ a firm qualified in this type of work to make the television inspection. Experienced personnel shall perform the inspection by closed

circuit color television. A CD and suitable log shall be submitted to the Owner after television inspection of the pipe. CD shall include voice description, as appropriate with stationing of services indicated. Data and stationing shall be included on video. The Engineer must be present during the Contractor's television inspection, unless otherwise authorized by Owner.

3. All CDs and run sheets shall be given to the Owner's Representative for storage and inspection by the Owner. All CDs and run sheets will become the property of Owner. Should any portion of the inspection CDs be of inadequate quality or coverage, as determined by the Owner, the Contractor will have the portion re-inspected and video at no additional expense to the Owner.
4. If repairs are required, another television inspection must be made after the repairs are completed at no additional cost to the Owner.
5. The video(s) and run sheets should be furnished directly to the Owner not to the Contractor. The firm must attach a decal to the CDs that states the following and signed by the officer of the firm: "I certify this CD represents all or a part of the television inspection performed on Contract No. XXXXX and has not been altered or changed in any manner."
  - a. Equipment, Video and Run Sheet Requirements. Video must be compatible with the Owner's equipment. All information gathered must be legible, easily read or viewed, and of high quality. All television equipment used shall have at least 250 lines of horizontal resolution. The picture shall be in color. The operator shall indicate following by voice on the video.
    - (i) Date and time the recording was made.
    - (ii) Contractor's name, project name, and contract number.
    - (iii) Name of the company performing the television inspection and the name of the operator.
    - (iv) Location, designation, and size of the main and the direction in which the test was made.
    - (v) Identify every 50-foot station.
    - (vi) Identify the station of each manhole.
    - (vii) Identify the location and station of deficiencies.
    - (viii) Identify the location and direction of entry of laterals.
    - (ix) A run sheet, compatible with the video, must be made noting deficiencies.
  - b. Television Inspection Special Procedures. Camera lens path shall follow the center of the pipeline. If the test is being run from manhole to manhole, the camera shall move downstream. If the test is being run from manhole to cleanout, the camera shall move upstream.
  - c. All wastewater pipes must be laced with enough water to fill all low points. The television inspection must be done immediately following the lacing of the pipe with no water flow. Allowable standing water depths at the end of construction for 6-in. through 24-in pipes shall be no greater than 1/2-in. for grade less than 0.7% and no standing water for grade 0.7% and greater. The Owner will determine if corrective action is required for not meeting above criteria.
  - d. Criteria for Acceptance of TV-Inspected Pipe. Acceptance criteria for TV-inspected wastewater lines shall be as follows:
    - (x) No pulled or slipped joints.

- (xi) No water infiltration.
- (xii) No cracked or damaged pipe.
- (xiii) No structural damage to the pipe.
- (xiv) Wastewater lines are clean.
- (xv) The Owner will decide if repairs are required for not meeting above acceptance criteria. The Owner's decision will be final. Repairs shall be made at no additional cost to the Owner.

END OF SECTION

## SECTION 03300

### CAST-IN-PLACE CONCRETE

#### PART 1 GENERAL

##### 1.01 SCOPE OF WORK

- A. This section contains all requirements for cast-in-place structural concrete.

##### 1.02 RELATED WORK

- A. Coordinate the requirements of this section with all other sections of Division 3 – Concrete.

##### 1.03 SUBMITTALS

- A. Submittals shall be made in accordance with all the requirements of the General Conditions and the Contract Documents.
- B. Submit for review a proposed design mix for each concrete strength and class required by these Specifications. Failure to include any items of information noted in this paragraph for a given concrete strength or type will be cause for requirement of a resubmittal. Information to be submitted for each strength and class shall include the following items:

1. Concrete mix design
  - a. Constituent quantities per cubic yard.
  - b. Sources of all concrete mix components including coarse aggregate, fine aggregate, cement, water, admixtures, and pozzolans where included.
  - c. Cement type and manufacturer, include chemical analysis (mill test report) for each cement type to be used.
  - d. Pozzolan type and source; include chemical analysis for each pozzolan type to be used.
  - e. Water/cement ratio, by weight.
  - f. Air content
  - g. Mix design slump.
  - h. Average compressive strengths conforming to the requirements of ACI 318 at 28 days. Provide both average strengths and sample standard deviation. Provide results at 7 and 14 days if available.
  - i. Laboratory shrinkage test results for concrete mix designs, where specified.
2. Aggregate:
  - a. Laboratory sieve analysis, conforming to ASTM C33.
  - b. Verification that aggregate is not "deleterious," or "potentially deleterious." Provide documentation or other certification that aggregate does not contain deleterious substances and has been used without issues on previous projects.
3. Admixtures. Submit Manufacturer's data brochures on all admixtures proposed for use and provide certification of compliance with specified ASTM standards for each admixture.

- C. Submit concrete placement drawings showing pour sequence, lift numbers, locations of all joints, concrete mix being placed, concrete finishes, and all pertinent embedments including embedded plates, sleeves, pipes, conduits, anchors, etc., where applicable. Where the Drawings permit the Contractor to select joint locations, show the selected dimensions on the placement drawings. Approval of the placement drawings shall not relieve the Contractor of the responsibility of placing all concrete and embedments as specified.
- D. If cold weather or hot weather concrete conditions are anticipated on the Project, submit a work plan for cold weather concreting and/or for hot weather concreting, describing proposed methods and procedures for mixing, delivering, placing, finishing, and curing concrete. Submit plans well in advance of cold or hot weather job conditions. Include procedures to be implemented upon abrupt changes in weather conditions or due to equipment failures. If a plan for either is not submitted and cold or hot weather concrete conditions are present, the Contractor will not be allowed to pour concrete until a plan is received and reviewed as long as cold or hot weather conditions are present on the Project.
- E. Furnish a delivery ticket for ready mixed concrete to the Owner's Representative as each truck arrives. Each ticket shall provide a printed record of the weight of cement batched and each separate aggregate individually batched. Use the type of indicator that returns for zero punch or returns to zero after a batch is discharged. Clearly indicate the weight of fine and coarse aggregate, cement, and water in each batch, the quantity delivered, the time any water is added, and the numerical sequence of the delivery. Show the time of day batched and time of discharge from the truck. Indicate the number of revolutions of mix trucks.
- F. Submit Manufacturer's data sheets and product specifications for curing compounds and items specified in other Sections including form release agents, bonding agents, etc. Identify the locations where each will be used in the Work as a part of the submittal.
- G. Submitted data shall demonstrate compliance with all requirements of this Specification or deviations shall be clearly noted.

#### 1.04 REFERENCE STANDARDS

- A. American Society for Testing and Materials (ASTM).
  - 1. ASTM C31: Standard Practice for Making and Curing Concrete Test Specimens in the Field
  - 2. ASTM C33: Standard Specification for Concrete Aggregates
  - 3. ASTM C39: Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
  - 4. ASTM C42: Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
  - 5. ASTM C87: Standard Test Method for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar
  - 6. ASTM C94: Standard Specification of Ready-Mixed Concrete

7. ASTM C109: Standard Test Method for Compressive Strength of Hydraulic Cement Mortars
8. ASTM C125: Terminology Relating to Concrete and Concrete Aggregates
9. ASTM C143: Standard Test Method for Slump of Hydraulic Cement Concrete
10. ASTM C150: Standard Specification for Portland Cement
11. ASTM C156: Standard Test Method for Water Retention Through Liquid Membrane-Forming-Curing Compounds for Concrete
12. ASTM C171: Standard Specification for Sheet Materials for Curing Concrete
13. ASTM C172: Standard Practice for Sampling Freshly Mixed Concrete
14. ASTM C173: Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
15. ASTM C191: Standard Test Method for Time of Setting of Hydraulic Cement by Vicat Needle
16. ASTM C192: Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
17. ASTM C231: Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
18. ASTM C260: Standard Specification for Air-Entraining Admixtures for Concrete
19. ASTM C293: Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading)
20. ASTM C309: Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
21. ASTM C330: Standard Specification for Lightweight Aggregates for Structural Concrete
22. ASTM C494: Standard Specification for Chemical Admixtures for Concrete
23. ASTM C595: Standard Specification for Blended Hydraulic Cements
24. ASTM C579: Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes
25. ASTM C580: Standard Test Method for Flexural Strength and Modulus of Elasticity of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes
26. ASTM C595: Standard Specification for Blended Hydraulic Cements
27. ASTM C618: Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
28. ASTM C683: Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
29. ASTM C806: Standard Test Method for Restrained Expansion of Expansive Cement Mortar

30. ASTM C827: Standard Test Method for Change in Height at Early Stages of Cylindrical Specimens of Cementitious Mixtures
31. ASTM C845: Standard Specification for Expansive Hydraulic Cement
32. ASTM C856: Standard Practice for Petrographic Examination of Hardened Concrete
33. ASTM C878: Standard Test Method for Restrained Expansion of Shrinkage-Compensating Concrete
34. ASTM C989: Standard Specification for Slag Cement for Use in Concrete and Mortars
35. ASTM C1017: Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
36. ASTM C1077: Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
37. ASTM C1107: Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-Shrink)
38. ASTM C1157: Standard Performance Specification for Hydraulic Cement
39. ASTM C1218: Standard Test Method for Water-Soluble Chloride in Mortar and Concrete
40. ASTM C1240: Standard Specification for Silica Fume used in Cementitious Mixtures
41. ASTM C1260: Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
42. ASTM C1293: Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction
43. ASTM C1602: Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
44. ASTM E329: Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection

B. American Concrete Institute (ACI).

1. ACI 117: Specification for Tolerances for Concrete Construction and Materials and Commentary
2. ACI 211.1: Standard Practice for Selecting Proportions for Normal, Heavy-weight and Mass Concrete.
3. ACI 214: Guide to Strength Test Results of Concrete
4. ACI 223: Guide for the Use of Shrinkage Compensating Concrete
5. ACI 301: Specification for Structural Concrete
6. ACI 302.1: Guide for Concrete Floor and Slab Construction
7. ACI 304: Guide for Measuring, Mixing, Transporting & Placing Concrete
8. ACI 304.2R: Placing Concrete by Pumping Methods



9. ACI 305R: Guide to Hot Weather Concreting
10. ACI 305.1: Specification for Hot Weather Concreting
11. ACI 306R: Guide to Cold Weather Concreting
12. ACI 306.1: Standard Specification for Cold Weather Concreting
13. ACI 308: Guide to Curing Concrete
14. ACI 308.1: Specification for Curing Concrete
15. ACI 309: Guide for Consolidation of Concrete
16. ACI 318: Building Code Requirements for Structural Concrete.
17. ACI 350: Code Requirements for Environmental Engineering Concrete Structures

#### 1.05 QUALITY ASSURANCE

- A. Installer Qualifications:
  1. An experienced installer who has completed concrete work of similar scope and complexity with similar materials as found on this Project.
- B. Manufacturer's Qualifications:
  1. An experienced manufacturer of ready-mixed concrete products complying with ASTM C94 requirements for production facilities and equipment. Manufacturer must be certified by the National Ready Mix Concrete Association's Certification of Ready Mixed Concrete Production Facilities.
- C. Testing Agency Qualifications:
  1. An experienced independent testing agency, acceptable to authorities having jurisdiction and the Engineer that is qualified according to ASTM C1077 and ASTM E329 to conduct the testing indicated.
- D. Source Limitations:
  1. Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, each aggregate from a single source and each admixture from the same manufacturer.
  2. Sources of materials may not be changed during the Project without prior written approval of the Engineer.
- E. Concrete Consistency
  1. Test for slump shall be performed at the job site immediately prior to placing in accordance with ASTM C143. Slump tests shall be performed for each batch of concrete to indicate workability and consistency from batch to batch.
  2. If the slump is outside the allowed limits, the concrete shall be rejected. Concrete showing either poor cohesion or poor coating of the coarse aggregate with paste shall be remixed or rejected.

3. If the slump is within the allowable limit, but excessive bleeding, poor workability, or poor finishability are observed, the concrete shall be rejected and changes in the concrete mix shall be made only by an adjustment of one or more of the following:
  - a. The gradation of aggregate.
  - b. The proportion of fine and coarse aggregate.
  - c. The percentage of entrained air, within the allowable limits.

F. Concrete Temperature

1. Concrete temperature shall be taken immediately before placement with the point of measurement being in the chute or bucket.
2. Perform temperature test for each batch and record result on batch ticket.
3. If fresh concrete temperature does not meet requirements in this section the concrete shall be rejected.

G. Concrete Air Content

1. Test for air content shall be made on a fresh concrete sample for each batch prior to placing in forms.
2. Air content for concrete made of ordinary aggregates having low absorption shall be made in accordance with either ASTM C231, or ASTM C173. If light weight aggregates or aggregates with high absorptions are used, use ASTM C173.
3. If air content of fresh concrete does not meet requirements specified in this Section, the concrete shall be rejected. Do not place concrete that does not meet the air entrainment requirements of this Section.

H. Compressive Strength

1. Compression test specimens shall be made, cured and tested in accordance with ASTM C31 and ASTM C39.
2. Compressive strength tests shall be made on cylinders at 7 and 28 days. The value of each test result shall be the average compressive strength of a minimum of 2 cylinders taken at the same time from the same batch of concrete.
3. Compressive test specimens shall be 6" x 12" cylinders; 4" x 8" cylinders are not permitted.
4. Sets of concrete test cylinders shall be cast for each concrete pour as follows.
  - a. A "set" of test cylinders consists of a minimum of six cylinders, two to be broken and strengths averaged at seven days; and two broken and strengths averaged at 28 days. Two hold cylinders will remain unbroken so that they will be available to be broken upon unforeseen circumstances or upon the option of the Engineer to break cylinders at different times.
  - b. A minimum of one "set" of cylinders will be made for each concrete pour up to 25 CY in volume. For pours larger than 25 CY, additional "sets" of cylinders will be made for each additional 25 CY of concrete poured.
5. Evaluation of compressive strength for compliance with design requirements will be conducted by the Engineer per ACI 318 – Section 26.12 based on the results of the 28 day test.

# I. Failure to Meet Requirements

1. The Owner may withhold payment for any section of concrete which does not meet the requirements of the Plans and Specifications. Withheld payment shall be based upon unit prices established for concrete, if available. Payment shall be withheld until the unacceptable concrete has been repaired or removed and replaced or otherwise brought into conformance with the Plans and Specifications.
2. Concrete Strength
  - a. If the 28 day strength test results fall below required values, additional curing may be performed and test cores may be obtained in accordance with ASTM C42 with approval of the Engineer. Additional curing, core removal and testing, if allowed by the Engineer, shall be at the Contractor's expense.
  - b. If the strength results from test cores do not exhibit the required strength, the Engineer or Owner's Representative reserves the right to require strengthening, replacement of substandard materials and/or additional testing at the Contractor's expense. The choice of remedy is at the sole discretion of the Engineer or Owner's Representative.
3. Other Concrete Properties
  - a. If concrete properties besides strength do not meet required values, the Engineer may require concrete samples to be obtained in accordance with ASTM C42 and evaluated in accordance with ASTM C856 at the Contractor's expense.
  - b. If concrete properties besides strength do not meet required values, and the results of additional examination per ASTM C856 are deemed unsatisfactory at the sole discretion of the Engineer, the Owner reserves the right to require strengthening, replacement of substandard materials and/or additional testing at the Contractor's expense.

## 1.06 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS (NOT USED)

## 1.07 DELIVERY, HANDLING AND STORAGE

- A. Cement: Store cement in watertight buildings, bins or silos to provide protection from dampness and contamination. Improperly stored cement shall not be used. No cement shall be used that has been stored on the site for more than 90 days or that is lumped or caked.
- B. Aggregate: Arrange and use aggregate stockpiles to avoid excessive segregation or contamination with other materials or with other sizes of like aggregates. Build stockpiles in successive horizontal layers not exceeding three feet in thickness. Complete each layer before the next is started. Do not use frozen or partially frozen aggregates.
- C. Sand: Before using, allow sand to drain until a uniform moisture content is reached.
- D. Admixtures: Store admixtures to avoid contamination, evaporation or damage. For those used in the form of suspensions or nonstable solutions, provide suitable agitating equipment to assure uniform distribution of ingredients. Protect liquid admixtures from freezing and other temperature changes which would adversely affect their characteristics.

1.08 MAINTENANCE/SPARE PARTS (NOT USED)

1.09 WARRANTY/EXTENDED WARRANTY (NOT USED)

## PART 2 PRODUCTS

### 2.01 CONCRETE MATERIALS

#### A. Cementitious Materials

##### 1. Portland Cement:

- a. Type II or Type I/II conforming to ASTM C150. Use the same brand of cement upon which the selection of concrete was based. Only one brand of each type will be permitted in any one structure, unless otherwise specified.
- b. Cement shall be low alkali; the total alkali content calculated as the percentage of sodium oxide ( $\text{Na}_2\text{O}$ ) plus 0.658 times the percentage of potassium oxide ( $\text{K}_2\text{O}$ ) shall not exceed 0.60.
- c. Cement used in concrete placed in openings in existing water bearing structures shall be shrinkage compensating cement, ASTM C845.

##### 2. Fly Ash:

- a. Fly ash, when used, shall meet the requirements of ASTM C618, Class F, except as follows:
  - (i) The loss on ignition shall not exceed 4.0%.
  - (ii) The maximum percent of sulfur trioxide ( $\text{SO}_3$ ) shall be 4.0%.
- b. Fly ash shall be considered a cementitious material for concrete proportioning.
- c. Fly ash content shall not exceed 25% by weight of the total cementitious content (Portland cement plus fly ash) of the concrete.

#### B. Coarse Aggregate

1. Crushed stone or gravel conforming to ASTM C33, in the specified gradation size. Use aggregate from only one source in a single structure. Aggregate shall not be "deleterious," or "potentially deleterious," and shall not contain deleterious substances. Use aggregates from known sources that have a history of use without durability issues.

<b>Gradation No. 467 (max aggregate size 1 1/2")</b>		
<b>Sieve Size</b>	<b>Percent Retained</b>	<b>Percent Passing</b>
2"	0	100
1 1/2"	0-5	95-100
3/4"	30-65	35-70
3/8"	70-90	10-30
No. 4	95-100	0-5

<b>Gradation No. 57 (max aggregate size 1")</b>		
Sieve Size	Percent Retained	Percent Passing
1 1/2"	0	100
1"	0-5	95-100
1/2"	40-75	25-60
No. 4	90-100	0-10
No. 8	95-100	0-5

<b>Gradation No. 67 (max aggregate size 3/4")</b>		
Sieve Size	Percent Retained	Percent Passing
1"	0	100
3/4"	0-10	90-100
3/8"	45-80	20-55
No. 4	90-100	0-10
No. 8	95-100	0-5

<b>Gradation No. 8 (max aggregate size 3/8")</b>		
Sieve Size	Percent Retained	Percent Passing
1"	0	100
3/8"	0-15	85-100
No. 4	70-90	10-30
No. 8	90-100	0-10
No. 16	95-100	0-5

C. Fine Aggregate

1. Washed and screened natural sand or sand manufactured by crushing stone conforming to ASTM C33 and meeting the following gradation. Use aggregate from only one source in a single structure. Aggregate shall not be "deleterious," or "potentially deleterious," and shall not contain deleterious substances.

Sieve Size	Percent Retained	Percent Passing
3/8"	0	100
No. 4	0-5	95-100
No. 8	0-20	80-100
No. 16	15-50	50-85
No. 30	40-75	25-60
No. 50	70-95	5-30
No. 100	90-100	0-10
No. 200	97-100	0-3

- D. Mixing Water: Potable and complying with ASTM C1602.
- E. Admixtures: Using the following admixtures as required or permitted. The use of calcium chloride will not be permitted. The products must conform to the referenced standards.
1. Air-Entraining Admixture. Conform to ASTM C260.
  2. Chemical Admixtures. Conform to ASTM C494.
  3. Set Retarding Admixtures. Conform to ASTM C494, Types B or D only. Follow all Manufacturer's recommendations.
  4. Water Reducing Admixture. Conform to ASTM C494, types A or D only. Follow all Manufacturer's recommendations.
  5. High-Range Water Reducing Admixtures (HRWR). Conform to ASTM C 494 Type F or G only. Follow all manufacturer's recommendations.
  6. Producing Flowing Concrete: Conform to ASTM C1017, Type 1 or 2 only. Follow all manufacturer's recommendations.
- F. Water Soluble Chlorides
1. Water soluble chloride ion content of all concrete constituents (water, aggregates, cementitious materials and admixtures) shall be measured per ASTM C1218.
  2. Maximum water soluble chloride ion content is limited per ACI 318, Table 19.3.2.1, see the table below.

<b>Maximum Water-Soluble Chloride Ion Content</b>	
Exposure	Percent by Weight of Cement
Dry or Protected from Moisture (C0)	1.00
Exposed to Moisture but not Chlorides (C1)	0.30
Exposed to Moisture and Chlorides (C2)	0.15

## 2.02 CHEMICAL HARDENER

- A. Provide a clear chemical hardener if called for in the Drawings. Coordinate concrete mix design, air content requirements and placement procedures with the chemical hardener manufacturer.
- B. Provide one of the following products:
  - 1. MASTERTOP 110 ABR/Maximent® HD; by BASF.
  - 2. Diamond-Plate; by Euclid.
  - 3. Emeryplate FF, by L&M.

## 2.03 CURING MATERIALS:

- A. Membrane Curing Compound.
  - 1. Conform to ASTM C309, commercial curing compound which will not permanently discolor concrete.
  - 2. All curing compound shall contain a fugitive dye of color strength to render the film distinctly visible on the concrete for at least 4 hours after application.
- B. Sheet Curing Material.
  - 1. Conform to ASTM C 171.
    - a. Waterproof paper.
    - b. Polyethylene film.
    - c. White burlap-polyethylene sheeting.

## 2.04 CONCRETE PROPORTIONING

- A. Design Criteria
  - 1. Use ACI 211.1 as the basis for selecting the proportions of ingredients to produce concrete having proper durability, strength, workability appearance and other required properties. Proportion ingredients to produce a homogenous mixture, which will work readily into corners and angles of forms and around reinforcement by methods of placing and consolidation employed on the work, but without permitting materials to segregate or allowing excessive free water to collect on the surface.
  - 2. Strength:
    - a. All concrete is required to have an average 28 day compressive strength equal to or greater than specified strength. Establish the required average compressive strength in accordance with ACI 301.
  - 3. Entrained Air:
    - a. Air-entrain all concrete, unless otherwise specified.
    - b. Drilled shafts do not require air entrainment unless placed underwater.
    - c. Provide for not less than three percent (3.0%) nor more than six percent (6.0%) by volume of total entrapped and entrained air for normal weight concrete.

- d. Do not air entrain finished floors that call for a troweled finish.
- 4. Slump:
  - a. Provide adequate slump to produce acceptable workability, do not exceed maximum specified slump.
- 5. Admixtures:
  - a. Proportion admixtures according to the Manufacturer's recommendations. All admixtures shall be batched at the batch plant only.

B. Concrete Classification

Class	Min. 28-Day Compressive Strength (psi)	Coarse Aggregate Size (in.)	Max. Water Cement Ratio	Max. Slump (in.)	Min. Cement Content (lb. per CY)
A	4000	1.5 (No. 467)	0.45	5	517
B	3000	1.5 (No. 467)	0.50	4	470
C	4000	1.0 (No. 57)	0.45	4	564
D	5000	0.75 (No. 67)	0.45	5	611
E	1500	1.5 (No. 467)	0.70	4	376
F	3000	0.375 (No. 8)	0.50	8	564



NOTE: Maximum slump shown may be increased to 9 in. if HRWR admixture is used.

C. Concrete Usage

Class	Usage
A	All reinforced concrete unless otherwise specified
B	Concrete Encasement; Sidewalks, Curbs, Driveways
C	Drilled Shafts; Pumped Concrete; Thin Wall Sections
D	Precast Concrete and Panels
E	Lean Concrete Backfill; Foundation Seal; Blocking/Cradling
F	Underground Duct Banks



## 2.05 BATCH PLANTS

- A. Both on and off site batch plants shall be an established concrete batching facility meeting the requirements of the Concrete Plant Standards of the Concrete Plant Manufacturers Bureau. All batching, mixing and delivery of concrete shall be in accordance with ASTM C94 or ASTM C685.

## 2.06 CONCRETE MIXING

### A. Ready-Mixed Concrete:

1. Mix and transport ready-mixed concrete according to ASTM C94.
2. Provide a suitable measuring device capable of measuring mixing water for each batch. Note the number of gallons of water as batched on printed batching tickets.
3. Compensate for varying moisture contents of both coarse and fine aggregates and change batch weights of materials if necessary before batching.
4. Provide adequate facilities for accurate measurement and control of each material entering each batch of concrete. Accuracy of weighing equipment must conform to applicable requirements of ASTM and NRMCA for such equipment.
5. Provide recorders/printers to produce tickets. Each ticket will provide a printed record of volume of water and weights for cement as batched and for separate aggregates as batched individually. Use the type of indicator that returns for zero punch or to zero after a batch is discharged. Clearly indicate by stamped letters or numerals the difference between aggregates and cement as batched. Show the time of day stamped or printed at intervals of not more than six minutes. The delivery ticket shall also show the volume of water, in gallons, added at the batch plant. Deliver recorded ticket copies with concrete. The testing agency will keep one copy.

### B. Transit Mix Truck Requirements:

1. Clean each transit mix truck drum and reverse drum rotation before the truck proceeds under the batching plant.
2. Transit mix trucks are to be in good working condition. Trucks which are not mechanically sound, have worn or obstructed mixing fins, have non-functioning drum counters, or leaking water valves shall not be used.
3. Keep the water tank valve on each transit truck locked at all times that the truck is in use. Any addition of water must be directed by the Engineer. Added water must be incorporated by additional mixing of at least 35 revolutions.
4. Equip each transit-mix truck with a continuous, nonreversible, revolution counter showing the number of revolutions at mixing speeds. Counter shall be reset to zero at the batch plant. Counters must have reached 70 revolutions, minimum, before concrete may be discharged to ensure uniformity of mixing.
5. Concrete must be discharged from the transit-mix truck before the drum has revolved 300 revolutions or before 90 minutes from completion of batching, whichever comes first. Concrete that falls outside these limits shall be rejected.

## C. Admixtures:

1. Charge air-entraining and chemical admixtures into the mixer as a solution using an automatic dispenser or similar metering device. Do not use admixtures in powdered form.
2. Two or more admixtures may be used in the same concrete, provided that the admixtures in combination retain full efficiency and have no deleterious effect on the concrete or on the properties of each other. Inject the admixtures separately during the batching sequence.
3. Add retarding admixtures as soon as practicable after the addition of cement.

## PART 3 EXECUTION

## 3.01 PREPARATION

- A. Notify the Engineer upon completion of various portions of the work required for placing concrete so inspection may be made as early as possible. Keep the Engineer informed of the anticipated concrete placing schedules.
- B. All items, including lines and grades, forms, waterstops, reinforcing, inserts, piping, electrical, plumbing and the Contractor's concreting materials and equipment shall be complete and in compliance with the plans and specifications before proceeding with concrete placement.
- C. Concrete finishing shall be completed in daylight hours. When this is not possible, brilliantly light the work site so that all operations are plainly visible.
- D. Prior to and during concrete placement, forms shall be clean of any and all foreign matter.
- E. Mix concrete only in quantities for immediate use. Discard concrete which has set; re-tempering is not permitted. Completely discharge concrete at the site within one hour and 30 minutes after adding cement to aggregate. In hot weather, reduce this time to one hour or less to prevent stiffening of concrete before it is placed.
- F. If concrete arrives at the project with slump below that specified, water may be added only if the addition of water does not exceed either the maximum permissible water-cement ratio or maximum slump. Mix adjustments to obtain specified slump must be approved by the Engineer.
- G. Protection from Adverse Weather
  1. If adverse weather is imminent, no concrete placement is permitted. Do not permit rainwater to increase mixing water or to damage the surface finish. If rainfall occurs after placing operations begin, provide adequate covering to protect the work.
- H. Cold Weather Concreting
  1. Prevent damage to concrete due to early age freezing and limit rapid changes in temperature at early ages consistent with the requirements of ACI 306R, ACI 306.1 and the requirements in this Section.

2. If the air temperature is at or below 40 degrees F, cold weather concreting shall be performed in accordance with ACI 306R and ACI 306.1. This includes cases where the temperature drops below 40 degrees F after concrete operations have been started. The temperature shall be taken in shade away from artificial heat.
3. When air temperatures are at or below 40 degrees F, heated mixing water or a combination of heated mixing water and heated aggregates shall be used, if required, to raise the concrete temperature at placement to the minimum values (or greater) listed in ACI 306R – Chapter 5. The temperature of the heated water or aggregates shall not exceed 150 degrees F when entering the mixer.
4. Concrete placement is not permitted when the air temperature is at or below 35 degrees F. The temperature shall be taken in shade away from artificial heat.
5. Do not place concrete against a frozen subgrade or formwork that is at or below 35 F.
6. Salts, chlorides, chemicals or other foreign materials shall not be mixed with the concrete to prevent freezing or act as an accelerator.
7. When temperatures at or below 35 F may be expected during the curing period, the concrete shall be maintained at a temperature of at least 50 degrees F for five days or 70 degrees F for three days after placement. Rapid cooling or heating of concrete shall not be permitted.

I. Hot Weather Concreting.

1. Hot weather concreting shall comply with ACI 305R and ACI 305.1. At air temperatures of 90 degrees F or above, concrete placement shall be in accordance with Hot Weather Concreting requirements in ACI 305R, ACI 305.1 and requirements in this Section.
2. The temperature of the concrete when placed in the work shall not exceed 90 degrees F. Use chilled water or ice or other approved methods to reduce the temperature of the concrete as required.
3. Concrete shall be placed in the forms without the addition of any more water than is required by design. No excess water may be added to the concrete surface to aid in finishing. Control of the initial set and extending the time for finishing may be accomplished through the use of admixtures in accordance with these Specifications.
4. Plastic shrinkage cracking, due to rapid evaporation of moisture, shall be prevented. Concrete shall not be placed when the evaporation rate (actual or anticipated) equals or exceeds 0.2 pound per square foot per hour, as determined by Figure 4.2 in ACI 305R.

### 3.02 EMBEDDED ITEMS

- A. Refer to Section 03250 – Concrete Joints and Embedded Items.

### 3.03 JOINTS

- A. Construction, control, isolation and expansion joints shall be installed and sealed as called for by the Drawings and in accordance with Section 03250 – Concrete Joints and Embedded Items.

### 3.04 WATERSTOPS

- A. Waterstops shall be installed as called for by the Drawings and in accordance with Section 03250 – Concrete Joints and Embedded Items.

### 3.05 GROUTING

- A. Perform all grouting as called for by the Drawings and in accordance with Section 03600 – Grout.

### 3.06 CONCRETE TRANSPORTATION AND CONVEYING

- A. Equipment for mixing and transporting concrete shall conform to ASTM C94 or ASTM C685.
- B. Delivery tickets shall be required for each batch and shall be in accordance with ASTM C94. Each ticket must clearly show the following:
  - 1. Specific class or designation of concrete.
  - 2. Volume of concrete
  - 3. Amount of water, in gallons, that can be added to the mixer truck at the site without exceeding the maximum water-cement ratio for that mix design.
  - 4. Time of batching cement, water and aggregates and initial reading of revolution counter if counter not zeroed.
- C. Handle concrete from mixer to placement as quickly as practicable while providing concrete of required quality in the placement area. Use methods which prevent loss of ingredients and segregation.
  - 1. Troughs, chutes and pipes shall be steel or steel lined.
  - 2. When steep slopes are necessary, provide baffles.
  - 3. Keep chutes, troughs and pipes clean and free from coatings of hardened concrete.
  - 4. Concrete pumping is permitted and shall comply with ACI 304.2R.

### 3.07 CONCRETE PLACEMENT

- A. Preparation
  - 1. Sprinkle semi-porous subgrades to eliminate suction.
  - 2. Seal extremely porous subgrades in an approved manner.
  - 3. Clean and prepare existing concrete surface in accordance with these Specifications prior to placing new concrete.

## B. General

1. Deposit concrete continuously, or in layers of such thickness that no concrete will be deposited on concrete which has hardened sufficiently to cause formation of cold joints, seams or planes of weakness within the section. If the section cannot be placed continuously, place construction joints as specified or as approved.
2. Proceed with placement at a rate such that concrete which is being integrated with fresh concrete is still plastic. Do not deposit concrete which has partially hardened or has been contaminated by foreign materials.
3. Remove temporary spreaders from forms when the spreader is no longer useful. Temporary spreaders may remain embedded in concrete only if made of galvanized metal or concrete, and if prior approval has been obtained.
4. Do not start placing of concrete in supported elements until concrete previously placed in columns and walls is no longer plastic.
5. Deposit concrete as nearly as practicable in its final position to avoid segregation. Do not subject concrete to a procedure which will cause segregation.
6. Deposit concrete through vertical drop chutes of rubber or metal of satisfactory size when operations involve placing concrete from above.
7. Concrete shall not be dropped more than 10 feet when HRWR admixture is used and 5 feet without HRWR.
8. Where surface mortar is to be the basis of a finish, especially those designated to be painted, work coarse aggregate back from forms with a suitable tool to bring the full surface of mortar against the form. Prevent formation of excessive surface voids.

## C. Slabs

1. After suitable bulkheads, screeds and if specified, jointing materials, have been positioned the concrete shall be placed continuously between construction joints, beginning at a bulkhead, edge form, or corner. Each batch shall be placed into the edge of the previously placed concrete to avoid stone pockets and segregation.
2. If there is a delay in casting, the concrete placed after the delay shall be thoroughly spaded and consolidated at the edge of that previously placed to avoid cold joints.
3. Concrete shall then be brought to correct level with a straightedge and struck off. Bullfloats or darbies shall be used to smooth the surface, leaving it free of humps or hollows.

## D. Formed Concrete

1. Place concrete in forms using tremie tubes and taking care to prevent segregation. Bottom of tremie tubes shall be in contact with the concrete already placed.
2. In walls, place concrete in 12" to 24" lifts, keeping the surface horizontal. Compaction shall be by vibrator and shall be supplemented by hand puddling; puddling shall be continuous while pouring concrete and shall be done primarily between forms and reinforcing steel, around openings, or wherever needed to prevent honeycomb, fill voids or drive out large air bubbles.

E. Concrete Poured Against Rock

1. Where concrete is poured against undisturbed rock, especially in drilled shafts, place concrete as soon as practicable after excavation to prevent weathering of exposed rock.
  - a. For footings and slabs, place mud slabs within 4 hours after the excavation is at final grade.
2. Remove all water from excavation or shaft before placing concrete.

3.08 CONSOLIDATION OF CONCRETE

A. All concrete shall be placed and consolidated with mechanical vibrators.

1. A minimum frequency of 7000 revolutions per minute is required for mechanical vibrators.
2. Do not use vibrators to transport concrete within forms.
3. Insert vibrators and withdraw at points from 18 to 30 inches apart. At each insertion, vibrate sufficiently to consolidate concrete, generally until a liquefied appearance is produced on the surface. Do not over-vibrate causing segregation.
4. Keep a spare vibrator on the site during concrete placing operations. No concrete shall be ordered until sufficient approved vibrators (including standby units in working order) are on the job.

B. Concrete for slabs shall be compacted with vibrating screeds and internal vibrators.

C. Internal vibrators shall be exclusively used; form attached vibrators are not permitted.

3.09 FINISHING OF FORMED SURFACES

A. Forms shall be removed as specified in Section 03100. Patch, repair, finish and clean concrete within 7 days of form removal in accordance with the Specifications. Cure concrete as finishing progress in accordance with the Specifications.

B. No Finish: A finish is not required on surfaces which are not visible from the inside or outside of the structure or more than 12 inches below finished grade.

C. Smooth Form Finish:

1. Unless otherwise specified, all surfaces not meeting the requirements for "no finish" shall receive a smooth form finish. Use a smooth form finish on all surfaces exposed to view and liquid.
2. Provide a smooth, hard uniform texture on the concrete surface. Use plywood or fiberboard linings or forms in as large sheets as practicable and with smooth, even edges and close joints.
3. Patch tie holes and defects.
4. Provide a smooth, uniform, rubbed surface texture. Rub fins and joint marks and other irregularities with carborundum stone immediately after forms are stripped to leave a smooth, unmarred finish surface. If rubbing of surface is delayed to the

point where the concrete surface is dry and cannot be rubbed to produce a smooth, uniform surface Contractor shall provide a blast finish to achieve a smooth uniform surface at no additional cost to the Owner.

- D. Related Unformed Surfaces: Tops of piers, walls, bent caps and similar unformed surfaces occurring adjacent to formed surfaces shall be struck smooth after concrete is placed. Float unformed surfaces to a texture reasonably consistent with that of the formed surfaces. Final treatment on formed surfaces shall continue uniformly across the unformed surfaces.

### 3.10 FINISHING SLABS AND SIMILAR FLAT SURFACES

- A. Comply with the recommendations in ACI 302.1R for screeding, restraighening and finishing operations for concrete surfaces. Do not wet concrete surfaces.
- B. Finish slabs and similar flat surfaces monolithically and apply as indicated in the Plans and as follows:
  - 1. Rough Finish.
    - a. Tank floors and slabs that receive grout or additional concrete toppings.
    - b. Provide a rough surface by screeding only without further finish.
  - 2. Trowel Finish
    - a. Slab surfaces exposed to view, liquids or to be covered with a coating system, flooring coverings or membranes.
    - b. After apply float finish, apply trowel finish and consolidate by hand or power driven trowel. Continue troweling passes and restraighen until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.
  - 3. Broom Finish
    - a. Sidewalks, walkways and platforms.
    - b. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route.

### 3.11 CONCRETE CURING

- A. All concrete shall be cured in accordance with the Specifications. The curing methods shall be wet curing, sheet materials or membrane curing compound. Unless the curing method is specified otherwise, select one of the appropriate curing methods below.
- B. Length of Curing Period
  - 1. A "curing day" shall be any day on which the atmospheric temperature taken in the shade, or the air temperature adjacent to the concrete, remains above 50 degrees F for at least 18 hours.
  - 2. Continuously cure concrete for a period until 7 curing days have been reached. In cold weather, curing may be terminated after a period of 14 consecutive days.

## C. Wet Curing

1. Immediately after the finishing operations are completed or forms are stripped, the concrete shall be covered with wet cotton mats or with a temporary covering of canvas or burlap, thoroughly saturated with water before placement. A temporary covering shall be used when factors dictate that cotton mats cannot be placed immediately after finishing operations without marring the finishing of the concrete surface.
2. When temporary coverings are used keep them in place only until the surface has sufficiently hardened so that a cotton mat can be substituted without marring or disturbing the concrete finish.
3. The coverings shall remain in contact with the concrete for the duration of the curing period.
4. The coverings shall be kept saturated with water for the entire curing period.
5. Water used for curing shall be potable and free from any injurious materials or deleterious substances.

## D. Sheet Curing

1. Immediately after the finishing operations are completed or forms are stripped, install sheet curing materials in accordance with all Manufacturer's recommendations.
2. Sheet curing shall be in contact with the entire concrete surface so as to prevent drying for the duration of the curing period.
3. When pedestrian traffic is unavoidable, provide suitable walkways to protect the sheet material.

## E. Membrane Curing

1. Membrane curing compound is not permitted on surfaces to be rubbed or on surfaces to receive additional concrete, grout, plaster or coatings.
2. Immediately after the finishing operations are completed or forms are stripped, apply membrane curing compound solution under pressure with a spray nozzle so the entire exposed surface is completely covered with a uniform film. The rate of application shall insure complete coverage but shall not exceed 150 square feet per gallon of curing compound.
3. After application and under normal conditions, the curing compound shall be dry to the touch within 1 hour and shall be dry thoroughly and completely within 4 hours. When thoroughly dry it shall provide a continuous flexible membrane free from cracks and pinholes and shall remain intact during the required curing period.
4. If the membrane seal is broken during the curing period, immediately repair it with additional curing compound.

- F. After the curing period, the temperature of the exposed surface shall not be permitted to drop faster than 30 degrees F in 24 hours.



3.12 CONCRETE SURFACE REPAIRS

- A. Repair defective areas immediately after the removal of forms in accordance with this Section and Section 03740 – Concrete Repair and Modification. Repair of defective areas shall be at no additional cost to the Owner.
- B. If the concrete surface is bulged, uneven or exhibits defects which in the Engineer's opinion cannot be satisfactorily repaired, remove and replace the entire concrete section as directed at no additional cost to the Owner.
- C. Patch tie holes immediately after removal of forms. After cleaning and thoroughly dampening the tie hole, fill solid with non-shrink, non-metallic grout.

3.13 FIELD QUALITY CONTROL

- A. Concrete Testing
  - 1. General
    - a. Tests shall be required throughout the work to monitor the quality of concrete. Take all samples in accordance with ASTM C172.
    - b. Testing of concrete shall be conducted by an independent, qualified testing agency.



END OF SECTION

## SECTION 11282

### ROLL OFF CONTAINERS

#### PART 1 GENERAL

##### 1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment, and incidentals required to install and test, complete and ready for operation, two Owner-provided roll-off containers as shown on the Drawings and as specified herein. The Owner shall lease the equipment from the waste management company; therefore, the roll off container will not be available until near the time the facilities are placed into service. 
- B. The Contractor shall furnish and install all necessary accessory equipment and auxiliaries, whether specifically mentioned in these specifications or not, as required for an installation incorporating the highest standards for the type of service including field testing. 

##### 1.02 RELATED WORK

- A. Maintenance of plant operations and sequence of construction is included in Section 01310 – Construction Schedules.
- B. Painting, except as specified herein, is included in Division 9 – Finishes.

##### 1.03 SUBMITTALS (NOT USED)



##### 1.04 REFERENCE STANDARDS

- A. AWS - American Welding Society.
- B. AISI - American Iron & Steel Institute.
- C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

##### 1.05 QUALITY ASSURANCE (NOT USED)



- A. The equipment covered by this section shall be the product of a single reputable and qualified Manufacturer who is of proven ability.

##### 1.06 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS (NOT USED)



##### 1.07 DELIVERY, HANDLING AND STORAGE (NOT USED)

##### 1.08 MAINTENANCE/SPARE PARTS (NOT USED)



##### 1.09 WARRANTY/EXTENDED WARRANTY (NOT USED)



- A. Provide equipment warranty as specified in Section 01750 – Warranties and Bonds.

PART 2 PRODUCTS (NOT USED)



PART 3 EXECUTION

3.01 PREPARATION

- A. Contractor shall field verify dimensional requirements for discharge chutes and coordinate with the Owner's chosen Manufacturer for proper function of the equipment.



3.02 INSTALLATION

- A. Installation shall be in strict accordance with the Manufacturer's instructions and recommendations in the locations shown on the Drawings. Contractor to coordinate with the Owner's chosen Manufacturer to ensure proper alignment with dumpster guides and embedded plates called out in the Drawings.



END OF SECTION

**SECTION 15072****DUCTILE IRON PIPE AND FITTINGS****PART 1 GENERAL****1.01 SCOPE OF WORK**

- A. Furnish all labor, materials, equipment and incidentals required and install, in the locations inside, under and outside of structures as shown on the Drawings, all ductile iron piping, cast iron or ductile iron fittings, and appurtenances as shown on the Drawings and as specified herein.

**1.02 RELATED WORK**

- A. Division 02 – Site Work.
- B. Division 03 – Concrete.
- C. Division 15 – Mechanical.

**1.03 SUBMITTALS**

- A. Submit to the Engineer in accordance with Section 01300 – Submittal Procedures, a list of materials to be furnished, the names of the suppliers and the date of delivery of materials to the site.
- B. All ductile iron pipe and cast iron or ductile iron fittings to be installed under this Contract shall be inspected and tested at the foundry as required by the standard specifications to which the material is manufactured. Furnish in duplicate to the Owner sworn certificates of such tests and their results. In addition, all ductile iron pipe and fittings to be installed under this Contract may be inspected at the foundry for compliance with these Specifications by an independent testing laboratory selected by the Owner. The Manufacturer's cooperation shall be required in these inspections.
- C. Shop Drawings including piping layouts within, under, or between structures shall be submitted to the Engineer for approval in accordance with General Requirements and shall include dimensioning, methods and locations of supports and all other pertinent technical specifications for all piping to be furnished.
- D. Submit product data on pipe, fitting and appurtenances describing materials of construction and dimensional data.
- E. Verifiable Certificate of Compliance with the NSF 61 Standard for all pipe and fittings.
- F. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

**1.04 REFERENCE STANDARDS**

- A. American Water Works Association (AWWA).

**1.05 QUALITY ASSURANCE (NOT USED)****1.06 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS (NOT USED)**

## 1.07 DELIVERY, HANDLING AND STORAGE

- A. Care shall be taken in loading, transporting, and unloading to prevent injury to the pipe or coatings. Pipe or fittings shall not be dropped. All pipe or fittings shall be examined before laying, and no piece shall be installed which is found to be defective. Any damage to the pipe coatings shall be repaired as recommended by the Manufacturer.
- B. All pipe and fittings shall be subjected to a careful inspection and hammer test just prior to being installed.
- C. If any defective pipe is discovered after it has been laid it shall be removed and replaced with a sound pipe in a satisfactory manner at no expense to the Owner. All pipe and fittings shall be thoroughly cleaned before installing, shall be kept clean until they are used in the work, and when installed, shall conform to the lines and grades required.

## 1.08 MAINTENANCE/SPARE PARTS (NOT USED)

## 1.09 WARRANTY/EXTENDED WARRANTY (NOT USED)

## 1.10 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' experience.  
  
Permanently mark each length of pipe with Manufacturer's name or trademark and indicate conformance to standards.

## PART 2 PRODUCTS

## 2.01 MATERIALS

- A. Ductile Iron Pipe:
  - 1. Ductile iron pipe shall conform to the requirements of AWWA C150 and AWWA C151.
    - a. Use thickness Class 53 for interior and flanged pipe.
    - b. Use thickness Class 52 for other applications.
  - 2. Ductile iron piping and fittings shall be double thickness cement mortar lined and bituminous seal coated in accordance with AWWA C104 for water applications. Provide Manufacturer's standard bituminous coating outside of all buried ductile iron pipe and fittings. For all above grade pipe and fittings, provide Manufacturer's standard prime coat before transporting to jobsite. Apply intermediate and finish coats in the field, per Section 09900. Provide Protecto 401 coating inside of all ductile iron pipe and fittings for use in sanitary sewer, wastewater, sludge, and grit slurry applications.
- B. Fittings: Exposed pipe shall be flanged unless noted otherwise. Exposed fittings for use with flanged joints on ductile pipe shall be cast iron or ductile iron fittings conforming to ANSI B16.1 or AWWA C153. Flanges shall be faced and drilled in accordance with ANSI B16.1, Class 125. All fittings shall be pressure rated at 250 psig. Buried fittings shall be restrained mechanical joints
- C. Flanges: All above grade pipe shall be flanged unless noted otherwise. Flanges for ductile or cast iron pipe shall be ductile or cast iron flanges screwed on threaded ends



of the pipe. Flanges shall conform to ANSI B16.1, Class 125. Screwed-on flanges shall be attached to the pipe in the shop; attachment, aligning and facing shall conform to AWWA C115.

- D. Mechanical Joints: Mechanical joints shall only be used on buried pipe or where specifically noted on the drawings for exposed pipe. Mechanical joints for use with ductile iron pipe shall conform to AWWA C111 and shall be restrained.
- E. Seal strips, where required on the Drawings shall be link seal as manufactured by Thunderline Corporation, Wayne, Michigan, or equal.
- F. Sleeve Type Couplings (use only where specifically indicated on the drawings):
  - 1. Sleeve-type couplings shall be as made by Dresser Manufacturing Division, Bradford, PA, Smith-Blair, Inc., San Francisco, California, R.H. Baker & Company, Inc., Huntington Park, California, or equal.
  - 2. Couplings for buried pipe shall be of cast iron and shall be Dresser Style 39, Smith-Blair Style 416, Baker Allcast, or equal. The couplings shall be provided with stainless steel bolts and nuts unless indicated otherwise.
  - 3. Couplings for exposed pipe shall be of steel and shall be Dresser Style 38, Smith-Blair Style 411, Baker Allsteel, or equal. The couplings shall be provided with black steel bolts and nuts unless indicated otherwise.
  - 4. All couplings shall be furnished with the pipe stop removed.
  - 5. Couplings shall be provided with gaskets of a composition suitable for exposure to the liquid within the pipe.
  - 6. Joint harness shall be provided on all couplings and shall be designed for the maximum pressures to which the line will be subjected.
- G. Restrained joints shall be in accordance with City of Oklahoma City Standard Specifications for Construction of Public Improvements, Section 524.
- H. Filler flanges and beveled filler flanges shall be furnished and installed as required. Filler flanges and beveled filler flanges shall be furnished faced and drilled complete with extra length bolts. Filler flanges shall be Clow Figure F-1984 or equal and beveled filler flanges shall be Clow Figure F-1986 or equal.
- I. Polyethylene Encasement. Encasement for buried pipe shall be 8 mil continuous polyethylene encasement conforming to AWWA C105.
- J. All buried fittings shall be provided with thrust blocks and mechanical restraints.

## 2.02 MARKING TAPE

- A. Detectable:
  - 1. For use above all pipe.
  - 2. Insert polyethylene, impervious to known alkalis, acids, chemical reagents, and solvents likely to be encountered in soil.
  - 3. Thickness: Minimum 5 mils.
  - 4. Width: 6 inches.
  - 5. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.
  - 6. Manufacturers and Products:

- a. Reef Industries; Terra Tape.
- b. Mutual Industries; Detectable Tape.
- c. Presco; Detectable Tape.

### PART 3 EXECUTION

#### 3.01 LAYING EXTERIOR PIPE AND FITTINGS

- A. Ductile iron pipe and fittings shall be installed in accordance with requirements of AWWA C600 except as otherwise provided herein. For buried piping a firm, even bearing throughout the length of the pipe shall be constructed by tamping selected material at the sides of the pipe up to the springline.
- B. All pipe shall be sound and clean before installing. When installing is not in progress, including lunch time, the open ends of the pipe shall be closed by watertight plug or other approved means. Good alignment shall be preserved in installing. Fittings, in addition to those shown on the plans, shall be provided, if required, to avoid interference with existing piping, conduit, etc. Provide restrained mechanical coupling where required for closures and fitup.
- C. When pipe cutting is required, the cutting shall be done by machine, leaving a smooth cut at right angles to the axis of the pipe. Cut ends of pipe to be used with a Tyton bell shall be beveled to conform to the manufactured spigot end. Cement lining shall be undamaged.
- D. Joint restraint shall be provided on all piping 30" and smaller. Gravity-fed buried piping that is 36" and larger does not require restrained joints. Buried piping shall be polyethylene encased in accordance with AWWA C105.
- E. Unless otherwise shown or approved by the Engineer, all buried pipe lines shall have a 4 foot minimum cover.
- F. Jointing Ductile-Iron Pipe:
  - 1. Mechanical joints at valves, fittings, and where designated shall be in accordance with the "Notes on Method of Installation" under ANSI Specification A 21.11 and the instructions of the Manufacturer (use on buried pipe and only where indicated on the drawings on exposed pipe). To assemble the joints in the field, thoroughly clean the joint surfaces and rubber gasket with soapy water before tightening the bolts. Bolts shall be tight to the specified torques. Under no condition shall extension wrenches or pipe over handle or ordinary ratchet wrench be used to secure greater leverage.
  - 2. Flanged joints shall be made using ring gaskets of rubber with cloth insertion. Gaskets 12-inch in diameter and smaller shall be 1/16-inch thick; larger than 12-inch 3/32-inch thick. All nuts and bolts shall be provided per Section 15120 – Piping Specialties. Bolts in flanged joints or mechanical joints shall be tightened progressively, drawing up bolts on opposite sides until bolts are uniformly tight; use torque wrench to tighten bolts to Manufacturer instructions. After installation two heavy bitumastic coatings comparable to Inertol No. 66 Special Heavy shall be applied to bolts and nuts.
  - 3. Carefully assemble mechanical joints in accordance with the Manufacturer's recommendations. Lubricate joint surfaces with heavy vegetable soap solution



immediately prior to installing gasket on spigot end. If seal is defective, disassemble the joint, thoroughly clean it, and reassemble the joint. Do not over tighten bolts to compensate for poor installation practice.

4. All valves, fittings and other appurtenances needed upon the pipe lines shall be set and jointed as indicated on the Drawings or as required.
5. After assembly and inspection and before backfill, all exterior surfaces of buried sleeve coupling and bolts and nuts shall be heavily and thoroughly coated with an approved heavy-bodied (high solids content) bituminous mastic.

### 3.02 TESTING

- A. All pipe lines shall be hydrostatically tested for leakage in accordance with procedures outlined in Section 15002 – Field Testing of Piping Systems.

END OF SECTION



**SECTION 15850****HVAC – STANDARD DX AIR-CONDITIONING EQUIPMENT****PART 1 GENERAL****1.01 SCOPE OF WORK**

- A. Furnish and install all ductless mini-split systems, make-up air-handling unit split systems, and self-contained wall-mounted air-handling units as shown on the Drawings, scheduled, and as specified herein.
- B. Refer to Section 15500 – HVAC - General Provisions for HVAC General Provisions relating to the work of this Section.
- C. Field attachment of items shipped loose, not installed on the equipment unit at the factory, as specified herein for a fully functioning system.
- D. Refer to Drawings and Section 15950 – HVAC - Controls for HVAC controls prior to purchasing equipment. Equipment supplier shall verify that equipment is provided with all components, controls options, etc. to fulfill the intent of the HVAC control sequence.

**1.02 RELATED WORK**

- A. Remote disconnects shall be provided under Division 16 – Electrical.
- B. Refer to Division 16 – Electrical for electrical requirements.
- C. Exterior louvers are included in Division 08 – Doors and Windows.
- D. Duct mounted instruments are specified in Division 15 – Mechanical and installed under this Section.
- E. Coordinate wall opening dimensions and locations with Structural.

**1.03 SUBMITTALS**

- A. Submit all Shop Drawings and Operating and Maintenance Manuals with all information required per Division 01 – General Provisions and Section 15500 – HVAC - General Provisions.

**1.04 REFERENCE STANDARDS**

- A. Refer to Section 15500 – HVAC - General Provisions and the following specific standards.
- B. ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers
  - a. ASHRAE 52 - Method of Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.

- C. NFPA - National Fire Protection Association
  - 1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems
  - 2. NFPA 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems.
- D. ASTM - American Society for Testing and Materials
  - 1. ASTM C1071 - Standard Specification for Thermal and Acoustical Insulation (Glass Fiber, Duct Lining Materials).
- E. AHAM - Association of Home Appliance Manufacturers
- F. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

#### 1.05 QUALITY ASSURANCE

- A. 15500 – HVAC - General Provisions Guarantee that refrigerant cooling equipment will provide indicated cooling capacities in Equipment Schedules.

#### 1.06 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS

- A. Refer to Section 15500 – HVAC - General Provisions and the following specific requirements related to this Section.
- B. Equipment Schedules
  - 1. This Section is incomplete without the information contained in the drawing schedules. All ductless split systems, split system make-up air-handling units, and packaged wall-mounted air-handling units shall be of the type, capacity and arrangement as listed on the schedules. Units shall consist of the components listed in the schedule and those components obviously required for the type of unit. The order of component assembly will be as called for on the schedule. Particular attention must be paid to the remarks and notes in these schedules.
- C. Coordination
  - 1. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 - Concrete.
  - 2. Coordinate installation of equipment supports/roof curbs with Division 05 - Metals.

#### 1.07 DELIVERY, STORAGE AND HANDLING

- A. Refer to Section 15500 – HVAC - General Provisions.

#### 1.08 MAINTENANCE/SPARE PARTS

- A. Refer to Section 15500 – HVAC - General Provisions.

## 1.09 WARRANTY/EXTENDED WARRANTY

- A. Refer to Section 15500 – HVAC - General Provisions for warranty requirements and the following specific requirements related to this Section.
- B. Compressor shall have 5-year parts warranty. For split systems, warranty is five year parts only, no labor.

## PART 2 PRODUCTS

### 2.01 GENERAL

- A. In general, units shall be factory fabricated, completely factory-assembled, tested and shipped in one piece with fan, coils, filters, access panels/doors, fan motor, motor base, drive, drive guard, dampers, condensate pans, complete controls, vibration isolators with seismic restraints and other components as specified herein, indicated on the Drawings and as required for safe and satisfactory operation of the equipment.
- B. Units shall be designed to provide an integrated assembly when all of the components are assembled. All transition sections and filler pieces required between sections are to be provided as part of the unit.
- C. Support brackets or rails are to be provided with the unit. Type of support is to be as required by the schedules and as shown on the Drawings, e.g. hung, floor mounted, etc. All air-handling units shall be provided with lugs, brackets or field supplied devices to allow the unit to be firmly bolted to the structure or fastened to specified vibration isolators. The lugs, brackets or field supplied devices shall be sized to withstand the required wind and seismic loads for the area and type of application. Refer to Section 15510 for additional requirements. Location of the attachments shall be based on the equipment being hung or base mounted as shown on the Drawings and the schedules.
- D. Units not mounted on vibration isolators shall have all rotating components internally isolated from the main unit with vibration isolators.

### 2.02 PAINTINGS AND COATINGS

- A. Units for outdoor installation shall have coatings as indicated under this Section and the following:
  - 1. Materials of construction shall be corrosion resistant, or provided with a corrosion and UV resistant coating system.
  - 2. All materials, other than stainless steel and aluminum, exposed to the environment shall be coated, including but not limited to the following:
    - a. Exterior of unit.
    - b. Interior of unit exposed to the outdoor environment.
    - c. All copper, steel, and galvanized materials not inside a sealed NEMA 4 enclosure.
  - 3. Refer to 15500 – HVAC - General Provisions for additional coating requirements.

## 2.03 DUCTLESS MINI-SPLIT SYSTEM UNITS (4-WAY CASSETTE)

- A. General - Units shall be factory assembled, single-zone split system unit consisting of one outdoor air-cooled condensing unit and one indoor 4-Way Ceiling Cassette ductless fan coil unit.
- B. Type - Equipment shall be Trane C-Series units based on the model number and type as called out on the Equipment Schedules, or approved equal.
- C. Air-Conditioning Unit
  - 1. General - The ductless indoor, air-handling unit shall consist of a filter, cooling coil, drain pan, condensate pump, fan, high water cutoff, and controls.
  - 2. Casing – Painted steel construction with ABS plastic fan grille.
  - 3. Supply Air Fan - Fans shall be centrifugal type, factory standard construction. Fans assembly shall be statically and dynamically balanced before shipment.
  - 4. Evaporator cooling coils – Coils shall be seamless copper tubes with aluminum fins mechanically bonded to copper tubes. Coils shall be pressure tested and leak tested at 300 psig with air under water.
  - 5. Condensate pan shall be sloped to drain with optional condensate pump, high water cut-off, and required fittings.
  - 6. Filters – Factory Standard.
  - 7. Electrical – Indoor unit shall be fed power from the condensing unit.
- D. Variable Frequency Drives
  - 1. Variable frequency drives shall be factory standard.
- E. Air Cooled Condensing Unit
  - 1. Air Cooled Condensing Unit – Condensing unit shall consist of variable speed inverter driven scroll compressors, condenser coils, hail guards, condenser fans and controls. The unit shall be air-cooled type, designed and constructed for mounting remote from its associated air handler with field fabricated interconnecting refrigerant piping, including associated specialties.
  - 2. Casing - Unit casing shall be painted galvanized steel. The unit shall have propeller condenser fans. Fans shall be provided with guards. Coils shall have copper tubes and aluminum fins. Fins shall be mechanically attached to the tubes. Coils shall be pressure and leak tested at 425 psig with air under water. Provide with factory standard wind baffles for low ambient control.
  - 3. Compressor - Shall be variable speed, inverter driven, scroll type, heat pump design. Compressor shall include internal thermal overload protection. Compressor controls shall include anti-short cycle timers.
  - 4. Controls – Provide factory wall mounted controller with LCD readout for status and room temperature display and auto-switchover from cooling and heating modes. Programmable thermostat shall be TREWIRE1AHANDA or approved equal.
  - 5. Electrical - Unit shall be single point connection, power for the indoor unit shall be fed from the condensing unit. A complete wiring diagram shall be supplied. Route control and power wiring on same rack as refrigerant tubing.

6. Coatings – All exposed materials outdoors shall have coatings per 15500 – HVAC - General Provisions. Coatings from manufacturer shall be approved equal.

F. Refrigerant Piping

1. Refrigerant piping – Interconnecting refrigerant piping between the air-handler and condensing unit shall be field-installed and sloped towards the condensing unit per the equipment manufacturer's recommendations.
2. Route above existing ceilings inside building.
3. Supports and hardware shall be galvanized steel for outdoor installation. Core through existing pre-cast wall panels for refrigerant piping and conduits. Do not cut rebar. See structural drawings for core notes. Seal all penetrations of existing concrete wall panels water tight with link style seals and grout exterior openings to match existing wall.
4. The refrigerant piping shall be sized per the equipment manufacturer's recommendations taking into account the adjusted pipe lengths including fittings. Piping shall be ACR Type rigid copper tubing with joints silver brazed. Brazing shall be done with an inert gas purge. Suction piping shall be insulated to protect personnel as required. Provide electronic linear thermal expansion valves.

- A. Acceptable Manufacturers – Air-Conditioning Units shall be of the type specified herein and equal to the manufacturer and model number as called on the Equipment Schedules on the Drawings. Acceptable manufacturers are Trane, LG, Daikin, Mitsubishi, Lennox, or approved equal.

2.04 SPLIT SYSTEM UNITS – MAKE-UP AIR-HANDLING UNIT AND CONDENSING UNIT

- A. General - Units shall be factory assembled, split system unit consisting of an indoor-mounted modular type air-handling unit and an outdoor-located condensing unit.

B. Air-Handling Unit

1. General - The indoor, modular air-handling unit shall consist of a mixing box section, filter section, cooling section (where required per the Equipment Schedules), electric heating section, fan section and access sections as required. Provide with motor, motor base, drive, drive guard, vibration isolators, filters, dampers and factory wired control panel. Refer to the HVAC Drawings and Equipment Schedules for arrangement of sections and configuration (vertical or horizontal).
2. Casing – Casing shall be zinc-coated, galvanized sheet steel construction with structural framing members as required. Provide with manufacturer's standard weather-resistant baked enamel finish. Pressure class rating of casing shall be for the total fan static pressure, with all sections of the unit of the same pressure class. The unit shall single wall construction with 1-in mat faced or neoprene coated fiberglass insulation, 1-1/2 lb minimum density, installed with stick clips and adhesives to prevent erosion of the insulation. All insulation edges sealed to prevent erosion. Provide with gasketed and hinged access doors at all sections to facilitate maintenance. All access doors shall be equally insulated as unit walls. Provide gaskets at each module section to minimize air leakage.

3. Supply Air Fan - Fans shall be plug or centrifugal type, single-width and single-inlet with adjustable belt drives, refer to equipment schedules for type. Fan blades shall be backward curved, airfoil type. Provide with belt guard and extended grease lines for re-lubrication. Motor shall be high-efficiency, TEFC, continuous duty, squirrel cage type. Motor shall be set on an adjustable base to allow belt tensioning adjustment. It shall have keyed shaft, be resilient mounted and thermally protected with automatic reset. Motor shall be UL listed. All bearings for fan and motor shall be as defined in Section 15500 – HVAC - General Provisions. Fan assembly shall be statically and dynamically balanced before shipment. All fans shall be AMCA rated for sound and air performance.
4. Evaporator cooling coils – Refrigerant-based, 5/8-inch seamless copper tubes with aluminum fins mechanically bonded to copper tubes, stainless steel frame, copper suction header and distribution tubes. Coils shall be pressure tested at 450 psig and leak tested at 300 psig with air under water. Coils shall be certified per ARI Standards. Provide 1 or 2 independent refrigerant circuits as called out on the attached Equipment Schedules.
5. Condensate drain pan - shall be double-wall, stainless steel construction and be positioned under the entire coil. Stainless steel pan shall be formed of 20-gauge steel, welded watertight. Drain pan shall be sloped and fitted with 1-in MPT, non-corrosive plastic drain connections on either side of the unit. Drain pan shall be insulated.
6. Filters
  - a. The unit shall be constructed with a contaminant control system consisting of five stages of filtration. Refer to Equipment Schedule for filter types by unit.
  - b. Pre-Filter shall be non-woven, pleated, reinforced cotton & synthetic fabric disposable type, framed filters, thickness as scheduled. Media shall be supported and retained with a corrosion resistant track securely attached to housing. Filter pressure drop for clean filters at 300 fpm face velocity shall be 0.15-in WG for 2-in. thick filters. Filter shall have 30 to 35 percent efficiency on ASHRAE Test Standard 52. Filter type shall be Farr 30/30, Flanders or equal Disposable Filters.
  - c. The intermediate first and second stages shall be chemical filter media. The first stage shall consist of activated carbon impregnated with potassium hydroxide to enhance the removal of acid gases, equal to Circul-Aire MM-9000. The second stage shall consist of activated alumina impregnated with potassium permanganate, equal to Circul-Aire MM-1000. Refer to the Equipment Schedules for specific chemical filter requirements including required range of contaminant removal. All filter media shall be supported and retained with a corrosion resistant track securely attached to the housing. Spaces between frames and housing shall be caulked, gasketed and sealed airtight to prevent air bypass. The filters shall be secured in the holding frame with felt gasketing and, where required, stainless steel retaining clips. Filters shall be capable of handling airstreams at the expected temperature, humidity and air contaminant ranges indicated in the Equipment Schedules. Media shall be disposable in standard dumpsters. Media shall be replaced either by discarding media housing or recycling housing by emptying spent media and refilling with new media. Media housing shall be aluminum or

epoxy coated steel. Coordinate with third party vendor for housing, access door(s), tracks, and dimensions for integration into air-handling unit.

- d. After Filter shall be non-woven, pleated, reinforced cotton & synthetic fabric disposable type, framed filters, thickness as scheduled. Media shall be supported and retained with a corrosion resistant track securely attached to housing. Filter pressure drop for clean filters at 300 fpm face velocity shall be 0.15-in WG for 2-in. thick filters. Filter shall have 30 to 35 percent efficiency on ASHRAE Test Standard 52. Filter type shall be Farr 30/30, Flanders or equal Disposable Filters.
- e. Final Filters shall have a corrosion resistant holding frame and replaceable type rigid filter cartridge with a minimum efficiency of 60 to 65 percent on ASHRAE Test Standard 52. Filter pressure drop for clean filters at 500 fpm face velocity shall not exceed 0.65-in WG. Filters shall be UL listed and manufactured by American Air Filter Co., Farr Co., Flanders, Cambridge, or equal.
- f. A minimum of three complete sets of pre-filters, after-filters, and final-filters shall be provided. The first set is to be installed for start-up, test and balancing. Additional sets of filters shall be provided as needed until final acceptance. Another set of filters shall be installed after final cleanup and acceptance by the Owner. A spare set of filters shall be turned over to the Owner.
- g. One spare set of chemical filter media shall be provided.

## 7. Gages

- a. For each pre, and after filter section, provide a differential static pressure gage. Each gage shall be provided with shut-off vent valves on each side of the gage to permit zeroing of the gage without disconnecting the gage. Tubing shall be aluminum. Static pressure sensors, valves and fittings shall be aluminum. Pressure range of gages shall be three times the clean pressure loss of the filters provided. Gages for local indication of indoor units shall be magnehelic or minihelic type. Gages shall have a zero adjustment screw and an adjustable set point indicator. Casing shall be cast aluminum. The unit shall be able to withstand an overpressure of 15 lbs/sq in. Gages shall be by Dwyer Magnehelic Series 2000, Minihelic II or equal. Dwyer minihelic gages are acceptable when mounted integral with the unit.
- b. For final filter section, provide a differential static pressure switch/transmitter for local indication and remote alarming of loss of air flow. Provided with shut-off vent valves on each side of the gage to permit zeroing of the gage without disconnecting the gage. Tubing shall be aluminum. Static pressure sensors, valves and fittings shall be aluminum. Pressure range of gage shall be three times the clean pressure loss of the filters provided. Gages shall have a zero adjustment screw, 2-DPDT relays rated for 10 amps at 110 VAC, and adjustable set point indicators. Casing shall be cast aluminum. The unit shall be able to withstand an overpressure of 15 lbs/sq in. Gages shall be by Dwyer Photohelic Series 3000, or equal.
- c. Mixing Box – shall have outdoor air opening as indicated on the drawings. Outdoor air opening shall have factory mounted and wired motor operated dampers and actuators. Actuators shall be power-open / spring-return type.

- d. DDC Controls – shall be factory wired and factory installed on the air-handling unit. Provide all required controls to meet the intent of the Sequence of Operations described on the drawings; all safety controls and interlocks; and terminal strip for remote wired devices. Provide with required step-down transformers for single-point connection; control voltage shall not exceed 120V. A Field Programmable Controller with screen and keypad for local monitoring, troubleshooting, and changing of setpoints shall be provided and factory mounted to the unit.
- e. Air-handling unit shall be equal to as manufactured by Trane, Series MCCB or approved equal.
- f. Temptrol is also an acceptable manufacturer for the air-handling unit.



C. Electric Duct Heater

- 1. The duct heater will be shipped loose for field installation by the Contractor.
- 2. The make-up air-handling unit's control panel shall be connected to enable/disable the duct heater based on fan operation, and cooling/dehumidification.
- 3. Provide interconnecting conduit and wire per Division 16 - Electrical.
- 4. Refer to Section 15550 – HVAC - Heating Equipment for additional requirements.

D. Condensing Unit – Condensing unit shall consist of compressors, condenser coil, condenser fans and drives. The unit shall be air-cooled type, designed and constructed for mounting remote from its associated air handler with field fabricated interconnecting refrigerant piping, including associated specialties.

- 1. Casing - Unit casing shall be provided with a corrosion resistant coating system for weather protection. Top of housing shall be constructed to prevent buckling and ponding of water. All rotating components in the condensing unit shall be internally isolated with vibration isolators. The unit shall have propeller or centrifugal fans as shown on the schedules. Exposed fans shall be provided with fan guards. Coils shall have copper tubes, aluminum fins, galvanized steel frame and copper headers. Fins shall be mechanically attached to the tubes. Coils shall be pressure and leak tested at 425 psig with air under water. Provide with louver panels or hail guards made of 18 gauge steel, consisting of hood and coil guard. Hood shall be primed and painted to match unit casing. Wire guards shall not be acceptable.
- 2. Compressor - Shall be of the type, number and capacity specified on the schedules. Compressors shall be provided with unloading or hot gas by-pass as required by the schedule. Each compressor shall be provided with a complete and independent refrigerant piping system. Compressor shall include suction strainer, crank case oil sight glass, oil strainer and oil heater and forced feed lubrication. Compressor controls shall include three-phase manual reset overload protection, hi-low refrigerant pressure cutout, manual reset low oil pressure cutout, non-cycle pump down relay. In addition multiple compressor units shall have a compressor sequence switch.
- 3. Controls – shall be factory wired and factory installed on the condensing unit. Provide with all required controls to meet intent of Sequence of Operations described on the drawings; all safety controls; and interlocks. Provide with required step-down transformers for single-point connection; control voltage shall



not exceed 120V. Options shall include low ambient controls; time delay relay (to keep both compressors on multiple compressor units from starting simultaneously) and anti-short cycle timer.

4. Coatings – All exposed materials outdoors shall have coatings per 15500 – HVAC - General Provisions. Coatings from manufacturer shall be approved equal.
5. Condensing unit shall be as manufactured by Trane, Series TTA or approved equal.
6. LG is also an acceptable manufacturer for the condensing unit.



E. Electrical

1. Air Handling Unit – Provide with integral motor starter, integral controllers and other sub-components ready for single point connection in the field by the Electrical Contractor. Remote disconnect switch shall be provided by Division 16 - Electrical.
2. Duct Heater – Provide with heater mounted control panel ready for single point connection in the field by the Electrical Contractor. Provide integral disconnect with heater control panel.
3. Condensing Unit - Provide with integral starter/capacitors and other sub-components ready for single point connection in the field by the Electrical Contractor. Remote disconnect switch shall be provided by Division 16 - Electrical.

- F. Refrigerant piping – Interconnecting refrigerant piping between the air-handler and condensing unit shall be field-installed per the equipment manufacturer's recommendations. Piping shall be Type K copper tubing with joints silver brazed. Brazing shall be done with an inert gas purge. Suction lines shall be insulated per Section 15900 – HVAC – Thermal Insulation. Hot gas piping shall be insulated to protect personnel as required. Valves shall be bronze body brazed connection and shall include compressor and condenser relief valves, condenser liquid line service valve, refrigerant charging valve, compressor discharge, suction service valves, liquid line solenoid and thermal expansion valve.

- G. Acceptable manufacturers – Split system units shall be of the type as specified herein and equal to the unit with the manufacturer and model number as called on the Equipment Schedules on the Drawings. Acceptable manufacturers are Trane, York, and AAON.

## 2.05 SELF-CONTAINED WALL-MOUNTED AIR-HANDLING UNITS

- A. General - Shall be factory assembled, high-efficiency packaged units suitable for exterior installation, complete with cabinet fan, heating section (where required per the Equipment Schedules), DX-refrigerant cooling section, compressors, refrigerant piping system, condenser, condenser fans and drives, factory wired control module, filters, dampers, access sections with hinged access doors, motor, motor base, drive, drive guard and vibration isolators. No outside air is to be introduced into the room by these units. Units shall be fully assembled and charged with refrigerant at the factory, ready for installation at the site via single-point electrical connection. Support brackets, lugs or other suitable support device are to be provided with the unit to allow the unit to be firmly bolted to the structure. The lugs, brackets or field supplied

devices shall be sized to withstand the expected loads for the area and type of application. Units shall have all rotating components internally isolated from the main unit with vibration isolators. Equipment shall be as manufactured by Bard, Inc. or approved equal and shall be the model number and type as called out on the Equipment Schedules.

- B. Casings - Shall be zinc-coated, galvanized sheet steel construction with structural framing members as required. Provide with manufacturer's standard weather-resistant baked enamel finish. Color shall be selected and approved by the Engineer from the manufacturer's full color range. Pressure class rating of casing shall be for the total fan static pressure, with all sections of the unit of the same pressure class. The unit shall be insulated with 1-in mat faced or neoprene coated fiberglass insulation, 1 lb minimum density, installed with stick clips and adhesives to prevent erosion of the insulation. The base of the unit shall be equally insulated and all insulation edges sealed to prevent erosion. The casing shall enclose all components for weather protection, with gasketed access doors provided for all sections to facilitate maintenance. Doors shall have provision for key locking to prevent unauthorized tampering. All access doors shall be equally insulated as unit walls. Top of housing shall be constructed to prevent buckling and ponding of water.
- C. Coatings – All exposed materials outdoors shall have coatings per 15500 – HVAC - General Provisions. Coatings from manufacturer shall be approved equal.
- D. Supply Air Fan - Fans shall be centrifugal cabinet fans, high-efficiency type, with belt drives, adjustable V-belt type. All bearings for fan and motor shall be as defined in this Section. Extended external lubrication fittings shall be provided. Fan motor shall be thermally protected with fan assembly internally isolated. Backwardly curved wheels shall be airfoil type. All fans shall be statically and dynamically balanced before shipment. All fans shall be AMCA rated for sound and air performance. Where called for on the schedules, fans shall be of spark-proof construction. On spark-proof fans, bearings shall not be placed in the air stream.
- E. Evaporator Cooling Coil Section – Refrigerant-based, 3/8-inch seamless copper tubes with aluminum fins mechanically bonded to copper tubes, galvanized steel frame, copper suction header and distribution tubes. Coil mounting shall minimize air by-pass around the coil. Coils shall be pressure and leak tested at 300 psig with air under water. Coils shall be certified per ARI Standards. Provide 1 or 2 independent refrigerant circuits as called out on the Equipment Schedules.
- F. Condensate drain pan – Material shall be stainless steel or plastic and be positioned under the entire coil. Stainless steel pan shall be formed of 20-gauge steel, welded watertight. Drain pan shall be fitted with 1-in NPT, non-corrosive plastic drain connection and sloped for complete drainage, allowing for no standing water in the pan. Drain pan shall be insulated.
- G. Heating section - Electric heating coils shall be open resistance, nickel-chrome heating type with coil and unit UL listed. Coils and coil controls shall meet NEC and UL requirements. The following built-in accessories and safety controls, in addition to the NEC and UL required safety controls, shall be included: primary over temperature,

thermal cut-out (automatic reset), secondary thermal protection (manual reset), fan/heater interlock and heater staging control via the unit's control module.

- H. Condenser section – shall be air-cooled type, integral to the packaged unit. All rotating components shall be internally isolated with vibration isolators from the main unit. The condenser shall have propeller or centrifugal fans as shown on the schedules. Exposed fans shall be provided with fan guards. All fans shall be statically and dynamically balanced before shipment, permanently lubricated and provided with built-in thermal overload protection. Condenser coils shall be 3/8-inch seamless copper tubes with aluminum fins mechanically bonded to copper tubes. Coils shall be leak tested at 200 psig and pressure tested at 450 psig with air under water. Provide condenser coils with louver panels or hail guards made of 18-gauge steel, consisting of hood and coil guard. Hood shall be primed and painted to match unit casing. Wire guards shall not be acceptable.
  - 1. Condenser Fan – Shall be sealed type, no exposed copper windings.
- I. Condenser Fan – shall be sealed type, no exposed copper windings.
- J. Compressors - shall be of the type, number and capacity specified on the Equipment Schedules. Compressors shall be provided with unloading or hot gas by-pass as required by the schedule. Compressor shall include suction strainer, crank case oil sight glass, oil strainer and oil heater and forced feed lubrication. Compressor controls shall include three-phase manual reset overload protection, hi-low refrigerant pressure cutout, manual reset low oil pressure cutout, non-cycle pump down relay. In addition, multiple compressor units shall have a compressor sequence switch.
- K. Filters - Filter Box shall have tracks for the specified filter types to allow filter replacement from either side. Sealing material shall be provided at tracks and ends to prevent air by-passing the filters. Filters shall be framed filters, 1-in or 2-in thickness as scheduled. Filter pressure drop for clean filters at 500 fpm face velocity shall be 0.2-in WG for 1-in thickness and 0.15-in WG for 2-in thick filters. Filter shall have 30 to 35 percent efficiency on ASHRAE Test Standard 52. Manufacturers and type shall be American Air Filter Co. AmAir 300X; Farr Co. 30/30; Cambridge Aeroplate or approved equal.
  - 1. A minimum of three complete sets of filters shall be provided. The first set is to be installed for start-up, test and balancing. Additional sets of filters shall be provided as needed until final acceptance. Another set of filters shall be installed after final cleanup and acceptance by the Owner. A spare set of filters shall be turned over to the Owner.
- L. Refrigerant Piping System - A complete refrigerant piping system shall be factory fabricated and installed in the unit. Piping shall be Type K copper tubing with joints silver brazed. Brazing shall be done with an inert gas purge. Complete refrigerant system shall be cleaned, leak tested and charged with refrigerant.
- M. Unit Control Panel - A factory wired control panel shall be furnished and mounted on the unit. Panels shall include all controls required and all safety controls and interlocks, control devices, motor starters and terminal strip for remote wired devices. Control sequence shall be as specified on the Drawings. Control voltage shall not

exceed 120V. A complete wiring diagram shall be permanently attached to the inside of the panel door. Where specific area classifications are called for or shown on the electrical drawings, all equipment and wiring shall be in conformance with the requirements for that classification.

N. Electrical

1. Provide unit with an integral magnetic starter, integral controllers and other sub-components ready for single point connection in the field by the Contractor.
2. Disconnect switch shall be provided by Division 16 - Electrical.

O. Accessories – Provide with remote wall mounted, auto changeover thermostat.

P. Units above 5 ton capacity shall be approved equal to the Specific Air models scheduled. Bard and Marvair are also approved manufacturers.



Q. Acceptable manufacturers – Packaged wall units shall be of the type as specified herein and equal to the unit with the manufacturer and model number as called on the Equipment Schedules on the Drawings. Acceptable manufacturers are Bard, Marvair and Specific Systems.

## 2.06 IDENTIFICATION

A. Provide each piece of equipment with a factory-applied stainless steel nameplate permanently attached to the exterior of the equipment, in an accessible location, external to any insulated surface and observable while the equipment is in operation.

B. As a minimum, include the following applicable information on the nameplate:

1. Manufacturer's name.
2. Equipment Model Number.
3. Equipment tag number.
4. Purchasers order number.
5. Serial Number.
6. Manufacturer's size and type.
7. Air Flow Rate – CFM.
8. Airside Design Pressure – in. W.G.
9. Fan Horsepower and RPM.
10. Cooling Capacity – Total and Sensible Cooling, MBH.
11. Heating Capacity – MBH or KW.
12. For gas-fired equipment, Type of Fuel Approved for use.
13. Refrigerant Type.
14. Volts/Phase/Hertz.
15. List of each individual component's electrical data: volts, amps or watts, phase.
16. Date of manufacture.
17. Approving Agency Seals.

C. Each piece of equipment shall be provided with a label with the equipment tag number as used in the contract documents.

- D. Refer to Section 15905 – HVAC - Identification for additional requirements.

### PART 3 EXECUTION

#### 3.01 INSTALLATION

- A. Equipment shall be installed in accordance with manufacturer's recommendation. Provide piping and ductwork connections in accordance with the requirements of the other related Sections.
- B. Install units level and plumb, maintaining manufacturer's recommended clearances or NEC clearances, whichever is greater.
- C. Where applicable, install units level on structural platform. Coordinate wall penetrations with wall construction. Secure units to structural support with anchor bolts.
- D. When units are shipped disassembled, field connect all sections together as shown on the Drawings to form single air handling unit. Seal all joints with gaskets and/or sealants.
- E. Use flexible duct connectors when attaching any and all ductwork to air-handling units. Refer to Section 15890 – HVAC - Metal Ductwork and Accessories for type.
- F. Ground equipment. Refer to Division 16 - Electrical for requirements.
- G. Do not operate equipment without filters. Do not run equipment with dirty filter pressure drop more than twice clean filter pressure drop. A minimum of three complete sets of filters shall be provided. The first set is to be installed for start-up, testing and balancing. Additional sets of filters shall be provided as needed until final acceptance. Another set of filters shall be installed after final cleanup and acceptance by the Owner. A spare set of filters shall be turned over to the Owner.
- H. The Contractor shall start up each piece of equipment and system and shall make all adjustments so that the system is placed in proper operating condition.

#### 3.02 FIELD INSPECTION AND TESTING

- A. Provide field inspection and testing per Section 15500 – HVAC - General Provisions, and as specifically mentioned in this Section.
- B. After verification of equipment operability and readiness for start-up, the contractor shall submit a written request for start-up date. Request shall include a list of equipment, buildings, or areas to be tested. Contractor shall coordinate the date, time, and availability with Owner's Designated Representative and Engineer for witness of start-up and testing.
- C. Factory-Trained Manufacturer's Representative

1. Provide an authorized representative of the manufacturer who has complete knowledge of proper installation, startup, and operation and maintenance (O&M) shall be provided as noted below.
2. The use of local sales representatives to perform this work is not acceptable, unless the manufacturer provides documented evidence that the sales representative has been specifically trained for this work.
3. If there are difficulties in operation of the equipment due to the manufacturers' design or fabrication, additional service shall be provided at no cost to the Owner.
4. Man-hour requirements tabulated below are exclusive of travel time and do not relieve the Contractor of obligation to provide sufficient service to place equipment in satisfactory operation.

Services Provided by Factory Representative	Minimum <sup>(a)</sup> No. of Trips	Minimum Time On Site Per Trip (hours)
1. Inspect and approve installation <sup>(b)</sup>	1	4
2. Perform start-up, adjustment and testing	1	4

(a) The manufacturer's factory representative shall be present at frequent enough intervals to ensure proper installation, testing, and initial operation of the equipment.

(b) The manufacturer's factory representative shall provide to the Owner's Representative a written certification that the system has been installed in accordance with the manufacturer's recommendations.

- D. The contractor may also provide someone that is fully knowledgeable and competent with these systems as a substitute for the manufacturer's representative.



E. Startup Service

1. Complete installation and startup checks according to manufacturer's written instructions and do the following:
  - a. Inspect for visible damage to unit casing.
  - b. Inspect for visible damage to heater.
  - c. Inspect for visible damage to fans.
  - d. Inspect internal insulation.
  - e. Verify that labels are clearly visible.
  - f. Verify that clearances have been provided for servicing.
  - g. Verify that controls are connected and operable.
  - h. Verify that filters are installed.
  - i. Clean heating coil and inspect for construction debris.
  - j. Adjust vibration isolators.
  - k. Lubricate bearings on fan.
  - l. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
  - m. Adjust fan belts to proper alignment and tension.
  - n. Start unit according to manufacturer's written instructions.

- 1) Complete startup sheets and attach copy with Contractor's startup report.
  - 2) Inspect and record performance of interlocks and protective devices; verify sequences.
  - 3) Operate unit for an initial period as recommended or required by manufacturer.
  - 4) Calibrate thermostat.
  - 5) Inspect outside-air dampers and return-air damper settings.
  - 6) Inspect controls for correct sequencing of heating and emergency shutdown.
  - 7) Measure and record the supply, outside and return airflows.
2. Verify operation of control panel, including pilot-light operation and failure modes. Inspect all alarms and safety devices.
  3. After startup and performance testing, change filters, vacuum heat exchanger, lubricate bearings, adjust belt tension, and inspect operation of power vents.
  4. Provide Manufacturer's Startup Form, otherwise provide applicable forms for the specific type of equipment.

### 3.03 MEDIA SAMPLING

- A. Manufacturer shall include sampling services of chemical media in cost of purchased media without additional cost to Owner. The manufacturer shall support media sampling services through a licensed and trained factory representative.
- B. Media shall be tested after Owner's final acceptance of equipment.
- C. Upon testing of media at manufacturer's facility, the manufacturer shall furnish an analysis report to the Owner indicating spent level of media and estimated remaining life.

### 3.04 CLEANING

- A. At the completion of the work, clean all equipment, piping, and associated components included in this Section.

END OF SECTION

**SECTION 15857****HVAC - VARIABLE REFRIGERANT FLOW SYSTEMS****PART 1 GENERAL****1.01 SCOPE OF WORK**

- A. Furnish and install the variable refrigerant flow systems (VRF), including but not limited to, outdoor condensing units, indoor branch circuit controllers, ceiling cassettes, concealed ducted units, refrigerant piping, and controls for a complete and operational system as shown on the Drawings, scheduled, and as specified herein.
- B. Refer to Section 15500 – HVAC - General Provisions for HVAC General Provisions relating to the work of this Section.

**1.02 RELATED WORK**

- A. Remote disconnects shall be provided under Division 16.
- B. Refer to Division 16 - Electrical for electrical requirements.
- C. Refer to Structural and Division 05 – Metals for additional requirements for supporting equipment, piping, and ductwork from roof structure.

**1.03 SUBMITTALS**

- A. Submit all shop drawings and Operating and Maintenance Manuals with all information required per Division 01 – General Provisions and Section 15500 – HVAC - General Provisions.
- B. Submit installer qualifications and certifications prior to commencing work.

**1.04 REFERENCE STANDARDS**

- A. Refer to Section 15500 – HVAC - General Provisions.

**1.05 QUALITY ASSURANCE**

- A. Refer to Section 15500 – HVAC - General Provisions and the following specific requirements related to this Section.
- B. Guarantee that refrigerant cooling equipment will provide indicated cooling capacities in Equipment Schedules.
- C. The units shall be listed by Electrical Testing Laboratories (ETL) and bear the ETL label.
- D. All wiring shall be in accordance with the National Electrical Code (N.E.C.).



- E. The units shall be manufactured in a facility registered to ISO 9001 and ISO14001 which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).
- F. All units must meet or exceed the 2010 Federal minimum efficiency requirements and the ASHRAE 90.1 efficiency requirements for VRF systems. Efficiency shall be published in accordance with the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 1230.
- G. A full charge of R-410A for the condensing unit only shall be provided in the condensing unit.
- H. Manufacturer shall have a minimum of twenty (20) years of HVAC experience in the U.S. market.
- I. All Manufacturer technical and service manuals must be readily available for download by any local contractor should emergency service be required. Registering and sign-in requirements which may delay emergency service reference are not allowed.
- J. The VRF system shall be installed by a contractor with extensive VRF install and service training. The mandatory contractor service and install training should be performed by the Manufacturer. **Manufacturer shall send a representative to assist in the supervision of start-up. An installer trained in Mitsubishi's Contractor Service Course must be present at all times.**

#### 1.06 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS

- A. The variable capacity, heat pump heat recovery air conditioning system shall be a Trane/Mitsubishi Electric CITY MULTI VRF (Variable Refrigerant Flow) zoning system.
- B. LG is also an acceptable manufacturer for the VRF system.
- C. The Y-Series system shall consist of TUHY outdoor unit, multiple indoor units, and M-NET DDC (Direct Digital Controls). The sum of connected capacity of all indoor air handlers shall not exceed 105% of outdoor rated capacity.
- D. Equipment Schedules
  - 1. This Section is incomplete without the information contained in the schedules. All VRF systems shall be of the type, capacity and arrangement as listed on the schedules. Units shall consist of the components listed in the schedule and those components obviously required for the type of unit. The order of component assembly will be as called for on the schedule. Particular attention must be paid to the remarks and notes in these schedules.
- E. Controls
  - 1. The control system shall consist of a low voltage communication network of unitary built-in controllers with on-board communications and a web-based operator interface. A web controller with a network interface card shall gather data from this system and generate web pages accessible through a conventional



web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface.

2. System controls and control components shall be installed in accordance with the Manufacturer's written installation instructions.
3. Furnish energy conservation features such as optimal start, night setback, request-based logic, and demand level adjustment of overall system capacity as specified in the sequence.
4. System shall provide direct and reverse-acting on and off algorithms based on an input condition or group conditions to cycle a binary output or multiple binary outputs.
5. Provide capability for future system expansion to include monitoring and use of occupant card access, lighting control and general equipment control.
6. System shall be capable of email generation for remote alarm annunciation.
7. Control system start-up shall be a required service to be completed by a duly authorized, competent representative that has been factory trained in Mitsubishi Electric controls system configuration and operation. The representative shall provide proof of certification for Mitsubishi Electric Controls Applications Training indicating successful completion of no more than two (2) years prior to system installation. This certification shall be included as part of the equipment and/or controls submittals. This service shall be equipment and system count dependent and shall be a minimum of one (1) eight (8) hour period to be completed during normal working hours.

#### 1.07 DELIVERY, STORAGE AND HANDLING

- A. Refer to Section 15500 – HVAC - General Provisions.

#### 1.08 MAINTENANCE/SPARE PARTS

- A. Refer to Section 15500 – HVAC - General Provisions.

#### 1.09 WARRANTY/EXTENDED WARRANTY

- A. Refer to Division 01 – General Provisions and Section 15500 – HVAC - General Provisions for Warranty requirements and the following specific requirements related to this Section.
- B. The units shall be covered by the Manufacturer's limited warranty for a minimum period of one (1) year parts and seven (7) year compressor to the original owner from date of installation.
- C. The units shall be covered by an extended Manufacturer's limited warranty for a period of ten (10) years to the original owner from date of installation.
- D. In addition the compressor shall have a Manufacturer's limited warranty for a period of ten (10) years to the original owner from date of installation.
- E. The VRF system shall comply with the following:

1. Designed by a certified CITY MULTI Diamond Designer using Diamond System Builder.
  2. Installed by a contractor that has successfully completed the Mitsubishi Electric three day service course.
  3. Verified with required materials submitted to and approved by the Mitsubishi Electric Service Department, which include:
    - a. As built Diamond System Builder file
    - b. A one (1) hour Maintenance Tool record with system information, in Ordinary Control Mode (not initial)
    - c. Outdoor and Indoor unit dip switch settings
    - d. Outdoor unit(s) function settings
- F. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the Manufacturer.
- G. The Manufacturer warranty does not include labor.

## PART 2 PRODUCTS

### 2.01 OUTDOOR UNIT (L-GENERATION R2-SERIES)

#### A. General

1. The R2-Series TURY outdoor unit shall be used specifically with CITY MULTI VRF components. The TURY outdoor units shall be equipped with multiple circuit boards that interface to the M-NET controls system and shall perform all functions necessary for operation. Each outdoor unit module shall be completely factory assembled, piped and wired and run tested at the factory.
2. The model nomenclature and unit requirements are shown below. All units requiring a factory supplied twinning kits shall be piped together in the field, without the need for equalizing line(s). If an alternate Manufacturer is selected, any additional material, cost, and labor to install additional lines shall be incurred by the contractor.
3. Outdoor unit shall have a sound rating no higher than 61 dB(A) individually or 64 dB(A) twinned. Units shall have a sound rating no higher than 51 dB(A) individually or 54 dB(A) twinned while in night mode operation. If an alternate Manufacturer is selected, any additional material, cost, and labor to meet published sound levels shall be incurred by the contractor.
4. Both refrigerant lines from the outdoor unit to the BC (Branch Circuit) Controller (Single or Main) shall be insulated in accordance with the installation manual.
5. The outdoor unit shall have the capability of installing the main refrigerant piping through the bottom of the unit.
6. There shall be no more than 3 branch circuit controllers connected to any one outdoor unit.
7. Outdoor unit shall be able to connect to up to 50 indoor units depending upon model.

8. The outdoor unit shall have an accumulator with refrigerant level sensors and controls.
9. The outdoor unit shall have a high pressure safety switch, over-current protection, crankcase heater and DC bus protection.
10. The outdoor unit shall have the ability to operate with a maximum height difference of 164 feet and have total refrigerant tubing length of 1804-3100 feet. The greatest length is not to exceed 541 feet between outdoor unit and the indoor units without the need for line size changes or traps.
11. The outdoor unit shall be capable of operating in heating mode down to -4°F ambient temperatures or cooling mode down to 23°F ambient temperatures, without additional low ambient controls. No capacity reduction shall occur up to this point. If an alternate Manufacturer is selected, any additional material, cost, and labor to meet low ambient operating condition and performance shall be incurred by the contractor.
12. The outdoor unit shall have a high efficiency oil separator plus additional logic controls to ensure adequate oil volume in the compressor is maintained.
13. Unit must defrost all circuits simultaneously in order to resume full heating more quickly. Partial defrost which may extend "no or reduced heating" periods shall not be allowed.

B. Unit Cabinet

1. The casing(s) shall be fabricated of galvanized steel, bonderized and finished. Units cabinets shall be able to withstand 960 hours per ASTM B117 criteria for seacoast protected models (-BS models)

C. Fan

1. Each outdoor unit module shall be furnished with one direct drive, variable speed propeller type fan. The fan shall be factory set for operation under 0 in. WG external static pressure, but capable of normal operation under a maximum of 0.24 in. WG external static pressure via dipswitch.
2. All fan motors shall have inherent protection, have permanently lubricated bearings, and be completely variable speed.
3. All fan motors shall be mounted for quiet operation.
4. All fans shall be provided with a raised guard to prevent contact with moving parts.
5. The outdoor unit shall have vertical discharge airflow.

D. Refrigerant

1. R410A refrigerant shall be required for TURY outdoor unit systems.
2. Polyolester (POE) oil shall be required. Prior to bidding, Manufacturers using alternate oil types shall submit material safety data sheets (MSDS) and comparison of hygroscopic properties for alternate oil with list of local suppliers stocking alternate oil for approval at least two weeks prior to bidding.

E. Coil

1. The outdoor Hexicoil™ heat exchanger shall be of zinc coated aluminum construction with turbulating flat tube construction.

2. The coil fins shall have a factory applied corrosion resistant blue-fin finish.
3. A stainless steel pipe connects the aluminum coil to copper piping.
4. The coil shall be protected with an integral metal guard.
5. Refrigerant flow from the outdoor unit shall be controlled by means of an inverter driven compressor.
6. The outdoor coil shall include 4 circuits with two position valves for each circuit, except for the last stage.

F. Compressor

1. Each outdoor unit module shall be equipped with one inverter driven scroll hermetic compressor. Non inverter-driven compressors, which cause inrush current (demand charges) and require larger wire sizing, shall not be allowed.
2. A crankcase heater(s) shall be factory mounted on the compressor(s).
3. The outdoor unit compressor shall have an inverter to modulate capacity. The capacity shall be completely variable with a turndown of 15%-5% of rated capacity, depending upon unit size.
4. The compressor will be equipped with an internal thermal overload.
5. The compressor shall be mounted to avoid the transmission of vibration.
6. Field-installed oil equalization lines between modules are not allowed. Prior to bidding, Manufacturers requiring equalization must submit oil line sizing calculations specific to each system and module placement for this project.

G. Controls

1. The outdoor unit shall have the capability of up to 8 levels of demand control for each refrigerant system

H. Electrical

1. The outdoor unit electrical power shall be 208/230 volts, 3-phase, 60 hertz.
2. The outdoor unit shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz), 207-253V (230V/60Hz).
3. The outdoor unit shall be controlled by integral microprocessors.
4. The control circuit between the indoor units, BC Controller and the outdoor unit shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.

## 2.02 BRANCH CIRCUIT (BC) CONTROLLERS (FOR R2-SERIES SYSTEMS)

A. General

1. The BC (Branch Circuit) Controllers shall include multiple branches to allow simultaneous heating and cooling by allowing either hot gas refrigerant to flow to indoor unit(s) for heating or subcooled liquid refrigerant to flow to indoor unit(s) for cooling. Refrigerant used for cooling must always be subcooled for optimal indoor unit LEV performance; alternate branch devices with no subcooling risk bubbles in liquid supplied to LEV and are not allowed.
2. The BC (Branch Circuit) Controllers shall be specifically used with R410A R2-Series systems. These units shall be equipped with a circuit board that interfaces to the M-NET controls system and shall perform all functions necessary for operation.

The unit shall have a galvanized steel finish. The BC Controller shall be completely factory assembled, piped and wired. Each unit shall be run tested at the factory. This unit shall be mounted indoors, with access and service clearance provided for each controller. The sum of connected capacity of all indoor air handlers shall range from 50% to 150% of rated capacity. The BC Controller shall be suitable for use in plenums in accordance with UL1995 ed 4.

B. BC Unit Cabinet

1. The casing shall be fabricated of galvanized steel.
2. Each cabinet shall house a liquid-gas separator and multiple refrigeration control valves.
3. The unit shall house two tube-in-tube heat exchangers.

C. Refrigerant

1. R410A refrigerant shall be required.

D. Refrigerant Branches

1. All BC Controller refrigerant pipe connections shall be brazed or flared.

E. Refrigerant valves

1. The unit shall be furnished with multiple branch circuits which can individually accommodate up to 54,000 BTUH and up to three indoor units. Branches may be twinned to allow more than 54,000 BTUH.
2. Each branch shall have multiple two-position valves to control refrigerant flow.
3. Service shut-off valves shall be field-provided/installed for each branch to allow service to any indoor unit without field interruption to overall system operation.
4. Linear electronic expansion valves shall be used to control the variable refrigerant flow.

F. Integral Drain Pan

1. An Integral resin drain pan and drain shall be provided.

G. Electrical:

1. The unit electrical power shall be 208/230 volts, 1 phase, 60 Hertz.
2. The unit shall be capable of satisfactory operation within voltage limits of 187-228 (208V/60Hz) or 207-253 (230/60Hz).
3. The BC Controller shall be controlled by integral microprocessors
4. The control circuit between the indoor units and outdoor units shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.

## 2.03 TPLFY- (4-WAY CEILING-RECESSED CASSETTE WITH GRILLE) INDOOR UNIT

A. General

1. The TPLFY shall be a four-way cassette style indoor unit that recesses into the ceiling with a ceiling grille. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic

modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, an emergency operation function and a test run switch. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

B. Unit Cabinet

1. The cabinet shall be a compact 22-7/16" wide x 22-7/16" deep so it will fit within a standard 24" square suspended ceiling grid.
2. The cabinet panel shall have provisions for a field installed filtered outside air intake.
3. Four-way grille shall be fixed to bottom of cabinet allowing two, three or four-way blow.

C. Fan

1. The indoor fan shall be an assembly with a turbo fan direct driven by a single motor.
2. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
3. The indoor fan shall consist of three (3) speeds, Low, Mid, and High.
4. The indoor unit shall have an adjustable air outlet system offering 4-way airflow, 3-way airflow, or 2-way airflow.
5. The auto air swing vanes shall be capable of automatically swinging up and down for uniform air distribution.

D. Filter

1. Return air shall be filtered by means of a long-life washable filter.

E. Coil

1. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
2. The tubing shall have inner grooves for high efficiency heat exchange.
3. All tube joints shall be brazed with phos-copper or silver alloy.
4. The coils shall be pressure tested at the factory.
5. A condensate pan and drain shall be provided under the coil.
6. The unit shall be provided with an integral condensate lift mechanism that will be able to raise drain water 19-3/4" inches above the condensate pan.
7. Both refrigerant lines to the PLFY indoor units shall be insulated in accordance with the installation manual.

F. Electrical

1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
2. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).

G. Controls:

1. This unit shall use controls provided by Mitsubishi Electric to perform functions necessary to operate the system.
2. Indoor unit shall compensate for the higher temperature sensed by the return air sensor compared to the temperature at level of the occupant when in HEAT mode. Disabling of compensation shall be possible for individual units to accommodate instances when compensation is not required.
3. Control board shall include contacts for control of external heat source. External heat may be energized as second stage with 1.8°F – 9.0°F adjustable deadband from set point.
4. Indoor unit shall include no less than four (4) digital inputs capable of being used for customizable control strategies.
5. Indoor unit shall include no less than three (3) digital outputs capable of being used for customizable control strategies.

## 2.04 TPEFY (CEILING-CONCEALED DUCTED) INDOOR UNIT

### A. General

1. The TPEFY shall be a ceiling-concealed ducted indoor fan coil design that mounts above the ceiling with a 2-position, field adjustable return and a fixed horizontal discharge supply and shall have a modulating linear expansion device. The TPEFY shall be used with the R2-Series outdoor unit and BC Controller, Y-Series outdoor unit, or S-Series outdoor unit. The TPEFY shall support individual control using M-NET DDC controllers. The unit shall be suitable for use in plenums in accordance with UL1995 ed 4.

### B. Indoor Unit

1. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, and an auto restart function. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

### C. Unit Cabinet

1. The unit shall be, ceiling-concealed, ducted.
2. The cabinet panel shall have provisions for a field installed filtered outside air intake.

### D. Fan

1. TPEFY models shall feature external static pressure settings from 0.14 to 0.6 in. WG.
2. The indoor unit fan shall be an assembly with one or two Sirocco fan(s) direct driven by a single motor.
3. The indoor fan shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings.
4. The indoor fan shall consist of three (3) speeds, High, Mid, and Low plus the Auto-Fan function



5. The indoor unit shall have a ducted air outlet system and ducted return air system.

E. Filter

1. Return air shall be filtered by means of a standard factory installed return air filter.
2. Optional return filter box (rear or bottom placement) with high-efficiency filter shall be available for all TPEFY indoor units.

F. Coil

1. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
2. The tubing shall have inner grooves for high efficiency heat exchange.
3. All tube joints shall be brazed with phos-copper or silver alloy.
4. The coils shall be pressure tested at the factory.
5. A condensate pan and drain shall be provided under the coil.
6. The condensate shall be gravity drained from the fan coil.
7. Both refrigerant lines to the TPEFY indoor units shall be insulated in accordance with the installation manual.

G. Electrical

1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
2. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).

H. Controls

1. This unit shall use controls provided by Mitsubishi Electric Cooling & Heating to perform functions necessary to operate the system. Please refer to Part 5 of this guide specification for details on controllers and other control options.
2. Indoor unit shall compensate for the higher temperature sensed by the return air sensor compared to the temperature at level of the occupant when in HEAT mode. Disabling of compensation shall be possible for individual units to accommodate instances when compensation is not required.
3. Control board shall include contacts for control of external heat source. External heat may be energized as second stage with 1.8°F – 9.0°F adjustable deadband from set point.
4. Indoor unit shall include no less than four (4) digital inputs capable of being used for customizable control strategies.
5. Indoor unit shall include no less than three (3) digital outputs capable of being used for customizable control strategies.

## 2.05 TPEFY (ALTERNATE HIGH STATIC OPTION), CEILING-CONCEALED DUCTED INDOOR UNIT

A. General

1. The TPEFY(Alternate High Static Option) unit shall be a ceiling concealed ducted indoor fan coil that mounts above the ceiling with a fixed rear return and a horizontal discharge supply, and shall have a modulating linear expansion device.

The TPEFY shall be used with the R2-Series outdoor unit and BC Controller, Y-Series outdoor unit, or S-Series outdoor unit. The IDU shall support individual control using M-NET DDC controllers. High static models shall feature external static pressure settings up to 1.00 in. WG. Units shall have the ability to control supplemental heat via connector CN24 or CN4F and a 12 VDC output. The unit shall be suitable for use in plenums in accordance with UL1995 ed 4.

B. Indoor Unit

1. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, and an auto restart function. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

C. Unit Cabinet

1. The cabinet shall be ceiling-concealed, ducted.
2. The cabinet panel shall have provisions for a field installed filtered outside air intake.

D. Fan

1. The indoor unit fan shall be an assembly with one or two Sirocco fan(s) direct driven by a single motor.
2. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
3. The indoor unit shall have a ducted air outlet system and ducted return air system.

E. Filter

1. Return air shall be filtered by a field-supplied filter.
2. Optional rear return filter box with long-life filter shall be available for all TPEFY indoor units.

F. Coil

1. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
2. The tubing shall have inner grooves for high efficiency heat exchange.
3. All tube joints shall be brazed with phosphor-copper or silver alloy.
4. The coils shall be pressure tested at the factory.
5. A condensate pan and drain shall be provided under the coil.
6. The condensate shall be gravity drained from the fan coil.
7. Both refrigerant lines to the TPEFY indoor units shall be insulated in accordance with the installation manual.

G. Electrical

1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.

2. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).

#### H. Controls

1. This unit shall use controls provided by Mitsubishi Electric to perform functions necessary to operate the system. Please refer to Part 5 of this guide specification for details on controllers and other control options.
2. Indoor unit shall compensate for the higher temperature sensed by the return air sensor compared to the temperature at level of the occupant when in HEAT mode. Disabling of compensation shall be possible for individual units to accommodate instances when compensation is not required.
3. Control board shall include contacts for control of external heat source. External heat may be energized as second stage with 1.8°F – 9.0°F adjustable deadband from set point.
4. Indoor unit shall include no less than four (4) digital inputs capable of being used for customizable control strategies.
5. Indoor unit shall include no less than three (3) digital outputs capable of being used for customizable control strategies.

### 2.06 CONTROLS

#### A. General

1. The CITY MULTI Controls Network (CMCN) shall be capable of supporting remote controllers, centralized controllers, an integrated web based interface, graphical user workstation, and system integration to Building Management Systems via BACnet® and LonWorks®.

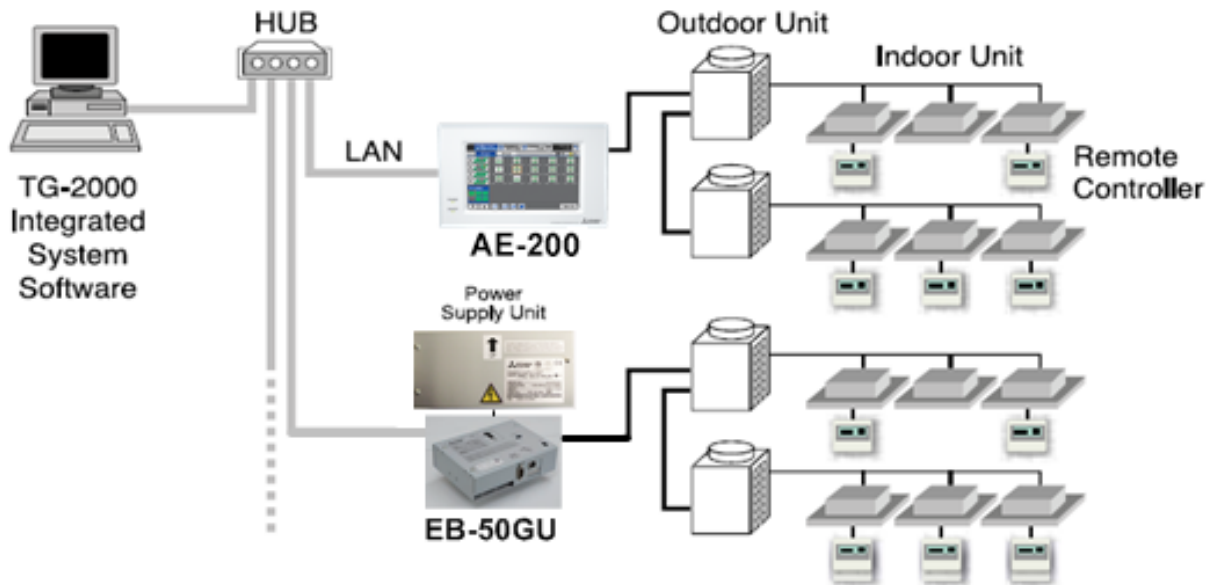
#### B. Electrical Characteristics

1. General
  - a. The CMCN shall operate at 30VDC. Controller power and communications shall be via a common non-polar communications bus.
2. Wiring
  - a. Control wiring shall be installed in a daisy chain configuration from indoor unit to indoor unit, to the BC controller (main and subs, if applicable) and to the outdoor unit. Control wiring to remote controllers shall be run from the indoor unit terminal block to the controller associated with that unit.
  - b. Control wiring for the Smart ME remote controller shall be from the remote controller to the first associated indoor unit (TB-5) M-NET connection. The Smart ME remote controller shall be assigned an M-NET address.
  - c. Control wiring for the Simple MA controllers shall be from the remote controller (receiver) to the first associated indoor unit (TB-15) then to the remaining associated indoor units (TB-15) in a daisy chain configuration.
  - d. Control wiring for centralized controllers shall be installed in a daisy chain configuration from outdoor unit to outdoor unit, to the system controllers (centralized controllers and/or integrated web based interface), to the power supply.

- e. The AE-200, centralized controller shall be capable of being networked with other centralized controllers for centralized control.
- 3. Wiring type
  - a. Wiring shall be 2-conductor (16 AWG), twisted, stranded, shielded wire as defined by the Diamond System Builder output.
  - b. Network wiring shall be CAT-5 with RJ-45 connection.

C. CITY MULTI Controls Network

- 1. The CITY MULTI Controls Network (CMCN) consists of remote controllers, centralized controllers, and/or integrated web based interface communicating over a high-speed communication bus. The CITY MULTI Controls Network shall support operation monitoring, scheduling, occupancy, error email distribution, personal web browsers, tenant billing, online maintenance support, and integration with Building Management Systems (BMS) using either LonWorks® or BACnet® interfaces. The below figure illustrates a sample CMCN System Configuration.



**CMCN System Configuration**

- 2. CMCN: Remote Controllers Backlit Simple MA Remote Controller (PAC-YT53CRAU)
  - a. The Backlit Simple MA Remote Controller (PAC-YT53CRAU) shall be capable of controlling up to 16 indoor units (defined as 1 group). The Backlit Simple MA Remote Controller shall be compact in size, approximately 3" x 5" and have limited user functionality. The Backlit Simple MA supports temperature display selection of Fahrenheit or Celsius. The Backlit Simple MA Remote Controller shall allow the user to change on/off, mode (cool, heat, auto (R2/WR2-Series only), dry, setback (R2/WR2-Series only) and fan), temperature setting, and fan speed setting and airflow direction. The Backlit Simple MA Remote Controller shall be able to limit the set temperature range from the Backlit Simple MA. The Backlit Simple MA Remote controller shall be capable of night setback control with upper and lower set temperature settings. The room

temperature shall be sensed at either the Backlit Simple MA Remote Controller or the Indoor Unit dependent on the indoor unit dipswitch setting. The Backlit Simple MA Remote Controller shall display a four-digit error code in the event of system abnormality/error.

- b. The Backlit Simple MA Remote Controller shall only be used in same group with Wireless MA Remote Controllers (PAR-FL32MA-E / PAR-FA32MA-E) or with other Backlit Simple MA Remote Controllers (PAC-YT53CRAU), with up to two remote controllers per group.
- c. The Backlit Simple MA Remote Controller shall require no addressing. The Backlit Simple MA Remote Controller shall connect using two-wire, stranded, non-polar control wire to TB15 connection terminal on the indoor unit. The Simple MA Remote Controller shall require cross-over wiring for grouping across indoor units.

<b>PAC-YT53CRAU (Backlit Simple MA Remote Controller)</b>			
<b>Item</b>	<b>Description</b>	<b>Operation</b>	<b>Display</b>
ON/OFF	Run and stop operation for a single group	Each Group	Each Group
Operation Mode	Switches between Cool/Drying/Auto/Fan/Heat/Setback. Operation modes vary depending on the air conditioner unit. Auto and Setback mode are available for the R2/WR2-Series only.	Each Group	Each Group
Temperature Setting	Sets the temperature from 40°F – 95°F depending on operation mode and indoor unit. Separate COOL and HEAT mode set points available depending on central controller and connected mechanical equipment.	Each Group	Each Group
Fan Speed Setting	Available fan speed settings depending on indoor unit.	Each Group	Each Group
Air Flow Direction Setting	Air flow direction settings vary depending on the indoor unit model.	Each Group	Each Group
Permit / Prohibit Local Operation	Individually prohibit operation of each local remote control function (Start/Stop, Change operation mode, Set temperature, Reset filter). *1: Centrally Controlled is displayed on the remote controller for prohibited functions.	N/A	Each Group *1
Display Indoor Unit Intake Temp	Measures and displays the intake temperature of the indoor unit when the indoor unit is operating.	N/A	Each Group
Display Backlight	Pressing the button lights up a backlight. The light automatically turns off after a certain period of time. (The brightness settings can be selected from Bright, Dark, and Light off.)	N/A	Each Unit
Error	When an error is currently occurring on an air conditioner unit, the afflicted unit and the error code are displayed	N/A	Each Unit

<b>PAC-YT53CRAU (Backlit Simple MA Remote Controller)</b>			
<b>Item</b>	<b>Description</b>	<b>Operation</b>	<b>Display</b>
Test Run	Operates air conditioner units in test run mode. *2 The display for test run mode will be the same as for normal start/stop (does not display "test run").	Each Group	Each Group *2
Ventilation Equipment	Up to 16 indoor units can be connected to an interlocked system that has one LOSSNAY unit.	Each Group	N/A
Set Temperature Range Limit	Set temperature range limit for cooling, heating, or auto mode.	Each Group	Each Group

D. Centralized Controller (Web-enabled)

1. TE-200 Centralized Controller

- a. The TE-200A Centralized Controller shall be capable of controlling a maximum of two hundred (200) indoor units across multiple outdoor units with the use of three (3) TE-50A expansion controllers. The TE-200A Centralized Controller shall be approximately 11-5/32" x 7-55/64" x 2-17/32" in size and shall be powered with an integrated 100-240 VAC power supply. The TE-200A Centralized Controller shall support system configuration, daily/weekly scheduling, monitoring of operation status, night setback settings, free contact interlock configuration and malfunction monitoring. When being used alone without the expansion controllers, the TE-200A Centralized Controller shall have five basic operation controls which can be applied to an individual indoor unit, a collection of indoor units (up to 50 indoor units), or all indoor units (collective batch operation). This basic set of operation controls for the TE-200 Centralized Controller shall include on/off, operation mode selection (cool, heat, auto (R2/WR2-Series only), dry, setback (R2/WR2-Series only) and fan), temperature setting, fan speed setting, and airflow direction setting. Since the TE-200A provides centralized control it shall be able to enable or disable operation of local remote controllers. In terms of scheduling, the TE-200A Centralized Controller shall allow the user to define both daily and weekly schedules (up to 24 scheduled events per day) with operations consisting of ON/OFF, mode selection, temperature setting, air flow (vane) direction, fan speed, and permit/prohibit of remote controllers.

<b>TE-200 (Centralized Controller)</b>			
<b>Item</b>	<b>Description</b>	<b>Operation</b>	<b>Display</b>
ON/OFF	Run and stop operation.	Each Block, Group or Collective	Each Group or Collective
Operation Mode	Switches between Cool/Dry/Auto/Fan/Heat. (Group of Lossnay unit: automatic ventilation/vent-heat/interchange/normal ventilation) Operation modes vary depending on the air conditioner unit. Auto mode is available for the R2/WR2-Series only.	Each Block, Group or Collective	Each Group

<b>TE-200 (Centralized Controller)</b>			
<b>Item</b>	<b>Description</b>	<b>Operation</b>	<b>Display</b>
Temperature Setting	Sets the temperature from 57°F – 87°F depending on operation mode and indoor unit.	Each Block, Group or Collective	Each Group
Fan Speed Setting	Available fan speed settings depending on indoor unit.	Each Block, Group or Collective	Each Group
Air Flow Direction Setting	Air flow direction settings vary depending on the indoor unit model. *1. Louver cannot be set.	*1 Each Block, Group or Collective	Each Group
Schedule Operation	Annual/weekly/today schedule can be set for each group of air conditioning units. Optimized start setting is also available. *1. The system follows either the current day, annual schedule, or weekly, which are in the descending order of overriding priority. Twenty-four events can be scheduled per day, including ON/OFF, Mode, Temperature Setting, Air Direction, Fan Speed and Operation Prohibition. Five types of weekly schedule (seasonal) can be set. Settable items depend on the functions that a given air conditioning unit supports.	*2 Each Block, Group or Collective	Each Group
Optimized Start	Unit starts 5 - 60 minutes before the scheduled time based on the operation data history in order to reach the scheduled temperature at the scheduled time.	Each Block, Group or Collective	Each Block, Group or Collective
Night Setback Setting	The function helps keep the indoor temperature in the temperature range while the units are stopped and during the time this function is effective.	Each Group	Each Group
Permit / Prohibit Local Operation	Individually prohibit operation of each local remote control function (Start/Stop, Change operation mode, Set temperature, Reset filter). *3. Centrally Controlled is displayed on the remote controller for prohibited functions.	Each Block, Group or Collective	*3 Each Group

<b>TE-200 (Centralized Controller)</b>			
<b>Item</b>	<b>Description</b>	<b>Operation</b>	<b>Display</b>
Room Temp	Displays the room temperature of the group. Space temperature displayed on the indoor unit icon on the touch screen interface.	N/A	Each Group
Error	When an error is currently occurring on an air conditioner unit, the afflicted unit and the error code are displayed *4. When an error occurs, the LED flashes. The operation monitor screen shows the abnormal unit by flashing it. The error monitor screen shows the abnormal unit address, error code and source of detection. The error log monitor screen shows the time and date, the abnormal unit address, error code and source of detection	N/A	*4 Each Unit or Collective
Outdoor Unit Status	Compressor capacity percentage and system pressure (high and low) pressure (excludes S-Series)	Each ODU	Each ODU
Connected Unit Information	MNET addresses of all connected systems	Each IDU, ODU and BC	Each IDU, ODU and BC
Ventilation Equipment	This interlocked system settings can be performed by the master system controller. When setting the interlocked system, use the ventilation switch the free plan LOSSNAY settings between "Hi", "Low" and "Stop". When setting a group of only free plan LOSSNAY units, you can switch between "Normal ventilation", "Interchange ventilation" and "Automatic ventilation".	Each Group	Each Group
Multiple Language	Other than English, the following language can be chosen. Spanish, French, Japanese, Dutch, Italian, Russian, Chinese, and Portuguese are available.	N/A	Collective



<b>TE-200 (Centralized Controller)</b>			
<b>Item</b>	<b>Description</b>	<b>Operation</b>	<b>Display</b>
External Input / Output	<p>By using accessory cables you can set and monitor the following.</p> <p>Input</p> <p>By level: "Batch start/stop", "Batch emergency stop"</p> <p>By pulse: "batch start/stop", "Enable/disable remote controller"</p> <p>Output: "start/stop", "error/Normal"</p> <p>*5. Requires the external I/O cables (PAC-YG10HA-E) sold separately.</p>	*5 Collective	*5 Collective

- b. All TE-200A Centralized Controllers shall be equipped with two RJ-45 Ethernet ports to support interconnection with a network PC via a closed/direct Local Area Network (LAN) or to a network switch for IP communication to up to three TE-50A expansion controllers for display of up to two hundred (200) indoor units on the main TE-200A interface.
- c. The TE-200A Centralized Controller shall be capable of performing initial settings via the high-resolution, backlit, color touch panel on the controller or via a PC browser using the initial settings.
- d. Standard software functions shall be available so that the building manager can securely log into each TE-200A via the PC's web browser to support operation monitoring, scheduling, error email, interlocking and online maintenance diagnostics. Additional optional software functions of personal browser for PCs and MACs and Tenant Billing shall be available but are not included. The Tenant Billing function shall require TG-2000 Integrated System software in conjunction with the Centralized Controllers.

E. Power Supply (PAC-SC51KUA)

1. The power supply shall supply 24VDC (TB3) for the TE-200/AE-50/EB-50GU centralized controller and 30VDC (TB2) voltage for the central control transmission.

### PART 3 EXECUTION

#### 3.01 INSTALLATION

A. General

1. System shall be installed in full accordance with Manufacturer's requirements and contract documents. Refer to the Manufacturer's installation manual for additional requirements.

B. Location

1. Locate indoor and outdoor units as indicated on drawings. Provide service clearance per Manufacturer's installation manual. Adjust and level outdoor units on support structure.

2. For climates that experience snowfall, mount the outdoor unit a minimum of 12" above the average snowfall line. In climates where this height requirement proves unfeasible, the outdoor units may be installed at the average snowfall line provided regular snow removal in the area surrounding the units keeps the snow line below the bottom of the units.

C. Components / Piping:

1. Installing contractor shall provide and install all accessories and piping for a fully operational system. Refer to Manufacturer's installation manual for full instructions.
2. Traps, filter driers, and sight glasses are NOT to be installed on the refrigerant piping or condensate lines.
3. Standard ACR fittings rated for use with R410A are to be used for all connections. Proprietary Manufacturer-specific appurtenances are not allowed.
4. Refrigerant pipe shall be made of phosphorus deoxidized copper, and has two types.
  - a. ACR "Annealed": Soft copper pipe, can be easily bent with human's hand.
  - b. ACR "Drawn Temper": Hard copper pipe (Straight pipe), being stronger than Type-O pipe of the same radical thickness.
5. The maximum operation pressure of R410A air conditioner is 4.30 MPa [623psi] . The refrigerant piping should ensure the safety under the maximum operation pressure. Refer to recommend piping specifications in Mitsubishi Electric's engineering manual. Pipes of radical thickness 0.7mm or less shall not be used.
6. Flare connection should follow dimensions provided in Manufacturer's installation manuals.

D. Insulation

1. Refrigerant lines, as well as any valves, shall be insulated end to end with 1/2" closed-cell pipe insulation for piping up to 1" in diameter, or 3/4" for piping 1-1/8" and larger, with a thermal conductivity no greater than 0.27 BTU-in/hr sq.ft °F. If state or local codes require insulation other than that specified above, the greater insulation shall be used.

E. Electrical

1. Installing contractor shall coordinate electrical requirements and connections for all power feeds with electrical contractor. Refer to Division 26 (Master Format 2004) or Division Section 16 (Master Format 1995) for additional information.

F. Third Party Controls:

1. Installing contractor shall coordinate all BAS/BMS control requirements and connections with controls contractor.

### 3.02 CERTIFIED INSTALLERS

- A. Contractor shall submit installer qualifications and project experience with bid. Provide letter of acknowledgment of this Section and its requirements. Any exceptions shall be noted with reasoning and/or how the requirement will be met.

### 3.03 MAINTENANCE TOOL SOFTWARE AND MN-CONVERTER (CMS-MNG-E)

- A. The Maintenance Tool, via the MN-Converter (CMS-MNG-E), shall enable the user to monitor and record the following parameters in a centralized system.
  - 1. Outdoor Unit.
    - a. Operation Mode (Cooling Only, Heating Only, Cooling Main, Heating Main).
    - b. Compressor Frequency, amperages, and voltages.
    - c. Compressor high- and low-side pressure.
    - d. System Temperatures.
    - e. Outdoor temperature.
    - f. Status of reversing valve.
  - 2. BC Controller.
    - a. Valve ON/OFF status.
    - b. Temperatures.
    - c. Pressures.
  - 3. Indoor Unit.
    - a. Entering Air Temperature.
    - b. Entering/Leaving Refrigerant Temperature.
    - c. Superheat/Subcool temperatures.
    - d. LEV position.
    - e. Room temperature setpoint .
    - f. Unit Mode and Status (Heat, Cool, Dry, Auto, Fan).
- B. The Maintenance Tool shall have the additional feature of controlling the following system components manually:
  - 1. Indoor Unit.
    - a. Indoor Unit ON/OFF.
    - b. Mode (Heat, Cool, Dry, Auto, Fan).
    - c. Room Temperature Setpoint.
    - d. Fan speed.
    - e. LEV Position.
  - 2. BC Controller.
    - a. Valve OPEN/CLOSE.
    - b. LEV Position.
- C. The Maintenance Tool shall be connectable to either the TB3 or TB7 communication bus lines on the MNET via alligator connectors.
- D. The Maintenance Tool shall be connectable to a PC via a USB cable.
- E. Trended data from Maintenance Tool shall be available to export to a data file for offline analysis.

### 3.04 VRF PROJECT SUPERVISION

#### A. General

1. VRF Manufacturer shall provide on-site *Project Supervision* as outlined in this specification section, providing: onsite technical review of installed VRF systems, review of activities related to the installation of the VRF system, VRF system components and associated controls.
2. All *Project Supervision* field activities shall be completed by an employee of the VRF Manufacturer whose primary job responsibilities are to provide direct technical support of their product; sales staff or in-house support staff are not permitted to complete this scope of work.
3. The installing contractor shall assist the VRF Manufacturer, in their completion of the system review and have available onsite a technician with appropriate diagnostic tools, materials and equipment, as required, for the duration of the inspection process. The technician assisting the VRF Manufacturer shall be fully licensed and insured to complete necessary duties as directed by the VRF Manufacturer.
4. The installing contractor shall have been certified by the Manufacturer to install VRF systems, having attended and successfully completed a minimum 3- day VRF Service & Installation course at an approved training facility. A copy of this certificate shall be presented to the VRF Manufacturer prior to the commencement of installation activity.

#### B. Site Visit

1. Each site visit shall consist of a single visit, not exceeding an 8 hour period. All visits shall occur during regular business hours of 8:30AM-4PM, Monday thru Friday.
2. Activities to be completed during each Site-Visit are as follows:
  - a. Meet with designated representative from the VRF installation contractor to discuss field activities and provide technical support related to the VRF systems.
  - b. Review installed VRF systems for compliance with Manufacturer's installation, service and engineering specifications.
  - c. Assist the contractor in updating the VRF Design software for as-built purposes and for calculating the appropriate refrigerant charge.
  - d. Provide a field report identifying any installation issues requiring attention. Report shall provide detailed information containing:
    - 1) Issue reference number.
    - 2) Priority Level of issue.
    - 3) Equipment M# & Reference TAG#.
    - 4) Status of issue.
    - 5) Description of issue being identified.
    - 6) Recommendation for corrective action.
    - 7) Follow-up requirements, if required.

### 3.05 PROJECT CLOSE OUT DOCUMENTS

- A. Documents completed during the project Supervision process shall be compiled and presented to the owner's representative at the completion of field activities.
- B. Close out documentation shall include the following:
  - 1. Project Supervision report outlining activities completed under this scope of work.
  - 2. As-built VRF design file depicting Model numbers and BTU capacity ratings of equipment installed, refrigerant pipe size & connection lengths between each system component, calculated refrigerant charge.
  - 3. Issue report.

END OF SECTION

**SECTION 16110****RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS****PART 1 GENERAL****1.01 SCOPE OF WORK**

- A. Section includes conduit and tubing, surface raceways, wireways, outlet boxes, pull and junction boxes.

**1.02 RELATED WORK**

- A. Division 16 – Electrical.

**1.03 SUBMITTALS**

- A. Submit per Division 01 – General Provisions, and Section 16000 – Basic Electrical Requirement.
- B. Product Data: Submit catalog data showing specified features of standard products.
- C. Product Data: Submit for the following:
  - 1. Rigid Aluminum Conduit.
  - 2. EMT Conduit.
  - 3. Galvanized Rigid Steel.
  - 4. Stainless Steel.
  - 5. PCV Coated Galvanized Rigid Steel.
  - 6. PVC Sch 40.
  - 7. PVC Sch 80.
  - 8. Liquid Tight Flexible Nonmetallic Conduit.
  - 9. Raceway / Conduit fittings and bodies.
  - 10. Wireways.
  - 11. Above grade pull and junction boxes.
- D. Manufacturer's Installation Instructions: Submit application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.
- E. For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.
  - 1. For handholes and boxes for underground wiring, including the following:
  - 2. Duct entry provisions, including locations and duct sizes.
  - 3. Frame and cover design.
  - 4. Grounding details.
  - 5. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
  - 6. Joint details.

- F. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
  - 1. Structural members in the paths of conduit groups with common supports.
  - 2. HVAC and plumbing items and other features in the paths of conduit groups with common supports.
- G. Division 1 – General Provisions.
- H. Project Record Documents:
  - 1. Record actual routing of conduits in yard using GPS technology. Provide a AutoCAD as-built drawing as part of closeout documentation.

#### 1.04 REFERENCE STANDARDS

- A. American National Standards Institute:
  - 1. ANSI C80.1 - Rigid Steel Conduit, Zinc Coated.
  - 2. ANSI C80.3 - Specification for Electrical Metallic Tubing, Zinc Coated.
  - 3. ANSI C80.5 - Aluminum Rigid Conduit - (ARC).
- B. National Electrical Manufacturers Association:
  - 1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
  - 2. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies.
  - 3. NEMA OS 1 - Sheet Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
  - 4. NEMA OS 2 - Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports.
  - 5. NEMA RN 1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
  - 6. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.
  - 7. NEMA TC 3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing.

#### 1.05 QUALITY ASSURANCE (NOT USED)

#### 1.06 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS

- A. Minimum Raceway Size: 1" unless otherwise specified.

#### 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Division 1 – General Provisions - Product storage and handling requirements.
- B. Protect conduit from corrosion and entrance of debris by storing above grade. Provide appropriate covering.
- C. Protect PVC conduit from sunlight.

1.08 MAINTENANCE/SPARE PARTS (NOT USED)

1.09 WARRANTY/EXTENDED WARRANTY (NOT USED)

1.10 COORDINATION

- A. Division 1 – General Provisions - Coordination and project conditions.
- B. Coordinate installation of in slab outlet boxes.
- C. Coordinate mounting heights, orientation and locations of outlets mounted above counters, benches, and backsplashes.

## PART 2 PRODUCTS

2.01 CONDUIT

### A. PVC Coated Rigid Aluminum Conduit

- 1. PVC coated rigid aluminum conduit shall have a minimum 0.040-in thick, polyvinyl chloride coating permanently bonded to rigid aluminum conduit and an internal chemically cured urethane or enamel coating. Rigid aluminum conduit shall be as manufactured by the Allied Tube and Conduit Corp.; Wheatland Tube Co.; Triangle PWC Inc. The ends of all couplings, fittings, etc. shall have a minimum of one pipe diameter in length of PVC overlap. PVC coated conduit and fittings shall be as manufactured by Perma-Cote, Robroy Industries, Triangle PWC Inc. or Ocal.
- 2. Elbows and couplings shall be PVC coated by the same Manufacturer supplying the conduit PVC coating system. Elbows and couplings used with PVC coated conduit shall be furnished with a PVC coating bonded to the aluminum, the same thickness as used on the coated aluminum conduit.

### B. Rigid Nonmetallic Conduit

- 1. PVC conduit shall be rigid polyvinyl chloride schedule 40 as manufactured by Can-tex; Prime Conduit; Allied Tube. Thinwall conduit designated for encased burial as (Type EB) is not acceptable for any application.

### C. Liquidtight Aluminum Flexible Metal Conduit

- 1. Liquidtight aluminum flexible metal conduit shall have an interlocked aluminum core, PVC jacket rated for 80 degrees C., meets NEC Article 351, UL 360 as manufactured by Ultratite AEF by Southwire, the Anaconda Metal Hose Div.; Anaconda American Brass Co.; American Flexible Conduit Co., Inc.; Universal Metal Hose Co.; ALFLEX.
- 2. Fittings used with liquidtight flexible aluminum conduit shall be extruded from 6063 alloy in temper designation T-1 with maximum 0.1% copper content and shall conform to FEDSPEC WW-C-540C ANSI C80.5, and UL-6.

### D. Aluminum Flexible Metal Conduit

- 1. Aluminum flexible metal conduit shall have an interlocked aluminum core, meeting NEC Article 348, UL 1 and Federal Specification WW-C-566C, as manufactured by



Southwire Alfex, the Anaconda Metal Hose Div.; Anaconda American Brass Co.; American Flexible Conduit Co., Inc.; Universal Metal Hose Co.

2. Fittings used with aluminum flexible metal conduit shall be extruded from AA 6063 alloy in temper designation T-1 and shall conform to FEDSPEC WW-C-540C ANSI C80.5, and UL-6.

E. Rigid Aluminum Conduit

1. Rigid Aluminum conduit shall be extruded from AA 6063 alloy in temper designation T-1 and shall conform to FED Spec WW-C-540C, ANSI C80-5 and UL-6. Rigid aluminum conduit shall be as manufactured by Wheatland Tube Company, or Allied.

F. PVC Schedule 40 Conduit

1. Schedule 40 PVC Rigid Nonmetallic Conduit (RNC) shall be designed for use above ground and underground as described in the NEC, resistant to sunlight. The conduits and fittings shall be manufactured to NEMA TC-2, Federal Specification WC1094A and UL 651 specifications. Fittings shall be manufactured to NEMA TC-3, Federal Specification WC1094A and UL 514B. Conduit shall have a UL Label. Conduit shall be Carlon, or Kraloy.

G. PVC Schedule 80 Conduit

1. Schedule 80 PVC Rigid Nonmetallic Conduit (RNC) shall be designed for use above ground and underground as described in the NEC, resistant to sunlight. The conduits and fittings shall be manufactured to NEMA TC-2, Federal Specification WC1094A and UL 651 specifications. Fittings shall be manufactured to NEMA TC-3, Federal Specification WC1094A and UL 514B. Conduit shall have a UL Label. Conduit shall be Cantex, Prime Conduit, or Allied Tube.

## 2.02 BOXES

- A. Boxes specified herein are for use with raceway systems only. Boxes used for housing electrical and instrumentation equipment shall be as described elsewhere in these Specifications.
- B. NEMA 1 Areas: NEMA 1 terminal boxes, junction boxes, pull boxes, etc, shall be of sheet or cast aluminum for wall mounting, or have mounting feet where self-standing. Boxes shall have continuously welded seams. Welds shall be ground smooth. Box bodies shall be flanged and shall not have holes or knockouts. Box bodies shall not be less than 14 gauge metal and covers shall not be less than 12 gauge metal. All boxes shall have hinged, gasketed doors with quarter-turn latches or a 3-point latch (single operator) system on enclosures larger than 36 inches wide or 32 inches tall. Terminal boxes shall be furnished with terminal mounting straps and brackets. Terminal blocks shall be NEMA type, not less than 20A. 600V. Boxes shall be furnished with hinged doors, terminal mounting straps and brackets. Boxes shall be Concept Series as manufactured by Hoffman Engineering Co.
- C. NEMA 4X Areas: NEMA 4X terminal boxes, junction boxes, pull boxes etc, shall be Type 316 stainless steel for wall mounting, or have mounting feet where self-standing. Boxes shall have continuously welded seams. Welds shall be ground smooth. Box bodies shall be flanged and shall not have holes or knockouts. Box bodies shall not be less than 14

gauge metal and covers shall not be less than 12 gauge metal. All boxes shall have hinged, gasketed doors with quarter-turn latches or a 3-point latch (single operator) system on enclosures larger than 36 inches wide or 32 inches tall. Terminal boxes shall be furnished with terminal mounting straps and brackets. Terminal blocks shall be NEMA type, not less than 20A., 600V. Boxes shall be furnished with hinged doors, terminal mounting straps and brackets. Boxes shall be Concept Series as manufactured by Hoffman Engineering Co.

- D. NEMA 7 Areas: Explosion-proof boxes shall be designed for Class 1, Group D, Division 1 hazardous locations, and shall also have O-ring seals to meet NEMA 4 requirements. Boxes shall be aluminum, with stainless steel hinged covers and stainless steel bolts; Type EJB-N4 as manufactured by the Crouse-Hinds Co.; Appleton Electric Co.; Adalet-PLM.
- E. Boxes for use in Chlorine and Caustic areas shall be of rigid PVC. Construction shall be the same as specified for NEMA 4X terminal boxes, junction boxes, pull boxes etc. as specified above.
- F. Malleable iron boxes shall not be used.

#### 2.03 CONDUIT HUBS

- A. Conduit hubs for use on raceway system pull and junction boxes shall be watertight aluminum, insulated throat, gasketed, with grounding screw, as manufactured by O-Z/Gedney, or Red-Dot.
- B. Conduit hubs for use on outlet boxes or boxes containing electrical or instrumentation equipment shall be watertight, threaded aluminum, grounding screw type, insulated throat, hub of female-female type, with locking nipple of male construction. Hubs shall be T&B HTGZ. Hubs with female locking nipples, where the hub projects into the box, will not be acceptable.

#### 2.04 CONDUIT SEALS

- A. Conduit wall seals for new concrete walls below grade shall be O.Z./Gedney Co. type WSK.
- B. Conduit wall seals for cored holes shall be type CSML-XXXXA as manufactured by the O.Z./Gedney Co.
- C. Conduit wall and floor seals for sleeved openings shall be type CSMI-XXXXA as manufactured by the O.Z./Gedney Co.
- D. Conduit openings exposed to the weather shall be sealed with Duxseal.



#### 2.05 EXPANSION-DEFLECTION FITTINGS

- A. Combination expansion-deflection fittings embedded in concrete, or exposed, with internal grounding, 4" movement, shall be stainless steel/cast iron, Type XJGD as manufactured by the Crouse-Hinds Co.

**2.06 EXPANSION FITTINGS**

- A. Expansion fittings shall be aluminum, 8" movement, Type XJGSA as manufactured by Crouse-Hinds Co., with internal grounding.

**2.07 EXPLOSION-PROOF FITTINGS**

- A. Explosion proof fittings shall be as manufactured by the Crouse-Hinds Co.; Appleton Electric Co.; O.Z./Gedney Co.

**2.08 KELLEMS GRIPS**

- A. Kellems grips to support cables shall be of 316 stainless steel.

**2.09 CONDUIT MOUNTING EQUIPMENT**

- A. All pull and junction box supports, spacers, conduit support rods, clamps, hangers, channel, nut, bolts, washers, etc. and shall be of 316 stainless steel.

**2.10 WIREWAYS**

- A. All wireways shall be constructed of NEMA 4X 316 stainless steel, with gasketed hinged covers and stainless-steel screws. Wireway shall be as manufactured by Hoffman.

**PART 3 EXECUTION****3.01 RACEWAY APPLICATIONS**

- A. Unless exact locations are shown on the Drawings, the Contractor shall coordinate the placement of conduit and related components with other trades and existing installations.
- B. Unless shown on the drawings or specified otherwise, the conduit type installed with respect to the location shall be as follows:

*Conduit Type**Location*

1.Rigid Galvanized Conduit

Air Conditioned Spaces.

2.PVC Coated Rigid Aluminum Conduit

All embedded conduit bends (except underground duct banks) and all conduit stub-ups to a minimum of 6" above finished floor or grade.



3.Liquidtight Flexible Aluminum Conduit

Raceway connection to vibrating equipment only in all areas. Maximum of 6' length.

4. Rigid Non-metallic, Schedule 40 PVC Conduit

Underground encased in reinforced concrete. Red dye powder sprinkled on top.



<i>Conduit Type</i>	<i>Location</i>
5. Rigid Non-metallic, Schedule 80 PVC Conduit	For use only in Chemical Areas.
6. Flexible Aluminum Conduit	Fixture whip connection to lighting fixtures in NEMA 1 areas (maximum 3-ft). BX or AC type prefabricated cables are not permitted.
7. Aluminum Rigid Metal Conduit	All above areas, except for concrete embedded and those areas described in Locations 2 through 6 above.
8. EMT	Admin Building only.

- C. All conduit of a given type shall be the product of one Manufacturer.

### 3.02 BOX APPLICATIONS

- A. Boxes installed in dry areas may be of NEMA 1 aluminum construction. All other boxes shall be of Type 316 stainless steel.
- B. Exposed switch, receptacle and lighting outlet boxes and conduit fittings shall be cast aluminum.
- C. Junction boxes and pull boxes shall have NEMA ratings suitable for the location in which they are installed, as specified in Section 16000 – Basic Electrical Requirements.
- D. Where the raceway system connects to junction and pull boxes in a NEMA 1 area, double locknut (one outer and one inner) plus insulated bushing.
- E. All boxes shall be provided with factory mounting lugs. Drilling through the back of any box or enclosure is prohibited, and if so installed shall be removed and replaced, with no increase in the Contract Price or Construction Schedule.
- F. The Contractor shall be responsible for sizing all junction boxes and pull boxes in accordance with the National Electrical Code, Article 314 and relevant sections of the NEC.
- G. Penetrations into the top of NEMA 4X and NEMA 7 boxes shall not be allowed.
- H. Exposed pull boxes or junction boxes installed outdoors, per NEMA 250 shall be NEMA 4X weatherproof and shall be provided with watertight gasketed covers fastened with stainless steel screws and be 316 stainless steel. All hardware shall be 316 stainless steel. Boxes shall be provided with integral mounting lugs.

- I. NEMA 1 boxes shall be provided for Air Conditioned spaces only, NEMA 7 for Class 1, Group D, Division 1 hazardous locations and NEMA 4X 316 stainless steel for all other locations.

### 3.03 FITTINGS APPLICATIONS

- A. Combination expansion-deflection fittings shall be installed where conduits cross structure expansion joints, on conduit transitions from underground to above ground, and where installed in exposed conduit runs such that the distance between expansion-deflection fittings does not exceed one hundred fifty (150) feet of conduit run.
- B. On exposed conduit transitions from underground to above ground, where the earth has been disturbed to a depth of more than ten (10) feet, an expansion fitting, with a minimum of 6" available movement, shall be installed on the exposed side of the transition, in lieu of a combination expansion-deflection fitting.

### 3.04 CONDUIT SEALS APPLICATIONS

- A. Conduit wall seals shall be used where underground conduits penetrate walls or at other locations shown on the Drawings.
- B. Conduit shall be installed to prevent water infiltration to the conduit system. Where conduit is exposed to the weather, the Contractor will utilize Duxseal to close the pathway and protect from water infiltration. Where the raceway transitions from above ground conduit to cable tray, the contractor will install a 90 degree vertical bend and fill the conduit with Duxseal to prevent water ingress.



### 3.05 INSTALLATION

- A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
- B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.
- D. Arrange stub-ups so curved portions of bends are not visible above the finished slab.
- E. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
- F. No conduit smaller than 1-in electrical trade size, shall be used, nor shall any have more than the equivalent of three 90 degree bends in any one run. Pull boxes shall be provided as required or as directed.
- G. No wire shall be pulled until the conduit system is complete in all details; in the case of concealed work, until all rough plastering or masonry has been completed; in the case of exposed work, until the conduit system has been completed in every detail.

- H. The ends of all conduits shall be tightly plugged to exclude dust and moisture during construction. Duxseal, or 3M seal spray shall be used in all applications. Plugging with tape is prohibited, even for a temporary time.
- I. Where raceways enter or leave the raceway system where the raceway origin or termination, could be subjected to the entry of moisture, rain or liquid of any type, particularly where the termination of such raceways terminate in any equipment, new or existing at a lower elevation, such raceways shall be tightly sealed at the higher elevation, both before and after the installation of cables, such that there shall be no entry of water or moisture to the Raceway System at any time. Any damage to new or existing equipment shall be corrected by complete replacement of such equipment, at no cost to the Owner. Cleaning or drying of such equipment will not be acceptable.
- J. Conduit supports, other than for underground raceways, shall be spaced at intervals of 8-ft or less, as required to obtain rigid construction.
- K. Single conduits shall be supported by means of one-hole pipe clamps in combination with one-screw back plates, to raise conduits from the surface. Multiple runs of conduits shall be supported on trapeze type hangers with horizontal members and threaded hanger rods. The rods shall be not less than 3/8-in diameter. Surface mounted panel boxes, junction boxes, conduit, etc shall be supported by spacers to provide a minimum of 1/2-in clearance between wall and equipment.
- L. Conduit hangers shall be attached to structural steel by means of beam or channel clamps. Where attached to concrete surfaces, concrete inserts of the spot type shall be provided.
- M. All conduits on exposed work shall be run at right angles to and parallel with the surrounding wall and shall conform to the form of the ceiling. No diagonal runs will be allowed. Bends in parallel conduit runs shall be concentric. All conduit shall be run perfectly straight and true.
- N. Conduit terminating in boxes and enclosures, other than NEMA 1 type, shall be terminated with conduit hubs.
- O. Conduits terminated into enclosures shall be perpendicular to the walls where flexible liquidtight or rigid conduits are required. The use of short sealtight elbow fittings for such terminations will not be permitted.
- P. Conduits containing equipment grounding conductors and terminating in boxes shall have insulated throat grounding bushings. The wire shall be grounded to the box.
- Q. Conduits shall be installed using threaded fittings. Running threads will not be permitted.
- R. All conduit fittings on PVC conduit shall be of the glued type.
- S. Liquidtight flexible aluminum conduit shall be used for the primary and secondary of transformers, generator terminations and other equipment where vibration is present. Use in other locations is not permitted. Liquidtight flexible aluminum conduit shall have a maximum length not greater than that of a factory manufactured long radius elbow

of the conduit size being used. The maximum bending radius shall not be less than that shown in the NEC Chapter 9, Table 2, "Other Bends". BX or AC type prefabricated cables will not be permitted.

- T. Where conduits pass through openings in walls or floor slabs, the remaining openings shall be sealed against the passage of flame and smoke.
- U. Conduit ends exposed to the weather or corrosive gases shall be sealed with conduit sealing bushings.
- V. Raceways terminating in Control Panels, or boxes containing electrical equipment, shall not enter from the top of the panel or box, and the raceway shall be sealed with a removable silicone sealant.
- W. All conduits from external sources entering or leaving a multiple compartment enclosure shall be stubbed up into the bottom horizontal wireway or other Manufacturer designated area, directly below the vertical section in which the conductors are to be terminated. Conduits entering from cable tray shall be stubbed into the upper section.
- X. Conduit sealing and drain fittings shall be installed in areas designated as NEMA 4X or 7.
- Y. A conduit identification plate shall be installed on all power, instrumentation, alarm and control conduits at each end of the run and at intermediate junction boxes, manholes, etc. Conduit plates shall be installed before conductors are pulled into conduits. Exact identification plate location shall be coordinated with the Owner/Engineer at the time of installation to provide uniformity of placement and ease of reading. Conduit numbers shall be exactly as shown on the Drawings.
- Z. Conduits noted as spare shall be capped or plugged at both ends with easily removable fittings.
- AA. Mandrels shall be pulled through all existing conduits that will be reused and through all new conduits 2-in in diameter and larger prior to installing conductors.
- BB. 3/16-in polypropylene pull lines shall be installed in all new conduits noted as spares or designated for future equipment.
- CC. All conduit that may under any circumstance contain liquids such as water, condensation, liquid chemicals, etc, shall be arranged to drain away from the equipment served. If conduit drainage is not possible, conduit seals shall be used to plug the conduits at the point of attachment to the equipment.
- DD. Where no type or size is indicated for junction boxes, pull boxes or terminal cabinets, they shall be sized in accordance with the requirements of the NEC.
- EE. Conduits shall not cross pipe shafts, access hatches or vent duct openings. They shall be routed to avoid such present or future openings in floor or ceiling construction.
- FF. The use of running threads is prohibited. Where such threads are necessary, a 3-piece union shall be used.

- GG. Conduits passing from heated to unheated spaces, exterior spaces, refrigerated spaces, cold air plenums, etc, shall be sealed with "Duxseal," as manufactured by Mansville or 3M, or seal fitting to prevent the accumulation of condensation.
- HH. Conduits shall be located a minimum of 3-in from steam or hot water piping. Where crossings are unavoidable, the conduit shall be kept at least 1-in from the covering of the pipe crossed.
- II. Conduits terminating at a cable tray shall be supported independently from the cable tray.
- JJ. Provide a conduit support within 1-ft of the cable tray. The weight of the conduit shall not bear on the cable tray.
- KK. Penetrations by conduit, raceways, cables, sleeves, etc., through rated walls, shafts, floors, ceilings, etc., shall be sealed by a closure foam, Dow Corning 3-6548 Silicone RTV, GE RTV 35D Silicone Foam.

### 3.06 EXISTING WORK

- A. Remove exposed abandoned raceway, including abandoned raceway above accessible ceiling finishes. Cut raceway flush with walls and floors, and patch surfaces.
- B. Remove concealed abandoned raceway to its source.
- C. Disconnect abandoned outlets and remove devices. Remove abandoned outlets when raceway is abandoned and removed. Install blank cover for abandoned outlets not removed.
- D. Maintain access to existing boxes and other installations remaining active and requiring access. Modify installation or provide access panel.
- E. Extend existing raceway and box installations using materials and methods compatible with existing electrical installations, or as specified.
- F. Clean and repair existing raceway and boxes to remain or to be reinstalled.

END OF SECTION



**SECTION 16231**  
**ENGINE GENERATORS**

**PART 1 GENERAL**

**1.01 SCOPE OF WORK**

- A. This section includes the following items from a single supplier:
  - 1. Engine Generator Set.
  - 2. Enclosure.
  - 3. Related Accessories as specified.
- B. Related Requirements
  - 1. It is the intent of this specification to secure an engine-driven generator set that has been prototype tested, factory built, production-tested, and site-tested together with all accessories necessary for a complete installation as shown on the plans and drawings and specified herein.
  - 2. Any exceptions to the published specifications shall be subject to the approval of the engineer and submitted minimum 10 days prior to the closing of the bid with a line by line summary description of all the items of compliance, any items that have been are omitted or have been taken exception to, and a complete description of all deviations.
  - 3. It is the intent of this specification to secure a generator set system that has been tested during design verification, in production, and at the final job site. The generator set will be a commercial design and will be complete with all of the necessary accessories for complete installation as shown on the plans, drawings, and specifications herein. The equipment supplied shall meet the requirements of the National Electrical Code and applicable local codes and regulations.
  - 4. All equipment shall be new and of current production by an international, power system Manufacturer of generators, transfer switches, and paralleling switch-gear. The Manufacturer shall be a supplier of a complete and coordinated system. There will be single-source responsibility for warranty, parts, and service through a factory-authorized representative with factory-trained technicians.

**1.02 RELATED WORK**

- A. Division 03 – Concrete.
- B. Division 15 – Plumbing.
- C. Division 15 – Heating, Ventilation, and Air Conditioning (HVAC).
- D. Division 16 – Electrical.

**1.03 SUBMITTALS**

- A. Submit per Division 1 – General Provisions, and Section 16000 – Basic Electrical Requirements.

- B. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:
  - 1. Thermal damage curve for generator.
  - 2. Time-current characteristic curves for generator protective device.
  - 3. Factory published specification sheet.
  - 4. Manufacturer's catalog cut sheets of all auxiliary components such as battery charger, control panel, enclosure, etc.
  - 5. Engine mechanical data, including heat rejection, exhaust gas flows, combustion air and ventilation air flows, fuel consumption, etc.
  - 6. Generator electrical data including temperature and insulation data, cooling requirements, excitation ratings, voltage regulation, voltage regulator, efficiencies, waveform distortion and telephone influence factor.
  - 7. Generator resistances, reactances and time constants.
  - 8. Generator locked rotor motor starting curves.
  - 9. Manufacturer's written warranty.
  
- C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
  - 2. Weights of all equipment.
  - 3. Layout and stub-up locations of electrical and fuel systems.
  - 4. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for the following:
    - a. Vibration Isolators.
    - b. Generator Fuel Tank.
    - c. Generator Enclosure.
  - 5. Interconnect wiring diagrams of complete emergency system, including power, signal, and control wiring for generator, switchgear, day tank, remote pumps, battery charger, control panel, and remote alarm indications.
  
- D. Qualification Data: For Manufacturer.
  - 1. Source quality-control test reports.
  - 2. Certified summary of prototype-unit test report.
  - 3. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
  - 4. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
  - 5. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
  - 6. Report of sound generation.
  - 7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

- E. Field test reports.
    - 1. Indicate results of performance testing.
    - 2. Indicate inspections, findings, and recommendations.
  - F. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section – Operation and Maintenance Data, include the following:
    - 1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
  - G. Division 1 - Closeout procedures.
  - H. Operation and Maintenance Data: Submit instructions and service manuals for normal operation, routine maintenance, oil sampling and analysis for engine wear, and emergency maintenance procedures.
- 1.04 REFERENCE STANDARDS
- A. NEMA - National Electrical Manufacturers Association.
  - B. NETA - International Electrical Testing Association.
  - C. NFPA - National Fire Protection Association.
  - D. UL - Underwriters Laboratories Inc.
- 1.05 QUALITY ASSURANCE
- A. Manufacturer Qualifications:
    - 1. A qualified Manufacturer who has 25 years of experience building this type of equipment.
    - 2. Manufacturer shall be ISO9001 certified.
    - 3. The engine-generator supplier shall maintain 24-hour parts and service capability within 200 miles of the project site.
    - 4. The distributor shall stock parts as needed to support the generator set package for this specific project. The supplier must carry sufficient inventory to cover no less than 80% parts service within 24hrs and 95% within 48 hours. Local service facility to maintain a minimum of 2 factory trained service technicians.
    - 5. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.
    - 6. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of Manufacturer's standard units in assemblies similar to those indicated for this Project.
  - B. Source Limitations: Obtain the following from a single supplier:
    - 1. Packaged Engine Generator Sets.

- 2. Automatic Transfer Switches unless the switches are part of power distribution equipment.
  - 3. All generator paralleling equipment if shown on the one-line diagrams.
  - C. All materials and parts comprising the equipment shall be new and unused.
  - D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
  - E. Comply with ISO8528.
  - F. Comply with ASME B15.1.
  - G. Comply with NFPA 37.
  - H. Comply with NFPA 70.
  - I. Comply with NFPA 110 requirements emergency power supply system.
  - J. Engine Exhaust Emissions: Comply with applicable state and local government requirements.
- 1.06 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS
- A. Description: Engine generator assembly and accessories to provide source of power for Level 1 applications in accordance with NFPA 110.
  - B. Capacity: Per One Line Drawing, at the elevation shown on the Civil Drawing for the project. The unit shall be classified as "Legally Required" by the NEC and designed for Standby Operation with an engine mounted radiator.
- 1.07 DELIVERY, HANDLING AND STORAGE (NOT USED)
- 1.08 MAINTENANCE/SPARE PARTS (NOT USED)
- A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of Manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by Manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment, and shall provide all recommended fluids, dealer labor, travel labor and travel mileage to complete the suggested preventive maintenance as defined in the Manufacturer's Operation and Maintenance Manual.
  - B. Division 1 - Execution and Closeout Requirements: Spare parts and maintenance products.
  - C. Furnish one set of tools required for preventative maintenance of engine generator system. Package tools in adequately sized metal toolbox.

1. Fuses: One for every 10 of each type and rating, but no fewer than two of each.
2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
3. Furnish two of each fuel, oil and air filter element.

#### 1.09 WARRANTY/EXTENDED WARRANTY

- A. Division 1 - Product warranties.
- B. Manufacturer's standard form in which Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within the specified warranty period.
  1. Warranty Period: Two years from date of Substantial Completion.
  2. The Manufacturer's standard warranty shall in no event be for a period of less than two (2) years from date of initial start-up of the system and shall include repair parts, labor, reasonable travel expense necessary for repairs at the job site, and expendables (lubricating oil, filters, antifreeze, and other service items made unusable by the defect) used during the course of repair. Running hours shall be limited to 500 hours annually for the system warranty by both the Manufacturer and servicing distributor. Submittals received without written warranties as specified will be rejected in their entirety.
  3. Extended Service Coverage shall be provided for a period of 5 years and shall be extendable to a term of 20 years from the original delivery date and shall include no deductible. Extended Service Coverage provides for 100 percent of usual and customary parts and labor costs for failures due to defects in materials and workmanship to the "as shipped consist" from the factory, excluding filters, fluids, vee belts, hoses, power take-offs, paint, batteries and clutches. Extended Service Coverage provides for a rental power unit due to unscheduled failures causing unexpected downtime to the customer in excess of 48 hours from the time of diagnoses. All repairs will be performed by factory trained dealer service personnel and allows for repairer travel and mileage for all repairs up to 8 hours and 320 miles per incident. (to be included in the base contract)
  4. Generator set supplier shall be the authorized warranty and service center for both the engine and the generator end and must be capable of providing parts and service support as defined within this specification for the 5 year extended warranty term.

### PART 2 PRODUCTS

#### 2.01 SERVICE CONDITIONS

- A. Temperature:
  1. Max Ambient Air Temp: 1221 degrees F.
  2. Min Ambient Air Temp: 0 degrees F.
- B. Altitude: 1200 Feet.

- C. Generator Derates: Generator shall be capable of outputting a minimum of 1750kW during the conditions listed above. The generator shall be upsized as needed to account for derating that may occur due to the site conditions listed above. A generator output below 1750kW with applicable derates is not acceptable. Generator Manufacturer shall produce associated derate tables with submittal package.

## 2.02 ENGINE-GENERATOR SET

- A. Manufacturers:
  - 1. Caterpillar; Engine Div.
  - 2. Cummins Power Generation.
  - 3. Kohler Co.; Generator Division.
- B. Factory-assembled and -tested, engine-generator set.
- C. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
  - 1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.
- D. Capacities and Characteristics:
  - 1. Power Output Ratings: The generator set shall be Standby Duty rated as shown on the One-Line Diagram. 0.8 power factor, 3-Phase, 60 hertz, including radiator fan and all parasitic loads.
  - 2. Each generator set shown shall consist of one (1) skid-mounted diesel engine generator set.
  - 3. Output Connections: Three-phase, four wire.
  - 4. Nameplates: For each major system component to identify Manufacturer's name and address, and model and serial number of components.
  - 5. Standby Rating as defined by the following:
    - a. Typical Load Factor = 70% of standby power rating with variable load.
    - b. Typical Hours per Year = 200 hours.
    - c. Maximum Expected Usage = 500 hours/year.
- E. Alternator
  - 1. The alternator shall be salient-pole, brushless, 2/3-pitch, with 4 bus bar provision for external connections, self-ventilated, with drip-proof construction and amortisseur rotor windings, and skewed for smooth voltage waveform. The ratings shall meet the NEMA standard (MG1-32.40) temperature rise limits. The insulation shall be Class H per UL1446 and the varnish shall be a vacuum pressure impregnated, fungus resistant epoxy. Temperature rise of the rotor and stator shall be limited to 105°C. The PMG based excitation system shall be of brushless construction controlled by a digital, three phase sensing, solid-state, voltage regulator. The AVR shall be capable of proper operation under severe nonlinear loads and provide individual adjustments for voltage range, stability and volts-per-hertz operations. The AVR shall be protected from the environment by conformal coating. The

waveform harmonic distortion shall not exceed 5% total RMS measured line-to-line at full rated load. The TIF factor shall not exceed 50.

2. The alternator shall have a maintenance-free bearing, designed for 40000 hour B10 life. The alternator shall be directly connected to the flywheel housing with a semi-flexible coupling between the rotor and the flywheel.
3. The generator shall be inherently capable of sustaining at least 300% of rated current for at least 10 seconds under a 3-phase symmetrical short circuit without the addition of separate current-support devices.
4. Motor starting performance and voltage dip determinations shall be based on the complete generator set. The generator set shall be capable of supplying 3950LRKVA for starting motor loads with a maximum instantaneous voltage dip of 30%, as measured by a digital RMS transient recorder in accordance with IEEE Standard 115. Motor starting performance and voltage dip determination that does not account for all components affecting total voltage dip, i.e., engine, alternator, voltage regulator, and governor will not be acceptable. As such, the generator set shall be prototype tested to optimize and determine performance as a generator set system.

F. Generator-Set Performance for Sensitive Loads:

1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.
  - a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
3. Transient Voltage Performance: Not more than 12 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 5 seconds.
4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Not more than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within 5 seconds.
7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.

10. Provide permanent magnet excitation for power source to voltage regulator.
11. Start Time: Comply with NFPA 110, Type 10, system requirements.

G. ENGINE

1. The engine shall be diesel fueled, four (4) cycle, water-cooled, while operating with nominal speed not exceeding 1800 RPM. The engine will utilize in-cylinder combustion technology, as required, to meet applicable EPA non-road mobile regulations and/or the EPA NSPS rule for stationary reciprocating compression ignition engines. Additionally, the engine shall comply with the State Emission regulations at the time of installation/commissioning. Actual engine emissions values must be in compliance with applicable EPA emissions standards per ISO 8178 – D2 Emissions Cycle at specified kW / bHP rating. Utilization of the "Transition Program for Equipment Manufacturers" (also known as "Flex Credits") to achieve EPA certification is not acceptable. The in-cylinder engine technology must not permit unfiltered exhaust gas to be introduced into the combustion cylinder. Emissions requirements / certifications of this package: EPA TIER 2.
2. Rated Engine Speed: 1800 rpm.
3. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm.
4. The engine governor shall be an electronic Engine Control Module (ECM) with 24-volt DC Electric Actuator. The governor shall be enclosed in an environmentally sealed, die- cast aluminum housing which isolates and protects electronic components from moisture and dirt contamination. Speed droop shall be adjustable from 0 (isochronous) to 10%, from no load to full rated load. Steady state frequency regulation shall be +/- 0.25%. Speed shall be sensed by a magnetic pickup off the engine flywheel ring gear. A provision for remote speed adjustment shall be included. The ECM shall adjust fuel delivery according to exhaust smoke, altitude and cold mode limits. In the event of a DC power loss, the forward acting actuator will move to the minimum fuel position.

H. Lubrication System: The following items are mounted on engine or skid:

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

I. Engine Fuel System: The fuel system shall be integral with the engine.

1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
3. In addition to the standard fuel filters provided by the engine Manufacturer, there shall also be installed a primary fuel filter/water separator in the fuel inlet line to the engine.



4. All fuel piping shall be black iron or flexible fuel hose rated for this service. No galvanized piping will be permitted. Flexible fuel lines shall be minimally rated for 300 degrees F and 100 psi.
- J. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity to ensure that genset will start within the specified time period and ambient conditions.
- K. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine Manufacturer.
  2. Size of Radiator: The cooling system shall be sized to operate at full load conditions and 122 F\* (50C\*) ambient air. The generator set supplier is responsible for providing a properly sized cooling system based on the enclosure static pressure restriction.
  3. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine Manufacturer.
  4. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
    - a. Rating: 50-psig maximum working pressure with coolant at 180 deg F, and non-collapsible under vacuum.
    - b. Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- L. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- M. Starting System: 24-V electric, with negative ground.
1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
  2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
  3. Cranking Cycle: As required by NFPA 110 for system level specified.
  4. Battery: A lead-acid storage battery set of the heavy-duty diesel starting type shall be provided. Battery voltage shall be compatible with the starting system. Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least three times without recharging.
  5. Battery Cable: Size as recommended by engine Manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
  6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 2 Service Conditions. Include accessories required to support and fasten batteries in place.

7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:
9. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
10. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
11. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
12. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
13. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
14. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet

N. Generator Set Controller

O. Controller

1. The generator set controller shall be a microprocessor based control system that will provide automatic starting, system monitoring, and protection. The controller system shall also provide local monitoring and remote monitoring. The control system shall be capable of PC based updating of all necessary parameters, firmware, and software.
2. The controller shall be mounted on the generator set and shall have integral vibration isolation. The controller shall be prototype and reliability tested to ensure operation in the conditions encountered.

P. Codes and Standards

1. The generator set controller shall meet NFPA 110 Level 1 requirements and shall include an integral alarm horn as required by NFPA.
2. The controller shall meet NFPA 99 and NEC requirements.
3. The controller shall be UL 508 listed.

Q. Applicability

1. The controller shall be a standard offering in the Manufacturer's controller product line.
2. The controller shall support 12-volt and 24volt starting systems.
3. The controller's environmental specification shall be: -40°C to 70°C operating temperature range and 5-95% humidity, non-condensing.

4. The controller shall mount on the generator or remotely within 40 feet with viewable access.

R. Hardware Requirements

1. Control Panel shall include:

- a. The control shall have a run-off/reset-auto three-position selector switch
- b. Emergency Stop Switch. The controller mounted, latch type remote stop switch shall be red in color with a "mushroom" type head. Depressing the stop button will immediately stop the generator set and lockout the generator set for any automatic remote starting.
- c. Five indicating lights (LED):
  - (i) System Ready – green.
  - (ii) Not in Auto – yellow.
  - (iii) Programming Mode – yellow.
  - (iv) System Warning – yellow.
  - (v) System Shutdown – red.
- d. Digital Display. The digital display shall be a vacuum fluorescent display with two lines of alphanumeric, with 2 lines of data and 20 characters. The display shall be viewable in all light conditions. The display shall display status of all faults and warnings. The display shall also display any engine faults. The 16-button keypad gives the user information access and local programming capability.
- e. Sixteen-position snap action environmentally sealed tactile-feel membrane keypad for menu selection and data entry.
- f. For ease of use, an operating guide shall be printed on the controller faceplate.
- g. Alarm Horn. The controller shall provide an alarm horn that sounds when any faults or warnings are present. The horn shall also sound when the controller is not in the AUTO mode.
- h. Lamp Test Button. When this button is depressed, it shall test all controller lamps.
- i. Alarm Off. This button will silence the alarm horn when the unit is AUTO.
- j. Panel lights shall be supplied as standard.

S. Control Functional Requirements

1. The generator controller shall display and monitor the following engine and alternator functions and allow adjustments of certain parameters at the controller:
  - a. Field-programmable time delay for engine start. Adjustment range 0-5 minutes in 1 second increments.
  - b. Field-programmable time delay engine cool down. Adjustment range 0-10 minutes in 1 second increments.
  - c. Capability to start and run at user-adjustable idle speed during warm-up for a selectable time period (0-10 minutes), until engine reaches preprogrammed temperature, or as supported by ECM-equipped engine.
  - d. The idle function including engine cooldown at idle speed.
  - e. Real-time clock and calendar for time stamping of events.

- f. Output with adjustable timer for an ether injection starting system. Adjustment range, 0-10 seconds
- g. Output for shedding of loads if the generator set reaches a user programmable percentage of its kW rating. Load shed shall also be enabled if the generator set output frequency falls below 59 Hz.
- h. Programmable cyclic cranking that provides up to 30 seconds of programmable cyclic cranking and up to 60 seconds rest with up to 6 cycles.
- i. The capability to reduce controller current battery draw, for applications where no continuous battery charging is available. The controller vacuum fluorescent display should turn off automatically after the controller is inactive for 5 minutes.
- j. Control logic with alternator protection for overload and short circuit matched to each individual alternator and duty cycle.
- k. Control logic with RMS digital voltage regulation. The system shall have integral microprocessor based voltage regulator system that provides +/- 0.25% voltage regulation no-load to full load with three phase sensing. A separate voltage regulator is not acceptable. The digital voltage regulator shall be applicable to single- or three-phase systems. The system shall be prototype tested and control variation of voltage to frequency. The voltage regulator shall be adjustable at the controller with maximum +/- 20% adjustable of nominal voltage.
- l. The capability to exercise the generator set by programming a running time into the controller. This feature shall also be programmable through the PC software.
- m. Alternator thermal overload protection. The system shall have integral alternator overload and short circuit protection matched to each alternator for the particular voltage and phase configuration.
- n. Control function shall include output voltage adjustment.
- o. The control shall detect the following conditions and display on control panel:
  - (i) Customer programmed digital auxiliary input ON (any of the 21 inputs available).
  - (ii) Customer programmed analog auxiliary input out of bounds (any of 7 inputs for ECM equipped engines).
  - (iii) Emergency stop.
  - (iv) High coolant temperature.
  - (v) High oil temperature.
  - (vi) Controller internal fault.
  - (vii) Locked rotor - fail to rotate.
  - (viii) Low coolant level.
  - (ix) Low oil pressure.
  - (x) Master switch error.
  - (xi) NFPA common alarm.
  - (xii) Overcrank.
  - (xiii) Overspeed with user-adjustable level, range 60-70 Hz.
  - (xiv) Overvoltage with user adjustable level, range 105% to 135%.

- (xv) Overfrequency with user adjustable level, range 102% to 140%.
- (xvi) Underfrequency with user adjustable level, range 80% to 90%.
- (xvii) Undervoltage with user adjustable level, range 70% to 95%.
- (xviii) Coolant temperature signal loss.
- (xix) Oil pressure gauge signal loss.
- p. Conditions resulting in generator warning (generator will continue to operate):
  - (i) Battery charger failure.
  - (ii) Customer programmed digital auxiliary input on (any of the 21 inputs available).
  - (iii) Customer programmed analog auxiliary input on (any of the 7 inputs available on ECM engines).
  - (iv) Power system supplying load.
  - (v) Ground fault detected - detection by others.
  - (vi) High battery voltage - Level shall be user adjustable. (Range 29-33 volts for 24-volt systems).
  - (vii) High coolant temperature.
  - (viii) Load shed.
  - (ix) Loss of AC sensing.
  - (x) Underfrequency.
  - (xi) Low battery voltage - level shall be user adjustable (Range 20-25 volts for 24-volt systems).
  - (xii) Low coolant temperature.
  - (xiii) Low fuel level or pressure.
  - (xiv) Low oil pressure.
  - (xv) NFPA common alarms.
  - (xvi) Overcurrent.
  - (xvii) Speed sensor fault.
  - (xviii) Weak battery.
  - (xix) Alternator protection activated.

T. Control Monitoring Requirements

1. The generator set shall have alarms and status indication lamps that show non-automatic status and warning and shutdown conditions. The controller shall indicate with a warning lamp and or alarm and on the digital display screen any shutdown, warning or engine fault condition that exists in the generator set system. The following alarms and shutdowns shall exist as a minimum:
  - a. All monitored functions must be viewable on the control panel display.
  - b. The following generator set functions shall be monitored:
    - (i) All output voltages - single phase, three phase, line to line, and line to neutral, 0.25% accuracy.
    - (ii) All single phase and three phase currents, 0.25% accuracy.
    - (iii) Output frequency, 0.25% accuracy.
    - (iv) Power factor by phase with leading/lagging indication.

- (v) Total instantaneous kilowatt loading and kilowatts per phase, 0.5% accuracy.
- (vi) kVARS total and per phase, 0.5% accuracy.
- (vii) kVA total and per phase, 0.5% accuracy.
- (viii) kW hours.
- (ix) A display of percent generator set duty level (actual kW loading divided by the kW rating).
- c. Engine parameters listed below shall be monitored:
  - (i) Coolant temperature both in English and metric units.
  - (ii) Oil pressure in English and metric units.
  - (iii) Battery voltage.
  - (iv) RPM.
  - (v) Lube oil temperature.
  - (vi) Lube oil level.
  - (vii) Crankcase pressure.
  - (viii) Coolant level.
  - (ix) Coolant pressure.
  - (x) Fuel pressure.
  - (xi) Fuel temperature.
  - (xii) Fuel rate.
  - (xiii) Fuel used during the last run.
  - (xiv) Ambient temperature.
- d. Operational records shall be stored in the control beginning at system startup.
  - (i) Run time hours.
  - (ii) Run time loaded hours.
  - (iii) Run time unloaded hours.
  - (iv) Number of starts.
  - (v) Factory test date.
  - (vi) Last run data including date, duration, and whether loaded or unloaded.
  - (vii) Run time kilowatt hours.
- e. The following operational records shall be a resettable for maintenance purposes:
  - (i) Run time hours.
  - (ii) Run time loaded hours.
  - (iii) Run time unloaded hours.
  - (iv) Run time kilowatt hours.
  - (v) Days of operation.
  - (vi) Number of starts.
  - (vii) Start date after reset.
- f. The controller shall store the last one hundred generator set system events with date and time of the event.
- g. For maintenance and service purposes, the controller shall store and display on demand the following information:

- (i) Manufacturer's model and serial number.
- (ii) Battery voltage.
- (iii) Generator set kilowatt rating.
- (iv) Rated current.
- (v) System voltage.
- (vi) System frequency.
- (vii) Number of phases.

U. Inputs and Outputs

1. Inputs.

- a. There shall be 21 dry contact inputs that can be user-configured to shut down the generator set or provide a warning.
- b. There shall be 7 user-programmable analog inputs for monitoring and control.
- c. Each analog input can accept 0-5 volt analog signals.
- d. Resolution shall be 1:10,000.
- e. Each input shall include range settings for 2 warnings and 2 shutdowns.
- f. All values shall be on the control panel display.
- g. Shall be user-assigned.
- h. Additional standard inputs required:
  - (i) Input for an external ground fault detector. Digital display shall show "ground fault" upon detection of a ground fault.
  - (ii) Reset of system faults.
  - (iii) Remote two-wire start.
  - (iv) Remote emergency stop.
  - (v) Idle mode enable.

2. Outputs

- a. All NFPA 110 Level 1 outputs shall be available.
- b. Thirty outputs shall be available for interfacing to other equipment.
  - (i) All outputs shall be user-configurable from a list of 25 functions and fault
  - (ii) These outputs shall drive optional dry contacts.
- c. A programmable user-defined common fault output with over 40 selections shall be available.

V. Communications (Modbus protocol)

- 1. The controller shall communicate with the ECM for control, monitoring, diagnosis, and meet SAE J1939 standards.
- 2. Industry standard Modbus communication shall be available.
- 3. A Modbus master shall be able to monitor and alter parameters and start or stop a generator.
- 4. The controller shall have the capability to communicate to a personal computer (IBM or compatible) running Windows XP, or Windows 7 or later.
- 5. Communications shall be available for serial, CAN, and Ethernet bus networks.
- 6. A variety of connections shall be available based on requirements:
  - a. A single control connection to a PC.

- b. Multiple controls on an intranet network connected to a PC.
- c. A single control connection to a PC via phone line.
- d. Multiple controls to a PC via phone line.
- 7. Generator and transfer switch controls shall be equipped with communications modules capable of connecting to the same communication network.
- 8. The capability to connect up to 128 controls (any combination of generator sets and transfer switches) on a single network shall be supported.
- 9. Cabling shall not be limited to the controller location.
- 10. Network shall be self-powered.

## 2.03 ACCESSORIES

### A. FUEL OIL STORAGE

- 1. Comply with NFPA 30.
- 2. The storage tank shall be a secondarily contained rectangular steel tank capable of mounting an engine generator to top of tank. The tank shall be "Special Purpose" UL142 listed and labeled.
- 3. The tank shall be designed, tested and labeled per UL requirements to support a specified generator, and lift lugs shall be approved by UL with a 4 to 1 safety factor.
- 4. Features include the following:
  - a. Tank level indicator.
  - b. Capacity: Fuel for 48 hours' continuous operation at 100 percent rated power output.
  - c. Vandal-resistant fill cap.
  - d. Containment Provisions: Double Wall Steel.
- 5. Fuel tank shall be State and Local Approved and provided with an electronic leak protection system and an audio/visual alarm indication. Provide fuel leak SCADA contact.
- 6. Fuel Tank Coating System:
  - a. Exterior Painting Schedule.
    - (i) Organic Zinc-rich/Urethane/Urethane Coating System.
    - (ii) Surface Preparation: SSPC-SP6; commercial blasting cleaning.
    - (iii) Prime Coat: Apply HSP-2128 Polyurethane Prime (DFT 1.7-2.2mils).
    - (iv) Intermediate Coat: Series 1075 Endura-Shield-Color at 2.0 to 3.0 mils DFT.
    - (v) Finish Coat: AUE-280 Polyurethane Topcoat (DFT 1.7 to 2.2mils).
    - (vi) Minimum Total DFT: 7.0mils.
    - (vii) Corrosion resistance per ASTM B-117 for 3000 hour salt test spray.
    - (viii) Humidity resistance per ASTM 2247 for 3000 hours.
    - (ix) UV resistance per ASTM D4587 1000 hours.
- 7. Access Stairs: Provide prefabricated aluminum access stairs with handrails for each generator enclosure access door. All stairs to meet OSHA requirements and project specification for access stairs and handrails.



8. Fuel tank to be mounted on 8" high I-Beams to allow for maintenance of bottom fuel tank.
9. Lift lugs shall be approved by UL with a 4 to 1 safety factor.
10. The primary and secondary tanks shall be fabricated from minimum 1/4" steel.
11. Primary tank shall be air pressure tested at three (3) PSI using a leak detection solution and the secondary tank shall be air pressure tested at one and one-half (1-1/2) PSI using a leak detection solution.
12. There shall be an annular space between the primary and secondary tank to provide an immediate leak path for external monitoring manually or electronically.
13. The tank shall include earthquake/tornado restraint tie downs and plates for grounding attachments.
14. All tank-top fittings shall be forged steel weld flanges.
15. All tank applications (installations) shall be reviewed by the proper fire district regulating authority and properly permitted. All tanks shall be labeled by product, capacity and Manufacturer.
16. Updraft and emergency venting shall be provided by tank Manufacturer per UL 142 requirements.
17. Provide 4-20mA signal proportional to fuel tank level for control system.
18. Provide mechanical reading fuel level gauge, low fuel level alarm contact, and fuel tank rupture alarm contact.

**B. HOUSING**

1. The generator set shall be supplied with a Weatherproof Enclosure, providing a sound pressure of 98.3 dB(A) while the generator is operating at 100% load at 7 meters (23 feet) – free field – using acoustic insulation and acoustic-lined inlet hoods, constructed from a minimum of 0.080 inch thick formed heavy duty aluminum panels. The acoustic insulation used shall meet UL 94 HF1 flammability classification. The enclosure shall be manufactured from bolted panels to facilitate service, future modifications, or field replacement. The enclosure shall use external vertical air inlet and outlet hoods with 90-degree angles to discharge air up and reduce noise. The enclosure shall have an integral rodent guard and skid end caps and shall have bracing to meet 120 mph wind loading.
2. The enclosure components and skid shall be cleaned with a two-stage alkaline cleaning process to remove grease, grit, and grime from parts. Components shall then be subjected to a Zirconium-based conversion coating process to prepare the metal for electrocoat (e-coat) adhesion. All enclosure parts shall receive an 100% epoxy primer electrocoat (e-coat) with high-edge protection. Apply DX-1791 Etch Wash Prime (DFT 0.2 to 0.4 mils) and HSP-2128 Polyurethane Primer (DFT 1.7 – 2.2mil). Following the e-coat process, the parts shall be finish coated with powder baked paint for superior finish, durability, and appearance with applied AUE-280 Polyurethane Topcoat (DFT 1.7 to 2.2mils).
3. The enclosure must surpass a 3,000 hour salt spray corrosion test per ASTM B-1117.
  - a. The enclosure must meet Humidity Resistance (ASTM 2247): 2000 Hours with respect to cross-hatch adhesion and 24 hour recovery adhesion per ASTM D3359 -5B.

- b. Tabor Abrasion per ASTM D4060.
  - c. Gravel-o-meter per ASTM D3170.
  - d. Select chemical resistance with no effect to the following with a 24-hour watch glass:
    - (i) Sodium Hydroxide, sulphuric acid, acetic acid (20%), diesel fuel, nitric acid, hydrochloric acid, water, citric acid (50%), hydraulic oil, & phosphoric acid.
  - 4. Enclosures will be finished in the Manufacturer's standard color.
  - 5. The enclosures shall allow the generator set to operate at full load in an ambient temperature of 50°C with no additional derating of the electrical output of the generator set.
  - 6. Enclosures shall be equipped with sufficient side and end doors to allow access for operation, inspection, and service of the unit and all options. Minimum requirements are two doors per side. When the generator set controller faces the rear of the generator set, an additional rear facing door is required. Access to the controller and main line circuit breaker shall meet the requirements of the National Electric Code.
  - 7. Doors shall be fitted with hinges, hardware, and the doors shall be removable.
  - 8. Doors shall be equipped with lockable latches. Locks shall be keyed alike. Door locks shall be recessed to minimize potential of damage to door/enclosure.
  - 9. A duct between the radiator and air outlet shall be provided to prevent re-circulation of hot air.
  - 10. The complete exhaust system shall be internal to the enclosure.
  - 11. The generator set enclosure shall be furnished with the battery charger wired into the load center.
  - 12. The generator set enclosure shall be furnished with a 25kVA, 30 circuit, 120/240 single phase Mini Power Zone Panel (NEMA 3R). The panel shall serve the following:
    - a. Generator Block Heater.
    - b. Generator Batter Charger.
    - c. Generator Enclosure Heaters.
    - d. AC lights vapor tight and gasketed.
    - e. (2) duplex GFI receptacles.
  - 13. The generator set enclosure shall be furnished with the block heater wired into the load center.
  - 14. Provide an LED wallpack light with photo cell to provide 5fc for entry door and walkway lighting. Circuit to mini power zone inside generator enclosure.
- C. Muffler/Silencer: Critical grade silencer, companion flanges, and flexible stainless-steel exhaust fitting, sized as recommended by engine Manufacturer and selected with exhaust piping system to not exceed engine Manufacturer's engine backpressure requirements. The silencer shall be mounted so that its weight is not supported by the engine nor will exhaust system growth due to thermal expansion be imposed on the engine.
- 1. Minimum sound attenuation of 25 dB at 500 Hz.
  - 2. Sound level measured at a distance of 10 feet from exhaust discharge after installation is complete shall be 85 dBA or less.

## 2.04 SOURCE QUALITY CONTROL

- A. Provide shop inspection and testing of completed assembly.
- B. Make completed engine-generator assembly available for inspection at Manufacturer's factory prior to packaging for shipment. Notify Owner/Engineer at least seven days before inspection is allowed.
- C. Allow witnessing of factory inspections and tests at Manufacturer's test facility. Notify Owner/Engineer at least seven days before inspections and tests are scheduled.

## PART 3 EXECUTION

### 3.01 EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.
- B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.02 INSTALLATION

- A. Comply with packaged engine-generator Manufacturers' written installation and alignment instructions and with NFPA 110.
- B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- C. Install packaged engine generator with restrained spring isolators having a minimum deflection of 1 inch on 4-inch- high concrete base. Secure sets to anchor bolts installed in concrete bases.
- D. Electrical Wiring: Install electrical devices furnished by equipment Manufacturers but not specified to be factory mounted.

### 3.03 CONNECTIONS


- A. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
- B. Connect engine exhaust pipe to engine with flexible connector.
- C. Connect fuel piping to engines with a gate valve and union and flexible connector.
- D. Ground equipment according to Division 16 - Electrical.
- E. Connect wiring according to Division 16 - Electrical.

### 3.04 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. The Contractor shall provide the Owner with a written report of the results.

### 3.05 TESTS AND INSPECTIONS:

- A. The owner will supply all fuel used for all generator testing. The generator shall be full of fuel when turned over to the owner. Fuel provided by the owner.
- B. Perform tests recommended by Manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- C. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full- load pickup test and 2-hour load bank test at 1.0 PF at Nameplate rating. Load bank, cables and other equipment required for this test to be supplied by the genset supplier. Coordinate all start-up and testing activities with the Engineer and Owner.
- D. Load Test: Perform a 2-hour load test (per NFPA 110 7.13.4.3) for all three generators in a parallel configuration. During the test, the generator supplier shall use resistive load banks connected to 2500kVA padmount transformers at the Primary Electrical Building and the Influent PS/Headworks Electrical Building. In addition, actual VFD based plant load will be used from the Aeration Basin. Load bank supplied will be limited to 2 – 2.5 MW with the Aeration Basin full of water and the Aerators Running. Coordinate testing with General Contractor.
  - 1. As part of the test the load will be varied for 50% to 100% of the generator system capacity to see the load control capability of the switchgear.
  - 2. Following failure will be simulated:
    - a. Gen Fail to Sync.
    - b. Gen Fail while operating.
    - c. Breaker fails to close.
    - d. Utility fails to close.
  - 3. Manually parallel and retransfer to utility will also be tested.
  - 4. Additional test as directed by the Engineer.
  - 5. If during the 2-hour NFPA 110 load test any part of the generator or paralleling system fails to operate as specified or designed, the entire test will be repeated.
  - 6. The owner shall provide all fuel required for the testing.
- E. 30 Day Plant Operational Test:
  - 1. During the 30-Day Plant Operation Test, the generators will be tested 4 times at random intervals for up to 2 hours. During these operational tests, plant load will be used as the generator load.
  - 2. The test will be simulated power outages and simulated generator outages.

3. If the generator system fails to operate as intended during any of these random tests during the 30-Day Plant Operational Test, the 2-hour NFPA 110 Load test will be repeated and all 4 of the 2-hour random test will be repeated.
  4. The owner shall provide all fuel required for the testing.
- 
- F. Battery Tests: Equalize charging of battery cells according to Manufacturer's written instructions. Record individual cell voltages.
  - G. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
  - H. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
  - I. Verify acceptance of charge for each element of the battery after discharge.
  - J. Verify that measurements are within Manufacturer's specifications.
  - K. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
  - L. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
  - M. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
  - N. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
  - O. Coordinate tests with tests for transfer switches and run them concurrently.
  - P. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.
  - Q. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - R. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - S. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  - T. Remove and replace malfunctioning units and retest as specified above.

- U. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- V. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- W. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.
  - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.
  - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  - 3. Record of Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each cable termination on conductors No. 3 AWG and larger. Remove box and equipment covers so terminations are accessible to portable scanner.
  - 4. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each termination 11 months after date of Substantial Completion.
  - 5. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values.
  - 6. Record of Infrared Scanning: Prepare a written report that identifies which terminations were checked and that describes scanning results. Include notation of deficiencies detected, the remedial action taken, and observations after remedial action. The reports shall include the following:
    - a. Color images of each scan.
    - b. Calibration record for device.
    - c. Date and time of the scan.
    - d. Infrared scanner Manufacturer, model, and serial number.

### 3.06 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's operations and maintenance personnel to adjust, operate, and maintain packaged engine generators.
- B. The training shall be broken down in to two types of training: operations and maintenance.
- C. All training shall be performed at the Owner's site and using the Owner's equipment.
- D. The operations training session shall be a minimum of 4 hours (per class) and shall be provided in two classes scheduled on consecutive days for up to five of the Owner's operations personnel.

- E. The maintenance training shall be a minimum of 4 hours (per class) and shall be provided in two classes scheduled on consecutive days for up to five of the Owner's maintenance personnel.

3.07 FINAL FUELING

- A. The generator fuel tanks shall be filled prior to final acceptance by the Owner. Fuel provided by the Owner.



END OF SECTION

## **SECTION 16600**

### **UNDERGROUND SYSTEM**

#### **PART 1 GENERAL**

##### **1.01 SCOPE OF WORK**

- A. Furnish and install a complete underground system of raceways, manholes and handholes as shown on the Drawings and as specified herein.

##### **1.02 RELATED WORK**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Other sections that may relate to the work in this section include, but are not limited to, the following:
  - 1. Division 01 – General.
  - 2. Division 16 – Electrical.

##### **1.03 SUBMITTALS**

- A. Submit per Division 1 – General Provisions, and Section 16000 – Basic Electrical Requirements.
- B. Submit shop drawings and product data, for the following:
  - 1. Manholes, handholes and associated hardware.
  - 2. Underground Ducts.
  - 3. Concrete Backfill.
  - 4. Plastic duct spacers.
- C. Submittals shall also contain information on related equipment to be furnished under this Specification. Incomplete submittals not containing the required information on the related equipment will be returned unreviewed.
- D. Provide manhole and handhole NEC sizing calculations for all manholes and handholes used on the project. Sizing calculations shall be provided with initial submittal.

##### **1.04 REFERENCE STANDARDS**

- A. All products and components shown on the Drawings and listed in this specification shall be designed and manufactured according to latest revision of the following standards (unless otherwise noted):
  - 1. NFPA 70 – National Electrical Code (NEC).
  - 2. NFPA 70E – Standard For Electrical Safety in the Workplace.
  - 3. ASTM A615/A615M-06a – Standard Specification for Deformed and Plain Carbon-Steel Bars for concrete Reinforcement.
  - 4. ASTM A48 – Standard Specification for Gray Iron Castings.
  - 5. ASTM A536 – Standard Specification for Ductile Iron Castings.



6. AASHTO M306-04/ ASTM A48 – Drainage Structure Castings, Section 7.0 Proof Load Testing.
  7. ASTM C-850- Specifications for underground precast concrete utility structures.
- B. All excavation, trenching, and related sheeting, bracing, etc., as shown on the Drawings and listed in these Specifications, shall comply with the following standards (unless otherwise noted):
1. Occupational Safety and Health Administration (OSHA).
    - a. Excavation safety standards (29 CFR Part 1926.650 Subpart P) - Excavation.
  2. American Society for Testing and Materials (ASTM).
    - a. ASTM D 698a – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft<sup>3</sup> (600kN-m/m<sup>3</sup>)).
- C. All equipment specified in this section of the Specifications shall bear the appropriate label of Underwriters Laboratories.
- 1.05 QUALITY ASSURANCE
- A. The manufacturer of these materials shall have produced similar electrical materials and equipment for a minimum period of five (5) years. When requested by the Owner/Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- B. The precast manholes shall be manufactured in a NPCA (National Precast Concrete Association) Certified Plant.
- 1.06 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS (NOT USED)
- 1.07 DELIVERY STORAGE AND HANDLING
- A. Equipment shall be handled and stored in accordance with manufacturer's instructions.
- B. Protect equipment and materials from exposure to the elements and keep thoroughly clean and dry until installation.
- 1.08 MAINTENANCE/SPARE PARTS (NOT USED)
- 1.09 WARRANTY/EXTENDED WARRANTY
- A. Base Warranty per Division 1
- 1.10 COORDINATION
- A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.
- B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise

locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Engineer.

## PART 2 PRODUCTS

### 2.01 MATERIALS

#### A. Raceways

1. Raceways shall be rigid polyvinyl chloride conduit Schedule 40, encased in concrete, as manufactured by Cantex; Prime Conduit; Allied Tube. Thinwall conduit designated for encased burial as (Type EB) is not acceptable for any application.
2. All underground raceways of the underground system, terminating in manholes or handholes shall use bell end fittings of the same size and type as the raceway. Bell ends and duct spacers shall be as manufactured by Cantex or Prime Conduit.
3. Concrete encasement for raceways and duct banks shall be normal weight concrete weighing not more than 145 pcf with compressive strength a minimum of 3000 psi at 28 days, as specified in Section 16033, and of dimensions as shown on the Drawings.
4. Reinforcing steel shall comply with ASTM A615 Grade 60 as specified in Division 16 - Electrical, and of a size and installation as shown on the Drawings.
5. Where raceways terminate into existing and new manholes, handholes or structures which have flanged threaded couplers in the wall of the manhole or structure, threaded splice bars 24 inches in length shall be installed in all of the existing threaded couplers for that bank, and the threaded splice bars lapped into the duct bank steel for the last 24 inches length of the duct bank, and tied to the duct bank reinforcing steel at the end for that length.
6. Where raceways terminate into existing manholes, handholes or structures which do not have flanged threaded couplers in the wall of the manhole or structure, the bank duct reinforcing steel shall be dowelled into the existing structure, manhole or handhole wall at least  $\frac{1}{2}$  of the wall thickness, and secured with epoxy compound. The last 10' of the duct bank reinforcing shall be one bar size larger than shown for the encasement reinforcing.
7. All new manholes and handholes shall be provided with threaded splice bars, setting bars, and threaded rebar couplers, as manufactured by Meadow Burke Inc., Tampa, FL. for overlapping the duct bank reinforcing steel with screwlock couplers, as shown on the Drawings.
8. Where fiberglass elbows are allowed, they shall be manufactured by Champion Fiberglass or Atkore and comply with UL 1684.



#### B. Manholes and Handholes

1. General
  - a. Manholes and handholes shall be of the precast concrete type, designed for a Class H20 load with sizes as shown on the Drawings, and as manufactured by Oldcastle Precast, The Turner Company, or Champion Precast.
2. Construction
  - a. Concrete for manholes and handholes shall have a 28-day compressive strength of 5000 PSI. Cement shall be Type 1 or III. Reinforcing steel shall be Grade 60 with yield strength of 60,000 P.S. Design loadings shall be H-20-44 w/impact.

- b. Duct bank entries into the manhole or handhole shall be centered on the entering wall.
  - c. Where present or future duct banks are shown to terminate at a manhole or handhole, the terminating area of the manhole wall within the confines of the duct bank steel reinforcing shall be recessed approximately 1-1/2" for shear support, with beveled edges, all as shown on the Drawings.
  - d. Each manhole and handhole shall have a 18" x 18" x 24" deep concrete sump in one corner of the manhole or handhole.
3. Manhole Covers
- a. Unless otherwise shown on the Drawings, manhole and handhole covers shall be heavy duty 36 in. machined gray iron, and AASHTO M306-04/ ASTM A48 CL35B Min., 40,000-pound proof load value (Class H20 X 2.5) "True Traffic" load covers, complete with frame, and "Electric" or "Communication" raised lettering recessed flush, as required, on the cover. Covers shall be V-1600-5, with drop handles as manufactured by East Jordan Iron Works, Ardmore, OK.
  - b. All castings shall be made In the USA, cast with the foundry's name, part number, "Made in USA", and production date (example: mm/dd/yy). Castings without proper markings will be rejected. Manufacturer shall certify that all castings conform to the ASTM and AASHTO Designations as specified herein. All casting shall be true to pattern in form and dimension, free from pouring faults, sponginess, cracks, blow holes and other defects in positions affecting strength and value for the service intended. Angles shall be filleted, and arises shall be sharp and true.
4. Hardware
- a. Cable racks shall be of the heavy duty non-metallic type with arm lengths of 8", 14" and 20", each supporting a load of not less than 250 lbs. at the outer end. Racks shall be molded in one piece of U.L. listed glass reinforced nylon, Catalog CR36N with RA08N, RA14N and RA20N arms as manufactured by Underground Devices Inc. Northbrook, IL. Cable racks shall have reinforced nylon inserts cast flush in the manhole and handhole walls and the rack secured by 316 stainless steel bolts. Arms for racks shall be vertically spaced not greater than 24" on centers. Furnish inserts for all present and future cable racks as shown on the Drawings.
  - b. Pulling irons shall be of copolymer polypropylene coated 1/2" dia. cable, tensile strength rated at 270,000 psi, with polyethylene pulling iron pocket, all recessed in the manhole wall opposite each duct entry. Pulling irons for handholes shall have the pulling iron located in the floor of the handhole near the center of the handhole opposite the duct entry. Pulling irons shall be as manufactured by M.A. Industries, Inc. Peachtree, GA. or Bowco Industries, Portland OR.
  - c. Each manhole shall have a 3/4 x 30' stainless steel ground rod inserted through the floor of the manhole or handhole, and epoxy sealed. Provide a #4/0 bare tinned copper conductor ring around the inside perimeter of the manhole. Connect the access hatch, ladder, etc. with a #6 AWG tinned copper conductor. Utilize bronze connectors, suitable for grounding and bonding applications, in configurations required for the particular installation.
  - d. Manhole and handhole ladders shall be constructed of fiberglass reinforced plastic, safety yellow, 18" rung width with 12" rung spacings, Safrail as

manufactured by Strongwell Corp., Bristol, VA. Furnish a total of two ladders, each of a length 4' greater than the deepest manhole in the underground system.

## 2.02 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE


- A. Description: Comply with SCTE 77.
  - 1. Color: Gray or Engineer approved equal.
  - 2. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
  - 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
  - 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
  - 5. Cover Legend: Molded lettering, as indicated for each service.
  - 6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
  - 7. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
  - 8. Handholes 12 inches wide by 24 inches long and larger shall have factory- installed inserts for cable racks and pulling-in irons.
- B. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
  - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or Engineer approved equal:
    - a. Armorcast Products Company.
    - b. Carson Industries LLC.
    - c. CDR Systems Corporation.
    - d. NewBasis.
- C. Fiberglass Handholes and Boxes with Polymer Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.
  - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or Engineer approved equal:
    - a. Armorcast Products Company.
    - b. Carson Industries LLC.
    - c. Christy Concrete Products.
    - d. Synertech Moulded Products, Inc.; a division of Oldcastle Precast.

- D. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete.
  - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or Engineer approved equal:
    - a. Carson Industries LLC.
    - b. Christy Concrete Products.
    - c. Nordic Fiberglass, Inc.
  
- E. High-Density Plastic Boxes: Injection molded of high-density polyethylene or copolymer-polypropylene. Cover shall be plastic.
  - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or Engineer approved equal:
    - a. Carson Industries LLC.
    - b. Nordic Fiberglass, Inc.
    - c. PenCell Plastics.

### PART 3 EXECUTION

#### 3.01 GENERAL

- A. The Contractor shall field verify the routing of all underground duct banks before placement. He shall modify the routing as necessary to avoid underground utilities or above ground objects. Modification or rerouting for the convenience of the Contractor, or to reduce the length of duct run as designed, will not be permitted. The Contractor shall provide any alternate routing of the duct banks to the Owner/Engineer and, after approval, shall proceed with the installation.
- B. The Contractor shall saw cut and repair existing pavements above new and modified existing duct banks. The Contractor shall provide the alternate routing of the duct banks to the Owner/Engineer and after approval shall proceed with the installation.
- C. Install raceways to drain away from buildings. Raceways between manholes or handholes shall drain toward the manholes or handholes. Raceway slopes shall not be less than 3 in per 100 ft.
- D. Reinforce raceway banks as shown on the Drawings.
- E. A #4/0 stranded tinned copper ground conductor shall be threaded through the upper tier of duct spacers, as shown on the Drawings, for the full length of each duct run between manholes and handholes, entering the duct bank opening at each manhole, and bonded to the ground rod in the floor of each manhole and handhole to a 3/4" x 30' ground rod.
- F. Lay raceway lines in trenches on compacted earth as specified in Division 16 – Electrical.

- G. Use plastic spacers located not more than 4 ft apart to hold raceways in place. Spacers shall provide not less than 2 in clearance between raceways.
- H. The minimum cover for raceway banks shall be 24 in unless otherwise permitted by the Owner/Engineer.
- I. Raceway terminations at all manholes, existing and new, shall be with end bells for PVC conduit.
- J. Where bends in raceways greater than 15 degrees are required, use long radius elbows, sweeps and offsets of PVC coated aluminum conduit.. Tape unions and transitions of PVC coated aluminum conduit such that the aluminum does not come into contact with the concrete. Fiberglass elbows acceptable in unclassified area. 
- K. The ends of all ducts shall be tightly plugged to exclude dust and moisture during construction. Duxseal shall be used in all applications. Plugging with tape is prohibited, even for a temporary time.
- L. Where raceways enter or exit the Underground System, and the raceways rise to a higher elevation upon entering or leaving the System, such raceways shall be tightly sealed at the higher elevation, both before and after the installation of cables, such that there shall be no entry of water or moisture to the Underground System at any time.
- M. No wire shall be pulled until the duct system has been completed in every detail.
- N. Swab all raceways clean before installing cable.
- O. Train cables in manholes and handholes and support and restrain them on cable racks. All cables passing manhole duct entrances in the manhole or handhole shall pass above all duct entrances. No cable shall pass in front of or below duct bank entrances.

### 3.02 TRENCH EXCAVATION

- A. The excavation shall extend to the width and depth as shown on the Drawings, or as specified, and shall provide suitable room for installing manholes, handholes, ducts and appurtenances.
- B. Furnish and place all sheeting, bracing and supports.
- C. Excavation shall include material of every description and of whatever substance encountered, regardless of the methods or equipment required to remove the material. Pavement shall be cut with a saw, wheel or pneumatic chisel along straight lines before excavating.
- D. The Contractor shall strip and stockpile topsoil from grassed areas crossed by trenches. At the Contractor's option, topsoil may be otherwise disposed of and replaced, when required, with approved topsoil of equal quality.
- E. While excavating and backfilling is in progress, traffic shall be maintained, and all utilities and other property protected, as provided for in the Contract Documents.

- F. Materials shall be excavated to the depth indicated on the Drawings and in widths sufficient for installing manholes and laying the ducts. Coordinate the trench width the Details shown on the Drawings. The bottom of the excavations shall be firm and dry in all respects acceptable to the Owner/Engineer. Trench width shall be a practical minimum, but not less than 6 inches greater than the total duct section arrangement, including reinforcing steel.
- G. Excavation and dewatering shall be accomplished by methods which preserve the undisturbed state of subgrade soils. The trench may be excavated by machinery to, or just below, the designated subgrade, provided that material remaining in the bottom of the trench is no more than slightly disturbed. Subgrade soils which become soft, loose or otherwise unsatisfactory as a result of inadequate excavation, dewatering or other construction methods, shall be removed and replaced by gravel fill, of aggregate as specified in Division 3, as required by the Owner/Engineer at the Contractor's expense.

### 3.03 EXCAVATION BELOW GRADE AND REFILL

- A. Regardless of the nature of unstable material encountered, or the groundwater conditions, trench and excavation drainage shall be complete and effective.
- B. If deemed necessary by the Owner/Engineer, or as shown on the Drawings, the Contractor shall be required to deposit pea gravel for duct bedding or gravel refill for excavation below grade, directly on the bottom of the trench immediately after excavation has reached the proper depth and before the bottom of the trench has become softened or disturbed by any cause whatsoever. All excavation shall be made in open trenches. Gravel used for this purpose, shall be aggregate as specified in Division 16, with a maximum coarse aggregate size of  $\frac{3}{4}$  inch.

### 3.04 BACKFILLING

- A. Remove from the excavation all materials which the Owner/Engineer may deem unsuitable for backfilling.
- B. Backfilling shall not commence until, not less than 48 hrs after placing of any concrete embedment, have lapsed.
- C. Where the ductbanks are laid in the yard, the remainder of the trench, after concrete encasement, shall be filled with common fill material, void of rock or other non-porous material, in layers not to exceed 8-in in loose measure and compacted to 90% standard Proctor density at optimum moisture content of +/- 4%. The backfill shall be mounded 6-in above the existing grade or as directed by the Owner/Engineer. Where a grass, loam or gravel surface exists prior to excavations in the yard, it shall be removed, conserved and replaced to the full original depth as part of the work under the duct items. In some areas it may be necessary to remove excess material during the cleanup process, so that the ground may be restored to its original level and condition.
- D. Where the ductbanks are laid in paved areas or designated future paved areas, existing or designated future structures, or other existing or future utilities, the remainder of the trench above the encasement, shall be backfilled with select common fill or select fill

material in layers not to exceed 8-inches loose measure and compacted at optimum moisture content.

- E. (+/- 3%) to 95 percent standard Proctor density. The top 18-inches below subgrade level shall be compacted at optimum moisture content (+/- 3%) to 100 percent of standard Proctor density.
- F. Compaction shall be by use of hand or pneumatic tamping with tools weighing at least 20 lbs. The material being spread and compacted shall be placed in layers not over 8-in loose thick. If necessary, sprinkling shall be employed in conjunction with rolling or ramming.
- G. Bituminous paving shall not be placed in backfill.
- H. Water jetting will not be accepted as a means of consolidating or compacting backfill.
- I. All road surfaces shall be broomed and hose-cleaned immediately after backfilling. Dust control measures shall be employed at all times.

### 3.05 RESTORING TRENCH AND ADJACENT SURFACES

- A. In paved areas, the edge of the existing pavement to be removed shall be cut along straight lines, and the pavement replaced with the same type and quality of the existing paving.
- B. In sections where the ductbank passes through grassed areas, the Contractor shall, at his own expense, remove and replace the sod, or shall loam and reseed the surface to the satisfaction of the Owner/Engineer.

### 3.06 CLEANING

- A. Remove all rubbish and debris from inside and around the underground system. Remove dirt, dust, or concrete spatter from the interior and exterior of manholes, handholes and structures, using brushes, vacuum cleaner, or clean, lint free rags. Do not use compressed air.

END OF SECTION



**SECTION 16660****GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS****PART 1 GENERAL****1.01 SCOPE OF WORK**

- A. Furnish all labor, materials, equipment and incidentals required and install a complete grounding system in strict accordance with Article 250 of the National Electrical Code (NEC), as shown on the Drawings and as specified herein.
- B. All raceways, conduits and ducts shall contain equipment grounding conductors sized in accordance with the NEC. Minimum sizes shall be No. 12 AWG.
- C. Section Includes:
  - 1. Rod electrodes.
  - 2. Active electrodes.
  - 3. Wire.
  - 4. Grounding well components.
  - 5. Mechanical connectors.
  - 6. Exothermic connections.

**1.02 RELATED WORK**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Other sections that may relate to the work in this section include, but are not limited to, the following:
  - 1. Division 01 – General.
  - 2. Division 16 – Electrical.

**1.03 SUBMITTALS**

- A. Submit per Division 01 – General Provisions, and Section 16000 – Basic Electrical Requirements.
- B. Product Data: Submit catalog data showing specified features of standard products.
- C. Product Data: Submit data on grounding electrodes and connections.
- D. Test Reports: Indicate overall resistance to ground and resistance of each electrode.
- E. Manufacturer's Installation Instructions: Submit for active electrodes.
- F. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.
- G. Section 01700 – Contract Closeout: Requirements for submittals.

- H. Project Record Documents: Record actual locations of components and grounding electrodes.

#### 1.04 REFERENCE STANDARDS

- A. Institute of Electrical and Electronics Engineers:
  - 1. IEEE 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.
  - 2. IEEE 1100 - Recommended Practice for Powering and Grounding Electronic Equipment.
- B. International Electrical Testing Association:
  - 1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
- C. National Fire Protection Association:
  - 1. NFPA 70 - National Electrical Code.
  - 2. NFPA 99 - Standard for Health Care Facilities.

#### 1.05 QUALITY ASSURANCE

- A. Provide grounding materials conforming to requirements of NEC, IEEE 142, and UL labeled.
- B. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum three years documented experience.
- C. Installer: Company specializing in performing work of this section with minimum 5 years documented experience.

#### 1.06 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS

- A. Grounding systems use the following elements as grounding electrodes:
  - 1. Metal underground water pipe.
  - 2. Metal building frame.
  - 3. Concrete-encased electrode.
  - 4. Ground ring as shown on the drawings.
  - 5. Rod electrode.
  - 6. Plate electrode.
- B. Grounding System Resistance: 5 ohms maximum.

#### 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Section 16000 – Basic Electrical Requirements.
- B. Accept materials on site in original factory packaging, labeled with manufacturer's identification.

- C. Protect from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original packaging.
- D. Do not deliver items to project before time of installation. Limit shipment of bulk and multiple-use materials to quantities needed for immediate installation.

#### 1.08 MAINTENANCE/SPARE PARTS (NOT USED)

#### 1.09 WARRANTY/EXTENDED WARRANTY (NOT USED)

#### 1.10 COORDINATION

- A. Complete grounding and bonding of building reinforcing steel prior concrete placement.

### PART 2 PRODUCTS

#### 2.01 ROD ELECTRODES

- A. Product Description:
  1. Material: Stainless Steel.
  2. Diameter: 3/4 inch (19 mm).
  3. Length: 10 feet (3.0 m).
- B. Connector: Connector for exothermic welded connection.



#### 2.02 WIRE

- A. Material: Stranded Tinned copper.
- B. Sizes:
  1. 4/0 Counterpoise.
  2. 4/0 Switchboard Bonding Jumpers.
  3. #2 Bonding jumpers for all other as allowed by the NEC.

#### 2.03 GROUNDING WELL COMPONENTS

- A. Test Well box: 12" x 12" x 12" Open Bottom Polymer Concrete.
- B. Well Cover: Polymer Concrete with legend "GROUND" cast in cover.

#### 2.04 MECHANICAL CONNECTORS

- A. Manufacturers:
  1. Burndy.
  2. Substitutions: Division 1 – General Provisions.
- B. Description: Bronze connectors, suitable for grounding and bonding applications, in configurations required for particular installation.

## 2.05 EXOTHERMIC CONNECTIONS

- A. Manufacturers:
  - 1. Cadweld.
  - 2. Substitutions: Division 1 – General Provisions
- B. Product Description: Exothermic materials, accessories, and tools for preparing and making permanent field connections between grounding system components.

## PART 3 EXECUTION

### 3.01 EXAMINATION

- A. Verify final backfill and compaction has been completed before driving rod electrodes.

### 3.02 PREPARATION

- A. Remove paint, rust, mill oils, surface contaminants at connection points.

### 3.03 EXISTING WORK

- A. Modify existing grounding system to maintain continuity to accommodate renovations.
- B. Extend existing grounding system using materials and methods compatible with existing electrical installations.

### 3.04 INSTALLATION

- A. Install in accordance with IEEE 142.
- B. Install rod electrodes at locations as indicated on Drawings. Install additional rod electrodes to achieve specified resistance to ground.
- C. Install grounding and bonding conductors concealed from view.
- D. Install grounding well pipe with cover at rod locations as indicated on Drawings. Install well boxes top flush with finished grade.
- E. Install grounding electrode conductor and connect to reinforcing steel in foundation footing as indicated on Drawings. Electrically bond steel together.
- F. Bond together metal siding not attached to grounded structure; bond to ground.
- G. Bond together reinforcing steel and metal accessories in fountain structures.
- H. Install isolated grounding conductor for circuits shown on the drawing in accordance with IEEE 1100.
  - 1. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

- I. Install grounding and bonding in patient care areas to meet requirements of NFPA 99.
- J. Equipment Grounding Conductor: Install separate, insulated conductor within each feeder and branch circuit raceway. Terminate each end on suitable lug, bus, or bushing.
- K. Connect to site grounding system.
- L. Bond to lightning protection system.
- M. Install continuous grounding using underground cold-water system and building steel as grounding electrode. Where water piping is not available, install artificial station ground by means of driven rods or buried electrodes.
- N. Permanently ground entire light and power system in accordance with NEC, including service equipment, distribution panels, lighting panelboards, switch and starter enclosures, motor frames, grounding type receptacles, and other exposed non-current carrying metal parts of electrical equipment.
- O. Install branch circuits feeding isolated ground receptacles with separate insulated grounding conductor, connected only at isolated ground receptacle, ground terminals, and at ground bus of serving panel.
- P. Accomplish grounding of electrical system by using insulated grounding conductor installed with feeders and branch circuit conductors in conduits. Size grounding conductors in accordance with NEC. Install from grounding bus of serving panel to ground bus of served panel, grounding screw of receptacles, lighting fixture housing, light switch outlet boxes or metal enclosures of service equipment. Ground conduits by means of grounding bushings on terminations at panelboards with installed number 12 conductor to grounding bus.
- Q. Grounding electrical system using continuous metal raceway system enclosing circuit conductors in accordance with NEC.
- R. Permanently attach equipment and grounding conductors prior to energizing equipment.
- S. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
  - 1. Install bus on insulated spacers 1 inch, minimum, from wall 6 inches above finished floor, unless otherwise indicated.
  - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.

### 3.05 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.
- B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or

handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

- C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.
- D. Pad-Mounted Transformers and Switches: Install four ground rods and a ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install bare copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 24 inches from the foundation. Install a ground rod at each corner of the ground ring.

### 3.06 FIELD QUALITY CONTROL

- A. Division 1 – General Provisions - Field inspecting, testing, adjusting, and balancing.
- B. Inspect and test in accordance with NETA ATS.
- C. Grounding and Bonding: Perform inspections and tests listed in NETA ATS.
- D. Perform ground resistance testing in accordance with IEEE 142.
- E. Perform leakage current tests in accordance with NFPA 99.
- F. Perform continuity testing in accordance with IEEE 142.
- G. When improper grounding is found on receptacles, check receptacles in entire project and correct. Perform retest.

### 3.07 DESIRED GROUND RESISTANCE

- A. The Contractor shall report ground resistances that exceed the following values:
  1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 5 ohms.
  2. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
  3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
  4. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm.
  5. Substations and Pad-Mounted Equipment: 5 ohms.

6. Manhole Grounds: 10 ohms.

END OF SECTION

## SECTION 17400

### INSTRUMENT PANELS

#### PART 1 GENERAL

##### 1.01 SCOPE OF WORK

- A. The Contractor shall furnish, deliver, and install the control panels as shown on the drawings with power supplies, communications equipment, PLC Equipment, prewired termination blocks, incoming power surge suppression, and miscellaneous equipment to provide a fully functional system as shown on the drawings and specified herein.
- B. This section specifies connection wiring within panel and electrical accessories such as switches, pilot lights, relays, terminal blocks, and fuses, which are included in the panel.
- C. All work and products shall conform to the designs shown on the applicable Drawings and shall comply with the provisions of this section. The control panel shall be factory wired. Panels and cabinet shall include all components indicated in the applicable Drawings, required to provide functions as specified in this section. Where specific requirements on the Drawings conflict with general design requirements in this section, the requirements shown on the Drawings shall prevail.
- D. **City of Oklahoma City Utilities Department SCADA Standards included in the Supplemental Special Provisions. Refer to City SCADA Standards section 3.2 for control panel requirements.**

##### 1.02 RELATED WORK (NOT USED)

##### 1.03 SUBMITTALS

- A. General: The Contractor shall provide submittals as defined herein and as required in Section 17000. Submittals shall be required for all equipment supplied. For each panel, the Contractor shall submit a certified factory (shop) test report before panel is shipped.
- B. Elementary Control Diagrams: The Contractor shall provide elementary control diagrams, using the ladder diagram format incorporating line number, operation function statement, contact location line number with an underline for a normally closed contact and a description of operation of each device. Label each contact, coil, and indicator with its function, as well as its number. Show terminals for field wiring. Show field wiring as dashed lines.
- C. Connection Diagrams: Connection diagrams shall show the placement, labeling and wiring of components within panels and cabinets. Components shall be shown arranged in the physical layout (not necessarily to scale) as it would appear to a person servicing the equipment. Wires shall be shown as a continuous line between their termination points. The direction of entry to a wire bundle shall be shown. Wire lists and wireless diagrams shall not be accepted. All additions and deletions of devices



and wires in existing enclosures shall be clearly shown. Each wire label designation shall be shown. The wire label designations on each end of a single wire must be identical. All wire termination point numbers shall be shown. Each wire color shall be shown. Signal and DC circuit polarities shall be shown. All jumpers, shielding and grounding details shall be shown. Wire pairs shall be shown. Spare wires and termination points shall be shown.

#### 1.04 REFERENCE STANDARDS

- A. All materials and workmanship shall conform to the latest published applicable provisions of the following codes and standards:

<i>Standards</i>	<i>Title</i>
NFPA	National Electrical Code (NEC)
ANSI/NEMA ICS 1	General Standards for Industrial Controls and Systems
ANSI/NEMA ICS 2	Industrial Control Devices, Controllers, and Assemblies
ANSI/NEMA ICS 3	Industrial Systems
ANSI/NEMA ICS 4	Terminal Blocks for Industrial Control Equipment and Systems
ANSI/NEMA ICS 6	Enclosures for Industrial Controls and Systems
ANSI/NEMA 250	Enclosures for Electrical Equipment (1000 Volts maximum)
EIA RS-310-C	Racks, Panels, and Associated Equipment
ANSI-C-37.13	Low-Voltage AC Power Circuit Breaker (600 Volt Insulation Class)
ANSI/IEEE	Electrical Isolation for Analog Signal Devices C39.5-1974
NFPA 70E	Standard for Electrical Safety in the Workplace

- B. Unless otherwise specified, electrical equipment and material provided under this contract shall be listed and labeled for the purpose for which it is used by the Underwriters Laboratories, Inc. (UL).
- C. Equipment components and devices shall be UL labeled wherever UL standards exist for such equipment. The completed panel shall be UL Labeled in accordance with UL 508 and 508A and other applicable UL standards. The panel shall also be UL labeled

for the environment in which it is to be placed. A UL label shall be affixed to the inside of the external door by the panel fabrication assembly. Submit a facsimile of the UL label in the submittal information.

#### 1.05 QUALITY ASSURANCE

- A. All equipment and accessories provided shall be the product of a manufacturer regularly engaged in manufacturing of this equipment whose products have been in satisfactory service for not less than three (3) years. Completed panels shall bear the UL label.

#### 1.06 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS (NOT USED)

#### 1.07 DELIVERY, HANDLING AND STORAGE (NOT USED)

#### 1.08 MAINTENANCE/SPARE PARTS

- A. The manufacturer shall provide the specified spare parts and/or tools as detailed below:
  1. Ten relays of each type.
  2. Ten lights of each type.
  3. Ten surge protectors of each type.
  4. Two power supplies of each type used.
  5. Fifty fuses of each type used.
  6. Two panel display of each type.
  7. Two panel heater of each type.
  8. Ten terminal blocks of each type used.
  9. One type of panel-mounted Air Conditional Unit.

#### 1.09 WARRANTY/EXTENDED WARRANTY

- A. The manufacturer shall provide an all-inclusive two (2)-year warranty.

### PART 2 PRODUCTS

#### 2.01 SERVER RACK

- A. SCADA Sever Rack
  1. Server rack shall be compatible with all leading OEM equipment and meets EIA-310-D standards for rack mounting equipment.
  2. Rack shall be 42U with side and back panel. Provide lockable front glass door. Provide two keys.
  3. Manufacturer and product line: Rack Solutions Server Cabinet Enclosures Model 151
- B. Network Panel Rack
  1. Refer 2.02 Control Panel specification.

## 2.02 CONTROL PANELS

- A. Panels shall conform to the layout shown on the Drawings and be sized to accommodate the initial and future Input/Output (I/O) point counts listed shown on the Drawings. Enclosure sizing was based on typical industry-standard equipment. Contractor shall advise the Owner if a larger enclosure is required to meet these I/O counts using the actual equipment to be supplied by the Contractor.
- B. For each PLC CPU, provide a minimum of one spare wired I/O card of each type: analog input (AI), analog output (AO), digital input (DI), and digital output (DO) or twenty percent spare wired I/O for each I/O type whichever greater.
- C. For each PLC remote I/O rack, provide a minimum of one spare wired I/O card of each type: analog input (AI), analog output (AO), digital input (DI), and digital output (DO) or twenty percent spare wired I/O for each I/O type whichever greater.
- D. The Contractor shall generally follow the arrangements of components shown on the Contract Drawings. However, the CONTRACTOR shall make adjustments as necessary to allow each component to be mounted as recommended by the manufacturer, to facilitate easy installation, removal and in-place maintenance of each component, and to allow normal operation of the component by operating and maintenance personnel. Component arrangements shall allow space for routing of wiring without kinking or bending around sharp edges, and for free flow of air around and through equipment, which requires ventilation for cooling.
- E. PLC panels shall be NFPA 70E compliance. Each PLC control panel shall consist of two separate panels: one high voltage panel for voltage above 50 VAC devices and one low voltage panel for voltage equal or below 50 VAC devices.
- F. All control panels containing voltages above 50V shall have an integral method to disconnect power interlocked with the "power" panel door. The disconnect method shall allow the interior of the panel to be accessed in a completely de-energized state. The power portion of the control panel shall be a Hoffman "Sequestr" or approved equal. (This allows for work inside of the panel without the need for Arc Flash PE per NFPA 70e).
- G. Panels shall be assembled together with section open for cables routing. Both high and low voltage shall be same size and same color painted.
- H. All cabinets shall be sized to accommodate the equipment required plus 25% spare space.
- I. Physical and Miscellaneous Specifications

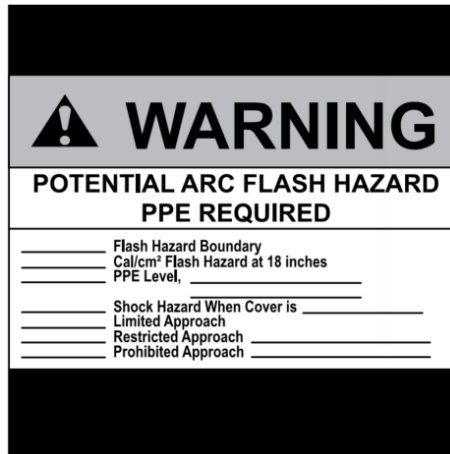
The enclosures shall:

- 1. Be NEMA 4X 316 stainless steel when located in non-air-conditioned, outdoor, or process spaces, with 3-point latching handle.
- 2. Be NEMA 12 steel enclosures when located in air-conditioned spaces, with 3-point latching handle.



3. Contain PLC equipment, surge arresters, circuit breakers, fuses, relays, transformers, terminal strips, nameplates, terminal labels, wire ducts, universal spiral wraps and any necessary parts for a complete system as shown on the drawings and specified herein.
  4. Allow expansion space to accommodate future system needs.
- J. Materials: The enclosure shall be made with 12 gauge minimum metal. Each shall be provided with a full-length interior panel with adjustable mounting on both vertical sides to rails located at the top, bottom, and middle of the enclosure.
- K. Acceptable manufacturers:
1. Hoffman Engineering Company ([www.hoffmanonline.com](http://www.hoffmanonline.com))
  2. The high voltage panel shall be Sequestr Disconnects Enclosure.
  3. **For the low voltage panel, refer to City of Oklahoma City Utilities Department SCADA Standards included in the Supplemental Special Provisions Section 3.2.**
- L. Dimensions: Panels shall be sized as shown on drawings.
- M. Coating
1. Metal surfaces of NEMA 4X Stainless Steel outdoor panels and cabinets shall be prepared, primed and finish coated in accordance with the requirements of this specifications and coating manufacturer's recommendations. Scratches or blemishes in panel faces shall be filled prior to finishing. One coat of primer shall be applied at the manufacturer's recommended dry film thickness and allowed to dry prior to applying the first finish coat. Provide a quart of finish paint from batch used for final finish coat.
  2. Finish coat of NEMA 4X Stainless Steel outdoor panels and cabinets shall be an aliphatic air-dry polyurethane or epoxy panel enamel.
  3. Sub-panel of all panels and cabinets shall be painted Fed. Std. color 27880, white.
- N. Face-Mounted Instrument Reinforcement: Face-mounted devices shall be mounted to panel doors using mounting methods recommended by the component manufacturer with mounting kit parts provided by the component manufacturer specifically for the component. If such a mounting method causes the door to deform or allows the component to sag so as not to be perpendicular to the door surface, then the Contractor shall design and install appropriate reinforcement to prevent these conditions.
- O. Miscellaneous
1. Face-mounted equipment shall be flush or semi-flush, with flat black escutcheons. Cutouts for future equipment and holes resulted from removal of existing devices shall be blanked off with suitable covers as required to retain the cabinet's NEMA rating. Component identification shall be hot ink stamped on the panel interior.
  2. All miscellaneous hardware and fittings shall be stainless steel. Stainless steel shall meet or exceed the corrosive-resistant properties of 316 stainless steel.

- P. Each PLC panel shall provide flash protection boundary warning label and permanently installed in front panel.



## 2.03 NAMEPLATES

- A. Machine engraved, three ply laminated phenolic nameplates shall be provided for all panels and cabinets as shown on the Contract Drawings. Nameplates shall be black with white lettering. Nameplates shall be attached to the panel with a minimum of two self-tapping 316 stainless steel sheet metal screws. The height of each character shall be a minimum of 3/16" except as noted.

## 2.04 PLC PANEL-MOUNTED INDUSTRIAL PERSONAL COMPUTER (IPC)

- A. Provide PLC panel mounted industrial personal computer for PLC-600 panel.
- B. The IPC shall be configured as remote SCADA HMI workstation.
- C. The IPC shall be NEMA 4X panel door mounted industrial PC, 18.5" color touch screen with 1920x1080 resolution, LCD life shall be 50,000-hour backlight Half-Life, 2 Ethernet ports, 8GB memory DDR3.
- D. Operation temperature: 0~50 degree °C.
- E. Windows 10 Profession (64 bit).
- F. 5 year warranty.
- G. Manufacturer and model: Phoenix Contact VL2 PPC 7000.
- H. Spare: one spare unit with all accessories.

## 2.05 WIRING AND ELECTRICAL DEVICES

- A. General: Provide the wiring and electrical devices specified below and install these and internal panel wiring as shown on the Contract Drawings. All spare PLC input/output points shall be wired to terminal blocks with interposing relays and surge protection.

- B. Refer to City of Oklahoma City Utilities Department SCADA Standards included in the Supplemental Special Provisions Section 3.2 for panel devices and wiring requirements.

## PART 3 EXECUTION

### 3.01 TEST REQUIREMENTS

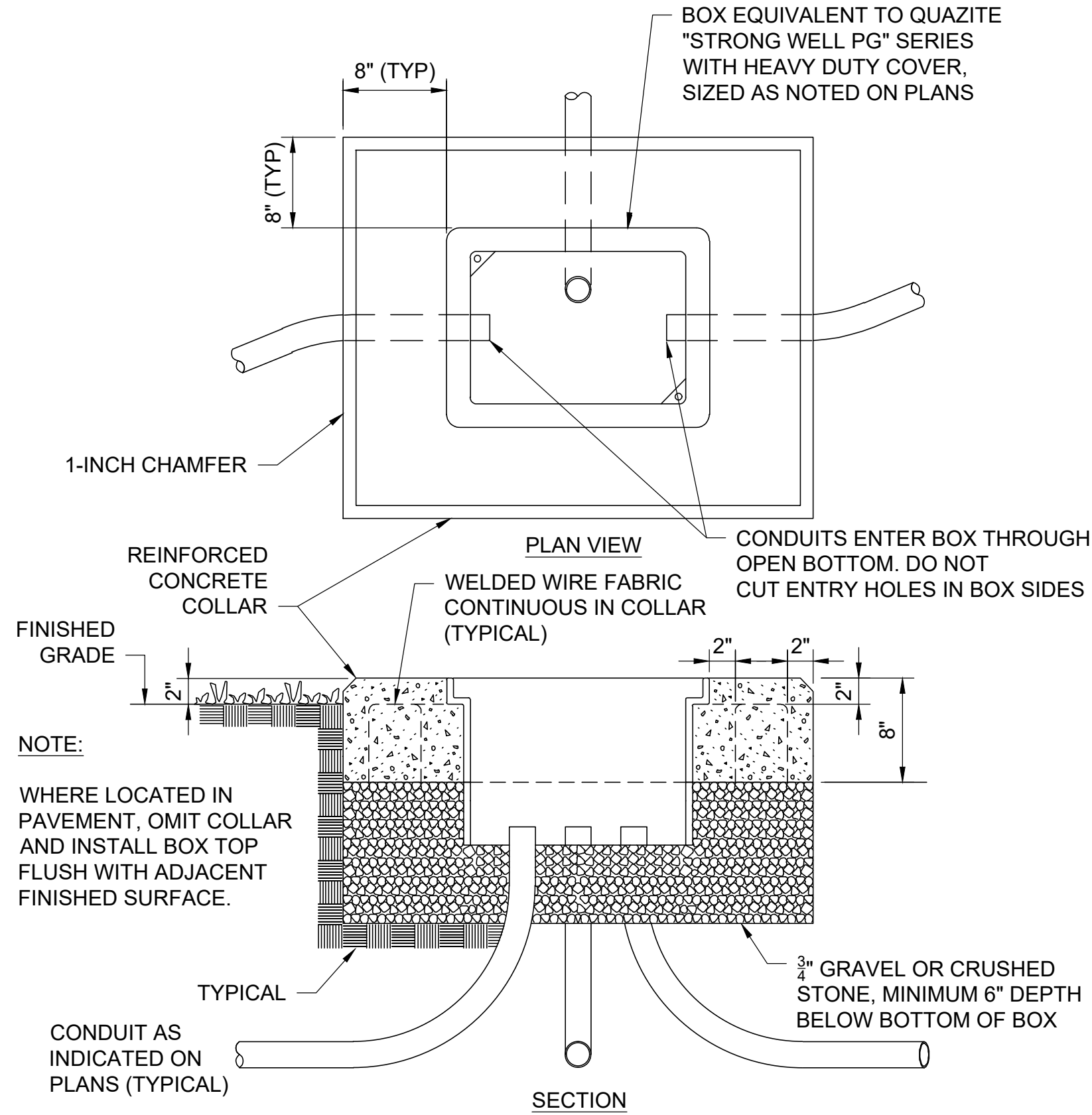
- A. The Contractor shall shop test the panels and correct any defects discovered prior to delivery. These tests shall consist of the following:
  - 1. The Contractor shall verify that each wiring connection is made properly by checking electrical continuity, assuring that connections have less than one Ohm resistance end to end, and that no cross continuity exists between separate circuits.
  - 2. The Contractor shall conduct a test of all power circuits and power supply equipment to verify that proper voltages are delivered and all power supply equipment is operating according to the manufacturer's specifications. These tests shall be witnessed by the Owner's representative. The Contractor shall certify the results in writing to the Owner.
  - 3. The Contractor shall functionally test each electrical device specified in Part 2 below to verify correct operation. The Contractor shall also test each input/output point. Inputs shall be exercised at the location in the panel the greatest distance in the circuit from the PLC chassis and verified through to the PLC processor. Results shall be demonstrated on a programming terminal. Each output shall be exercised from a programming terminal and verified through to the panel location the greatest distance in the circuit from the PLC chassis. At a minimum, analog inputs and outputs shall be tested at 0%, 25%, 50%, 75%, and 100% of range. This test shall be witnessed by the OWNER's representative and the Contractor shall certify the results in writing to the Owner. Test the operator interface unit, including simulated alarm conditions.
  - 4. The Contractor shall test Ground Fault Interrupter (GFI) receptacles and circuit breakers for proper operation by methods sanctioned by the receptacle manufacturer.
- B. Refer to City of Oklahoma City Utilities Department SCADA Standards included in the Supplemental Special Provisions Section 3.2 for panel test requirements.

### 3.02 PANEL INSTALLATION

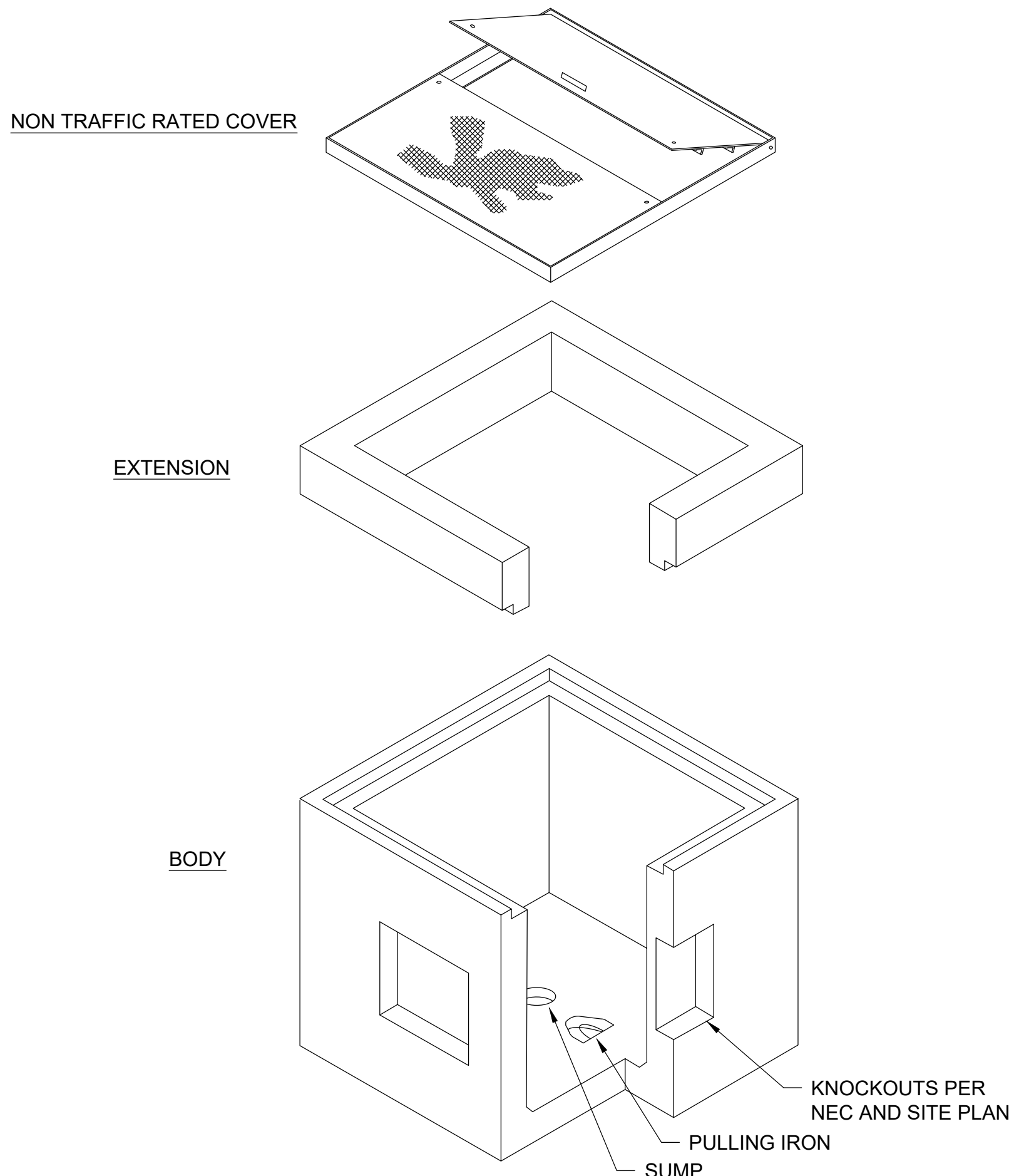
- A. Shop Testing: The Contractor shall coordinate panel delivery with the construction of the control room and panel locations to minimize field handling.

END OF SECTION

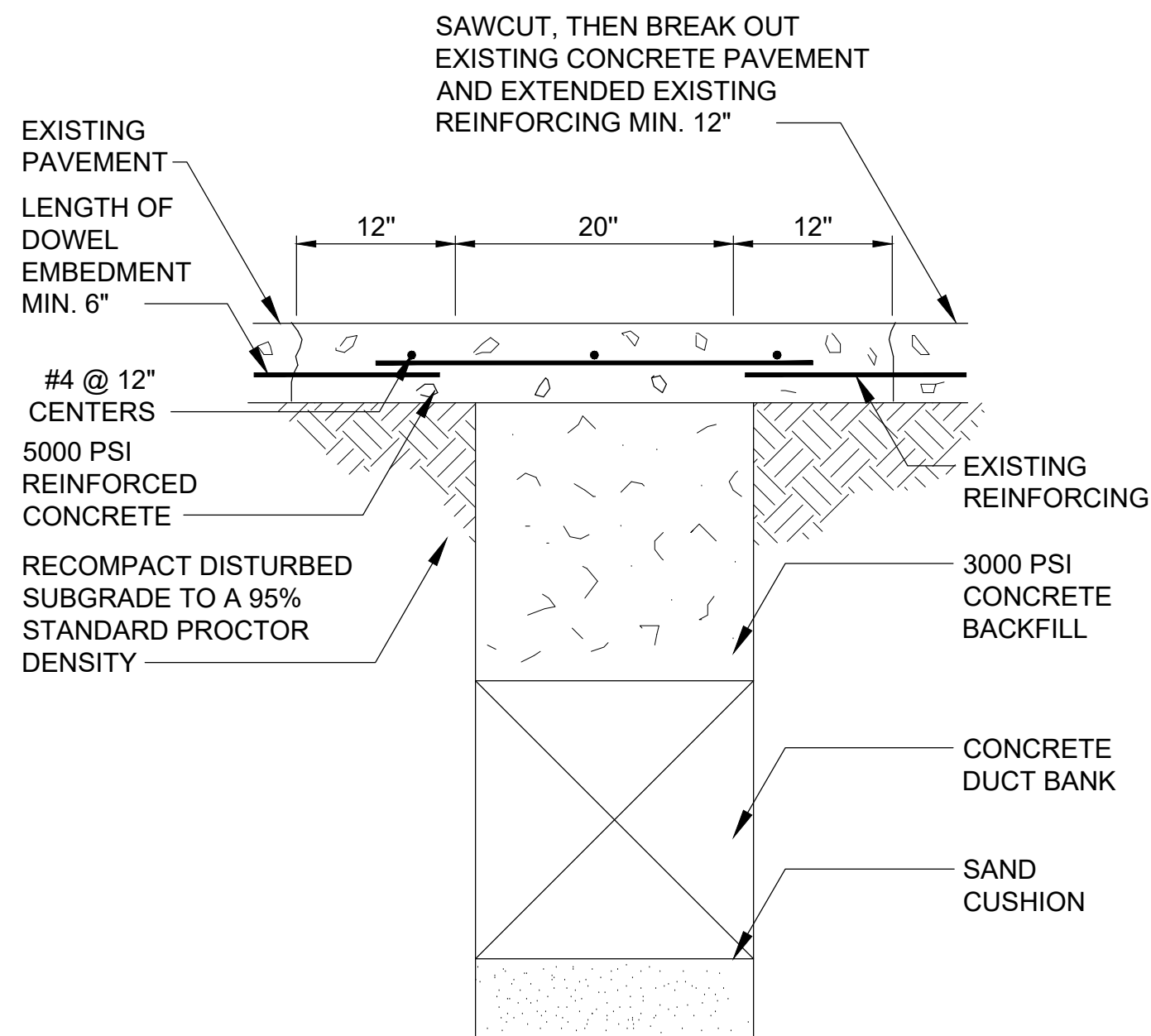
REFERENCES: OKCY14286 - Border\_Base.dwg OKCY14286 - Elec\_Detail\_Base.rvt  
Jul 05, 2022 - 11:31 am \\dalff02\Water\Active\_Projects\OKCY14286\01\8.30 Cut\_Sheets\OKCY14286 E-905 ELECTRICAL UNDERGROUND DETAILS.dwg LAYOUT: E-905 USER:



1 UNDERGROUND CONDUIT DETAIL - TYPICAL  
IN-GROUND ELECTRICAL HAND HOLE (UP TO 17"x30")  
N.T.S.



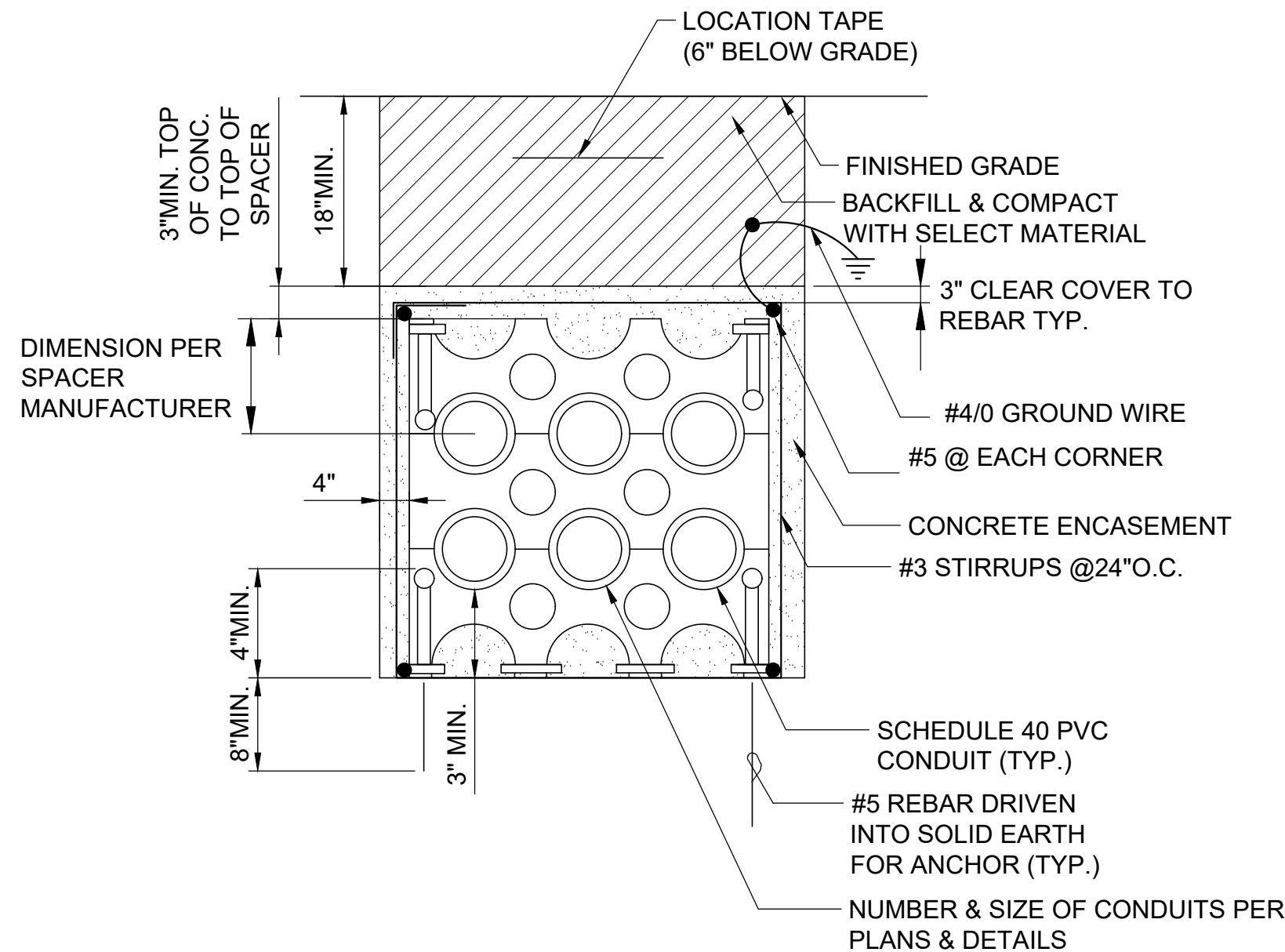
2 3'x3'x4' TO 6'x6'x6' HANDHOLE  
N.T.S.



1 3 SAWCUT DETAIL  
N.T.S.

NOTES:

1. CONCRETE ENCASEMENT: ALL CONCRETE TO HAVE COMPRESSIVE STRENGTH OF 3000 P.S.I. AT 28 DAYS. NO AGGREGATE LARGER THAN 3/4\".
2. INSTALL SPACERS EVERY 8 FEET. ALL SPACERS TO PROVIDE 3\". VERTICAL AND HORIZONTAL SEPARATION BETWEEN CONDUITS. CONDUITS CONTAINING MEDIUM VOLTAGE WIRING SHALL HAVE MINIMUM SEPARATION OF 7.5\" C-C. SPACERS TO BE CARLON SNAP-LOC PLASTIC SPACERS OR EQUIVALENT.
3. INSTALL #5 STEEL REINFORCING RODS THROUGH THE INTERNAL VERTICAL CHANNELS AT BOTH OUTER EDGES OF SPACER AND DRIVE REINFORCING RODS INTO EARTH TO ANCHOR ASSEMBLY.
4. INSTALL #5 STEEL REINFORCING RODS IN EACH CORNER OF THE CONCRETE ENCASEMENT. OVERLAP REBAR MINIMUM 1'-3\" AT EACH END. INSTALL #3 STIRRUPS AT 24\" O.C.
5. TIE HORIZONTAL AND VERTICAL RODS TOGETHER WITH #16 STEEL TIE WIRE.
6. GROUND THE STEEL REINFORCING RODS AT 100 FEET SPANS MAXIMUM. CONNECT TO GROUND CONDUCTOR ON TOP OF DUCT BANK WITH EXOTHERMIC WELD. GROUNDING CABLE SIZE SHALL BE 4/0 BARE COPPER.



1 4 ELECTRICAL CONDUIT SPACER FOR UNDER GROUND DUCTBANK  
N.T.S.

CITY OF OKLAHOMA CITY,  
OKLAHOMA

CP&Y, INC.  
CERTIFICATE OF AUTHORIZATION  
NO. 4008  
EXP. DATE: JUNE 30, 2022

THIS DRAWING IS PART  
OF A LARGER SET.  
REFER TO SHEET G-001  
FOR RESPONSIBLE  
SEALING ENGINEER.

NO. 1 CONTRACT MODIFICATION NO. 1

BY HAJ 7-8-22

VERIFY SCALE 1\"/>

CITY OF OKLAHOMA CITY  
SOUTH CANADIAN WASTEWATER  
TREATMENT PLANT IMPROVEMENTS  
ELECTRICAL UNDERGROUND  
DETAILS I

Date: FEBRUARY 2022

Designed: P. BAZNIK

Drawn: S. CAMPBELL

Reviewed: G. ROBINSON P.E.

CP&Y Proj. No. OKCY14286

SHEET  
E-905





**South Canadian WWTP  
Improvements - 22015SP****22015SP**15924 S. May Ave  
Oklahoma City, OK 73170**Subject:** Stainless Steel Ground Rods**Date:** 7/11/2022**Status:** New**Priority:** Normal**Reason:** Alternate Proposal**Discipline:** Electrical**Reference:**

Cost Effect	Cost Amount	Time Effect	Number of Days	Completed Date
Decrease				

**Author:** Justin Lillie - Crossland Heavy Contractors, Inc.**Response Distribution:****Question**

The original design called for 30' and 60' Stainless Steel Ground Rods. CHC proposes the use of 10' SS ground rods in lieu of the original design per VE Discussions. Please confirm.

Reference VE Engineering Letter 'Exhibit B' Item #5

**Proposed Solution****Response**

The use of 10' SS ground rods is approved. The Contractor will add additional ground rods as necessary to achieve specified ground resistance, and retest ground system (in accordance with 16660 3.06) as necessary. Section 16660 - Grounding and Bonding for Electrical Systems has been updated to reflect this change. Contractor to update record drawings with modification.

Primary Responder	Date Sent	Date Due	Date Responded
Haley Jones, P.E.	7/11/2022		07/13/2022

Digitally signed by Haley Jones, PE  
Date: 2022.07.13 10:37:29-05'00'

**South Canadian WWTP  
Improvements - 22O15SP****22O15SP**15924 S. May Ave  
Oklahoma City, OK 73170**Subject:** Restrained Joint on Low Pressure DIP**Date:** 7/11/2022**Status:** New**Priority:** Normal**Reason:** Alternate Proposal**Discipline:** Mechanical**Reference:**

Cost Effect	Cost Amount	Time Effect	Number of Days	Completed Date
Decrease				

**Author:** Justin Lillie - Crossland Heavy Contractors, Inc.**Response Distribution:****Question**

CHC proposes to remove the Restrained Joints on the Low Pressure P-401 DIP Lines and replace with P-401 Slip Joint Bell & Spigot Pipe with MJ Fittings with restraints. The 30" RJ DIP would remain as RJ due to being a pumped line, CHC is only requesting the change on the RJ on the 36" – 60". Please advise.

Reference Value Engineering Letter 'Exhibit B' Item #13

**Proposed Solution****Response**

The replacement of restrained joints on low pressure P-401 DIP lines with P-401 slip joint bell and spigot pipe with MJ Fittings with restraints is acceptable for DI pipelines 36"-60". For clarification, the referenced 30" RJ DIP downstream of the influent pump station is PVC. Refer to the updated section 15072 - Ductile Iron Pipe and Fittings. Contractor to update record drawings with modification.

Michael F. Graves, PE

Digitally signed by Michael F. Graves, PE  
DN: C=US,  
E=mgraves@cpyi.com,  
OU="CP&Y, Inc.",  
CN="Michael F. Graves, PE"  
Date: 2022.07.15  
08:17:42-05'00'

Primary Responder	Date Sent	Date Due	Date Responded

**South Canadian WWTP  
Improvements - 22O15SP****22O15SP**15924 S. May Ave  
Oklahoma City, OK 73170

<b>Subject:</b>	Stainless Steel Conduit		
<b>Date:</b>	7/11/2022	<b>Status:</b>	New
<b>Priority:</b>	Normal	<b>Reason:</b>	Alternate Proposal
<b>Discipline:</b>	Electrical	<b>Reference:</b>	

Cost Effect	Cost Amount	Time Effect	Number of Days	Completed Date
Decrease				

**Author:** Justin Lillie - Crossland Heavy Contractors, Inc.**Response Distribution:****Question**

CHC is requesting to use PVC Coated Aluminum Conduit in lieu of Stainless Steel Conduit. Please advise.

Reference VE Letter 'Exhibit B' #20.

**Proposed Solution****Response**

Contractor may use PVC coated aluminum conduit in lieu of stainless steel. Contractor to install per with tools specifically designed for PVC coated conduit and take care to prevent damage to coating. Repairs to coating must be made, if damaged, per manufacturer's instruction. Section 16110 - Raceway and Boxes for Electrical Systems has been updated to reflect this change. Contractor to update record drawings with updated conduit type.

Primary Responder	Date Sent	Date Due	Date Responded
Haley Jones			07/13/2022

Digitally signed by Haley Jones, PE  
Date: 2022.07.13 10:49:27-05'00'

**South Canadian WWTP  
Improvements - 22015SP****22015SP**15924 S. May Ave  
Oklahoma City, OK 73170

<b>Subject:</b>	20" Restrained Joint P-401 DI		
<b>Date:</b>	7/11/2022	<b>Status:</b>	New
<b>Priority:</b>	Normal	<b>Reason:</b>	Alternate Proposal
<b>Discipline:</b>	Mechanical	<b>Reference:</b>	

Cost Effect	Cost Amount	Time Effect	Number of Days	Completed Date
Decrease				

**Author:** Justin Lillie - Crossland Heavy Contractors, Inc.**Response Distribution:****Question**

CHC proposes to change RJ P-401 DIP that is less than or equal to 20" to DR 18 RJ PVC as Certa-Lok or Diamond Lok, all piping downstream of pumps shall remain as specified. Please advise.

Reference VE Letter 'Exhibit B' Item #28

**Proposed Solution****Response**

This is acceptable. All below slab process drains and floor drains are to be concrete encased, as called out in the plans. Contractor to update record drawings with modification.

Michael F. Graves, PE

Digitally signed by Michael F. Graves, PE  
DN: C=US,  
E=mgraves@cpyi.com,  
OU="CP&Y, Inc.", CN="Michael F. Graves, PE"  
Date: 2022.07.15 08:20:04-05'00'

Primary Responder	Date Sent	Date Due	Date Responded