Design Criteria for all of the Major Engineering Disciplines
1 PURPOSE AND SCOPE CLARIFICATION

1.1 Purpose

The purpose of this document is to define the criteria, which will form the basis for the detailed design, procurement, construction, and commissioning of the Chula Vista Energy Efficiency Upgrade Project. It is not intended to be an all-inclusive specification, but together with the specifications, drawings, etc. included in the document appendices, will ensure that the plant design, procurement, construction, and commissioning will meet the following goals:

- High level of reliability through component redundancy, quality construction implementation, quality equipment selection, and plant maintainability/operability.
- Maximum operational flexibility as dictated by California’s power market environment.
- Optimize initial capital costs to achieve lowest overall lifecycle costs.
- Efficient operation and maintenance through optimal equipment arrangement, convenient access, and convenient equipment maintenance laydown areas.
- Enhanced plant performance by optimum system and equipment design.
- Utilize safe, competent, and environmentally sound practices.
- To the extent practical, the plant will be constructed of non-combustible materials.
- Follow the requirements of any conditions imposed on engineering and construction activities by permitting authorities.
- Provide comprehensive plant design, construction, and commissioning documents for the Owner’s records.

2 DESIGN BASIS

The Project Technical Requirements provide specific criteria for the Chula Vista Energy Efficiency Upgrade Project, which is to govern the Contractor’s procurement, construction, and commissioning of the Project. These criteria are minimum requirements. Deviations from the Technical Requirements and design basis are at the specific written approval of the Owner.
2.1 Overall Facility Configuration

The project shall be a 2 x 0 x 0 simple cycle facility consisting of two (2) CTG’s.

The CTG’s shall be located outdoors with water proof enclosures provided by the CTG supplier.

The combustion turbine generators utilized shall be General Electric LM6000’s.

The combustion turbines shall be fueled by natural gas only. Three natural gas compressors shall be provided for pressure augmentation.

Power shall be generated in the CTG’s and stepped up through a single three-winding main transformer to the utility grid at 69 kV. Low side generator breakers shall be supplied for both generators.

CTG NOx emissions shall be controlled by dry low-NOx (DLN) combustors or water injection.

The CTG’s shall exhaust to aqueous ammonia type SCR systems for NOx control. In addition, the SCR’s shall each be equipped with a CO catalyst system for the reduction of CO emissions at the stack.

Water of the specified volume and pressure shall be supplied for use as CTG water wash, CTG “SPRINT” water injection for power augmentation, and/or CTG water injection for NOx control. Water treatment shall be accomplished by means of rental demineralizer equipment such as trailers or portable demineralizer skids to supply demineralized water for the plant.

The project shall be designed as an outdoor plant with major equipment located outdoors. The following buildings are included.

- Power Distribution Center (PDC)
- (2) CEMS buildings

Two (2) Continuous Emissions Monitoring systems shall be provided.

The plant shall be designed for an expected reliability of 98% over a 25-year life.

Preliminary Water balances are provided as Figure 2.1-5a and 2.1-5b.

A preliminary overall electrical single line diagram for the plant is provided as Figure 2.1-4.
Site layout and design, including underground utilities, shall be done to accommodate future noise barrier walls along with their foundations, to be located at exhaust duct inlet transition, and all four sides of the gas compressor.

2.2 Operating Mode and Basic Philosophy

- Operational flexibility and high reliability are of paramount importance.
- The plant shall be designed to run on a continuous basis between maximum output and minimum load at which emissions guarantees are met (typically 50% load).
- The plant shall be designed to achieve 10 minute starts, from initiation of starting sequence to full load with SPRINT.
- The plant shall not be designed to generate electricity while isolated from the utility grid. The anticipated amount of operating hours per years is 3,325.
- The BOP shall be designed to support the start up times listed above.
- The plant control system design shall be based on a PLC type system. Separate PLC’s shall be allowed for gas compressors, CEMS, and air compressors.
- The CTG’s and other BOP equipment shall be operated primarily from a work station in the control room.
- The power block shall be designed so that it can be started and operated at any load by a single operator.

2.3 Redundancy in Design

Standby components shall be provided for key auxiliary components that would cause an electrical production shut down by their failure. The stand by component shall be installed and kept in a ready status for immediate service.

<table>
<thead>
<tr>
<th>Component</th>
<th>Number of Components Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Compressors, with inlet scrubber, discharge filter separator and discharge cooler (Part of Owner purchased equipment)</td>
<td>3 – 50% Total Plant</td>
</tr>
<tr>
<td>Fuel Gas Final Filter Separators</td>
<td>1 – 100% Per CT</td>
</tr>
<tr>
<td>SCR Tempering Air Fans (as part of SCR vendor scope)</td>
<td>2 – 100% per SCR</td>
</tr>
<tr>
<td>Station Air Compressors</td>
<td>2 – 100% Total Plant</td>
</tr>
<tr>
<td>Instrument Air Dryers</td>
<td>2 – 100% Total Plant</td>
</tr>
<tr>
<td>Demineralized Water Pumps</td>
<td>2 – 100% Total Plant</td>
</tr>
</tbody>
</table>
### Component | Number of Components Required
--- | ---
Water Treatment Equipment | Space and hookup for two rental units in simultaneous use
Demineralized Water Tank | 1 – 100% Total Plant
Wastewater Sump Pumps | 2 – 100% Per Sump
Emergency Standby Generator | 1 – 100% Total Plant
UPS | 1 – 100% Total Plant
Battery Chargers (BOP, separate from OEM provided battery systems for CTG) | 2 – 100% Total Plant

#### 2.4 Air Emission Limitations

The plant design is based on being able to meet the following proposed emission limits for the CTG/SCR excluding startup and shutdown periods. Final emissions limits for continuous operation, startup and shutdown of the CTG, as well as emissions limits for the emergency generator, shall be defined in the site-specific air permits.

<table>
<thead>
<tr>
<th>Controlled Constituent</th>
<th>Units</th>
<th>SCR Stack Permit Limit for Natural Gas Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx</td>
<td>ppmvd @15% O2</td>
<td>2.5</td>
</tr>
<tr>
<td>CO</td>
<td>ppmvd @15% O2</td>
<td>6.0</td>
</tr>
<tr>
<td>VOC</td>
<td>ppmvd @15% O2</td>
<td>2.0</td>
</tr>
<tr>
<td>NH3 slip</td>
<td>ppmvd @15% O2</td>
<td>5.0</td>
</tr>
<tr>
<td>Particulates (PM10)</td>
<td>lb/hr</td>
<td>5.0</td>
</tr>
</tbody>
</table>

#### 2.5 Fuel Gas

Pipeline-quality natural gas shall be provided by SDG&E, with site-specific tie in points to be determined. The gas piping from the gas utility interconnection point to the generating equipment shall be part of power plant design and construction scope. Natural gas supply parameters are discussed in Section 4, Natural Gas.

#### 2.6 Natural Gas Composition:

See Section 4, Natural Gas for initial natural gas constituent analysis.

#### 2.7 Water Supply

2.7.1 Raw Water Supply

Raw water for each site shall be municipal water obtained from the local water agency. The water analysis details are discussed in Section 5.15.
2.7.2 Sewage Treatment System

See Section 3, Mechanical Systems & Equipment, for a detailed discussion of the Sewage Treatment system.

2.7.3 Plant Wastewater

See Section 3, Mechanical Systems & Equipment, for a detailed discussion of the Plant Wastewater System.

2.7.4 Stormwater Runoff

See Section 3, Mechanical Systems & Equipment, for a detailed discussion about Stormwater Runoff.

2.8 Noise Limits

Project far field noise levels shall meet local ordinance requirements of 60 dBA at the property line of the facility. The Engineer shall incorporate equipment noise mitigation features into the plant design.

2.9 Subsurface Conditions

All relevant Geotechnical Reports are included in Appendix 5.4

IMPORTANT LEGAL LIABILITY CONSTRAINT: No existing hazardous or contaminated material removal is to be included in the Engineering or Construction scope.

2.10 Performance Guarantees

2.10.1 Equipment Performance Guarantees

The Contractor shall conduct Equipment Performance Testing to verify the Facility shall meet the following guarantees when Equipment Performance Tests are conducted pursuant to the requirements of Section 4, Appendix Q, Section 7.

Detailed test procedures shall be developed by the Engineer prior to testing.

- Net Heat Rate Guarantee. The Net Heat Rate shall not be more than 9,773 BTU/kWh HHV, when corrected to design conditions.
- Net Electrical Output Guarantee. The Net Electrical Output of the Facility (per the ASME PTC 46) shall not be less than 92,358 kilowatts, when corrected to design conditions.
- Environmental Compliance Guarantee. The Facility shall comply with emissions guarantees and developed emission test methods during the entirety of Performance
Tests and during the Facility Test on the basis specified in Section 2 – Appendix Q, Sub-section 4.1.5 (“Environmental Compliance Guarantee”).

- Facility Reliability and Availability Guarantee. The Facility Reliability and Availability shall be 100% as determined in accordance with the Facility Reliability Test performed within six months after the date scheduled for Substantial Completion has occurred.

- Start-Up Times as stated in the Section 4, Appendix Q.

- Ramp Rates as stated in the Section 4, Appendix Q.

- Generator Capability as stated in the Section 4, Appendix Q.

- Black Start as stated in the Section 4, Appendix Q.

- Far Field Noise Guarantee. The Facility shall meet the far noise limit listed in Section 2.

- NOx concentration at ground level around the stack shall not exceed (later) average within any one hour time period.

2.10.2 Combustion Turbine Generator Performance

The continuous (base) load capability of each combustion turbine generator at site design conditions shall be 47,192 kW net (at 0.85 power factor lagging to 0.9 power factor leading) electrical power measured at the low voltage side of the generator transformer, after allowing for all coincident auxiliary power requirements for equipment provided under these specifications when firing with either fuel specified. The combustion turbine shall also be designed for peak load operation. Combustion turbine generator performance shall be based on the combustion turbine being in new and clean condition. New and clean condition shall refer to the condition of the combustion turbine prior to the accumulation of 100 fired hours of operation subsequent to initial commercial operation of the unit.

- Performance criteria for generators and excitation equipment shall be as specified in CHUL-1-SP-013001, Technical Specification Aeroderivative Gas Turbine Generator

- Combustion Turbine Generator Load Range and Operating Requirements. Each combustion turbine generator shall be capable of operating at the continuous (base) load at site design conditions for an unlimited time period. Each combustion turbine generator shall be capable of 400 normal cycle starts per year, and 100 fast cycle starts per year.

- Each combustion turbine generator shall be designed for the following maximum starting times, from cold standby to continuous (base) site rated load capability
including purge time and synchronization. Units incapable of being routinely started in the fast cycle mode shall not be acceptable.

**Maximum Allowable Starting Time**

**Normal cycle start**  30 minutes  
**Fast Cycle Start**  10 minutes  

- The maximum allowable starting times specified above shall be based on station power being available to the combustion turbine generator unit for starting.

- Each combustion turbine generator shall operate satisfactorily at 10 percent of the continuous (base) site rated load capability for extended periods of time without structural damage to the unit.

- Each combustion turbine generator shall operate satisfactorily, and without structural damage to the unit, in daily load swings from 10 percent of the continuous (base) site rated load capability to the full continuous (base) site rated load capability of the unit.

- Each combustion turbine generator shall be capable of operating across the full range of ambient conditions specified under Part 4 Appendix 4 SITE DATA herein.

- Each combustion turbine generator shall be capable of operating with the specified fuel at the site rating load capability with oxides of nitrogen emissions not exceeding the following stated values with 15 percent O2 with heat rate correction measured at the exhaust stack.

<table>
<thead>
<tr>
<th>Ambient Conditions</th>
<th>Case # 100</th>
<th>Case # 101</th>
<th>Case # 102</th>
<th>Case # 200</th>
<th>Case # 201</th>
<th>Case # 202</th>
<th>Case # 300</th>
<th>Case # 301</th>
<th>Case # 302</th>
<th>Case # 400</th>
<th>Case # 401</th>
<th>Case # 402</th>
<th>Case # 500</th>
<th>Case # 501</th>
<th>Case # 502</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Bulb, °F</td>
<td>75.0</td>
<td>75.0</td>
<td>75.0</td>
<td>69.0</td>
<td>69.0</td>
<td>69.0</td>
<td>111.0</td>
<td>111.0</td>
<td>111.0</td>
<td>29.0</td>
<td>29.0</td>
<td>29.0</td>
<td>63.8</td>
<td>63.8</td>
<td>63.8</td>
</tr>
<tr>
<td>Wet Bulb, °F</td>
<td>65.3</td>
<td>65.3</td>
<td>65.3</td>
<td>60.1</td>
<td>60.1</td>
<td>60.1</td>
<td>71.2</td>
<td>71.2</td>
<td>71.2</td>
<td>25.4</td>
<td>25.4</td>
<td>25.4</td>
<td>58.4</td>
<td>58.4</td>
<td>58.4</td>
</tr>
<tr>
<td>Altitude, ft</td>
<td>54.0</td>
<td>54.0</td>
<td>54.0</td>
<td>60.0</td>
<td>60.0</td>
<td>60.0</td>
<td>70.0</td>
<td>70.0</td>
<td>70.0</td>
<td>70.0</td>
<td>70.0</td>
<td>70.0</td>
<td>70.0</td>
<td>70.0</td>
<td>70.0</td>
</tr>
<tr>
<td>CO ppmvd Ref 15% O2</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>10</td>
<td>10</td>
<td>15</td>
<td>6</td>
<td>6</td>
<td>9</td>
<td>41</td>
<td>39</td>
<td>44</td>
</tr>
<tr>
<td>HC ppmvd Ref 15% O2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>NOx as NO2, lb/hr</td>
<td>41.4</td>
<td>33.0</td>
<td>24.9</td>
<td>42.3</td>
<td>33.0</td>
<td>24.9</td>
<td>40.0</td>
<td>32.0</td>
<td>26.0</td>
<td>28.0</td>
<td>30.0</td>
<td>26.0</td>
<td>28.0</td>
<td>30.0</td>
<td>26.0</td>
</tr>
<tr>
<td>CO, lb/hr</td>
<td>8.15</td>
<td>6.40</td>
<td>7.00</td>
<td>10.38</td>
<td>8.43</td>
<td>9.22</td>
<td>6.00</td>
<td>4.66</td>
<td>5.39</td>
<td>42.68</td>
<td>32.09</td>
<td>27.77</td>
<td>11.07</td>
<td>9.15</td>
<td>9.97</td>
</tr>
<tr>
<td>CO2, lb/hr</td>
<td>53,169.28</td>
<td>42,359.82</td>
<td>32,228.37</td>
<td>54,132.60</td>
<td>42,996.42</td>
<td>32,638.62</td>
<td>51,312.84</td>
<td>41,125.66</td>
<td>31,389.44</td>
<td>55,751.14</td>
<td>44,238.54</td>
<td>33,656.86</td>
<td>54,512.59</td>
<td>43,426.23</td>
<td>32,902.41</td>
</tr>
<tr>
<td>SO2, lb/hr</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Natural gas firing NOx Emission Limit:  25 ppmvd

- Carbon monoxide (CO) emissions from the project site shall be limited to allow for the maximum daily hours of operation for the combustion turbines, CO emissions from each combustion turbine when operating at the continuous (base) site rating load.
2.10.3 Combustion Turbine Performance Guarantees

Each combustion turbine generator shall operate safely, reliably, and without undue maintenance or operator attention.

- **Combustion Turbine Generator Performance Guarantees.** The performance guarantees for each combustion turbine generator shall be as specified herein.

- **Load Change Operation.** Each combustion turbine generator shall be guaranteed to operate satisfactorily, and without structural or mechanical damage to the unit, in daily load swings from 10 percent of the continuous (base) site rated load capability to the full continuous (base) site rated load capability of the unit at the rate of load change stated in the Proposal Data. The turbine generator unit shall be guaranteed to operate satisfactorily without damage to the unit and to retain power supply to the plant auxiliaries in the event of a sudden load loss.

- **Noise Limits.** The noise emanating from each combustion turbine generator at all capacity levels shall not exceed the limits specified herein under Technical Specification Aeroderivative Gas Turbine Generator, CHUL-1-SP-013001, over specified operating range and operating requirements.

- **Exhaust Emissions.** The exhaust smoke produced when operating at the guaranteed continuous (base) site rated load capability, at the guaranteed heat rate, with each specified fuel shall not exceed the limits specified herein.

- The NOx emissions shall not exceed the values specified herein when operating at the guaranteed continuous (base) site rated load capability, at the guaranteed heat rate, with each specified fuel.

- The CO emissions shall not exceed the values specified herein when operating at the guaranteed continuous (base) site rated load capability, at the guaranteed heat rate, with each specified fuel.
• The UHC emissions shall not exceed the value specified herein when operating at the guaranteed continuous (base) site rated load capability, at the guaranteed heat rate, with each specified fuel.

• The PM10 emissions shall not exceed 5 lbs/hr when operating at the guaranteed continuous (base) site rated load capability, at the guaranteed heat rate, with each specified fuel.

2.10.4 Auxiliary Equipment Guarantees.

In addition to the guarantees specified in this section, individual equipment guarantees shall be met as specified in the respective technical sections of these specifications

2.11 Electrical / Communication Interconnection

2.11.1 Permanent Electric Power Export and Backfeed

The facility shall be connected to the electric utility system through high voltage (HV), circuit breakers and disconnect switches located adjacent to the associated GSUT. During facility startup and shutdown, the power required for the facility electrical auxiliary systems shall be backfed from the utility system through the GSUT.

The utility design electrical interface parameters are as follows:

• Utility voltage variation maximum +/-5 percent of nominal kV.
• Utility available short-circuit is (later) kA.

2.11.2 Temporary Power for Construction and Start-up Electric Power

Temporary power shall be arranged by the Contractor to meet construction needs including service to Owner’s, Contractor’s, Vendor’s, Engineer’s, and Sub-Contractor’s Offices, plus power for start-up loads until backfeed is available. The Contractor is responsible for the entire temporary power system design, supply, installation, safety inspection, maintenance, and removal. The construction power supply will not be converted to a permanent alternate source.

2.11.3 Stand-by Electric Power

Stand-by electric power of 450 kW capacity shall be provided in the form of a diesel driven Emergency Generator. The generator shall be connected via a dedicated circuit breaker to the plant 480V switchgear.

2.11.4 Communications

Telephone and communication links between the facility and utility, the fuel supplier, and other outside parties will be provided by Owner. Appropriate interface will be provided
in the final Plant Design. Project-specific interconnect communications are required to the following entities:

<table>
<thead>
<tr>
<th>Entity (check all that apply)</th>
<th>Link type &amp; quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Transmission Provider (Interconnect Utility)</td>
<td>One T-1 line and one dial-up line</td>
</tr>
<tr>
<td>Regional Transmission System Operator (ISO)</td>
<td>TBD</td>
</tr>
<tr>
<td>Fuel Gas Supplier(s)</td>
<td>TBD</td>
</tr>
<tr>
<td>Temporary Telephone for Owner and Contractor(s)</td>
<td>50 Pair and One T-1</td>
</tr>
</tbody>
</table>

Refer to Section 4.19 for further detail on communications.

2.12 Codes, Standards, and Specifications

The building code for the project location is the 2001 version of the California Building Code.

The following codes, standards, and specifications of U.S. organizations shall be consulted to establish a basis for quality and safety in facility design and operation. Systems and equipment shall be designed in accordance with the latest edition and addenda in effect at the date of contract execution, unless noted otherwise:

AASHTO American Association of State Highway and Transportation Officials
AFBMA Anti-Friction Bearing Manufacturers Association
ACI American Concrete Institute
AMCA Air Moving and Conditioning Association
AGMA American Gear Manufacturers Association
AISC American Institute of Steel Construction
AISI American Iron and Steel Institute
ANSI American National Standards Institute
API American Petroleum Institute (Applicable sections shall be referenced)
ASCE American Society of Civil Engineers
ASHRAE American Society of Heating, Refrigeration and Air Conditioning Engineers
ASME American Society of Mechanical Engineers
ASNT American Society for Nondestructive Testing
ASTM American Society for Testing and Materials
AWS American Welding Society
AWWA American Water Works Association
CBC California Building Code
CMAA Crane Manufacturers Association of America
CTI Cooling Technology Institute
EJMA Expansion Joint Manufacturing Association
FM Factory Mutual (Applicable sections shall be referenced)
HEI Heat Exchange Institute
Design specifications and construction of the Project shall also be in accordance with all applicable local, state, and federal laws, including but not limited to those set forth below.

- Comprehensive Environmental Response, Compensation, and Liability Act of 1980
- Clean Air Act and Amendments
- Environmental Protection Agency Regulations
- Federal Aviation Administration Regulations
- Federal Energy Regulatory Commission Regulations
- Federal Power Act
- Noise Control Act of 1972
- Occupational Safety and Health Act
- Occupational Safety and Health Standards
- Resource Conservation and Recovery Act (RCRA)
- Safe Drinking Water Act
- Solid Waste Disposal Act
- Superfund Amendments and Reauthorization Act of 1988
- Toxic Substances Control Act
In the event conflicts arise between the codes, standards of practice, specifications or manufacturer recommendations described herein and codes, laws, rules, decrees, regulations, standards, etc., of the locality where the equipment is to be installed, the more stringent code shall apply.

2.13 **Banned Materials**

No materials or products containing the following materials are allowed in the project:

- Asbestos
- PCB’s
- Hexavalent Chrome
- Mercury (Exception: A limited number of mercury tube level switches may be supplied)

### 3 **CIVIL/STRUCTURAL/ARCHITECTURAL FEATURES**

This section describes the civil, structural, and architectural design basis for the facility’s structures, and general civil work. All civil/structural work shall be designed in accordance with applicable codes, industry standards, and local, state, and federal regulations. All required local building permits and inspections shall be obtained by the Contractor.

#### 3.1 **Facility Description**

The plant complex shall consist of the CTG’s, transformers, high voltage equipment, BOP equipment, power distribution centers, water treatment trailer area, miscellaneous enclosures, utility racks, and access platforms.

The CTG shall not be enclosed in a building. Grading of the finished site shall be as indicated on the General Arrangement drawing provided as Figure 2.1-1. The project shall include a perimeter fence around the site. Main access to and from the site shall be by the paved main entrance road.

#### 3.1.1 **Plant Layout and Access**

The facility shall be laid out to accommodate the spaces required to service equipment as well as to maintain and operate the plant. Access aisles and clearance shall be provided for safe operation, maintenance, inspection, and equipment removal. Provisions shall be made for personnel walkways including, doors, stairs, landings, ladders, and other approved access means.
Personnel and plant maintenance equipment access to plant equipment, piping and their related features shall include the following:

- In plant equipment areas, personnel access aisles for operation and maintenance activities shall nominally be 4'-0” wide and 7'-6” high.

- The plant shall be subdivided into separate fire areas as determined by a Fire Risk Evaluation for the purpose of limiting the spread of fire, protecting personnel, and limiting the resultant consequential damage to the plant. Fire areas should be separated from each other by fire barriers, spatial separation, or other approved means.

- The plant shall be arranged to facilitate the economic performance of maintenance activities with appropriate use of:
  - Mobile Cranes
  - Forklifts
  - Monorails

- Adequate clear space shall be provided above equipment to ensure that foundation bolts or other devices do not obstruct removal.

- Plant fire protection and life safety features shall be considered in the plant layout and be designed in accordance with local codes, permits, and insurance requirements.

- Location of natural gas relief valves, any potential chemical releases, and significant heat rejection to ambient air shall be separated from CT and generator air intakes.

- A plant grid shall be established that makes 10,000 (N), 5,000 (E) equate to the centerline of the exhaust stack. Plant “called” North shall be in-line with the CT power train in the direction closest to the “true” North. An elevation of 100.00 shall be established for the top of the CT foundation. This requirement applies to all design disciplines except Civil. The civil drawings (site grading, erosion control, roads, storm drainage piping and facilities, and offsite discharge lines) shall use the actual site datum.

### 3.2 Sitework

Clearing, excavation, backfill, and grading shall be performed as required to construct the facility and achieve finished site grades as described in this section.
3.2.1 Surveying

Owner will establish a permanent construction base line grid system for both horizontal and vertical control. The Engineer shall include a plan sheet within the civil drawings that shows how the plant coordinates relate to real coordinates and elevations. All calculations and baseline information shall be included on this sheet. The Contractor shall maintain the control points to provide basic measurement control for the project during construction. The Contractor shall be responsible to do all necessary staking and engineering services to layout and control the work to the elevations, lines, and dimensions shown on the plans.

3.2.2 Site Clearing

The site shall be cleared of trees, shrubs, and vegetation to the extent necessary to construct the facility. The Contractor shall dispose of waste materials in an environmentally acceptable and approved manner. The Engineer shall make provisions for special features (i.e., trees, monuments, or other items) that are to remain and be protected during construction as identified by Owner.

3.2.3 Excavation

Excavation work shall consist of the removal of earth, sand, gravel, vegetation, organic matter, rock, boulders, and debris to the lines and grades necessary for construction.

Materials suitable for backfill shall be stockpiled at designated locations using proper erosion protection methods. Disposal of any excess uncontaminated backfill material shall be the Contractor’s responsibility.

Contractor shall provide dewatering of excavations when necessary to support construction activities.

3.2.4 Backfilling

Backfilling shall be done in uniform layers of specified thickness. Soil in each layer shall be properly moistened to obtain its specified density. To verify compaction, representative field density and moisture-content tests shall be taken during compaction as described in Section 2.6 Testing.

Structural fill supporting foundations and other critical structures, and general site fill shall be compacted in accordance with the criteria specified by the Engineer based on the Geotechnical Investigation Report.
3.2.5 Grading

Site grading design shall comply with applicable land development regulations. Graded areas shall be smooth, compacted, free from irregular surface changes, and sloped to drain. Final earth grade adjacent to equipment and buildings shall be below finished floor elevations and shall be sloped away from foundations as necessary to maintain proper drainage.

Prior to any further construction all graded areas under roadways, foundations, or other supportive areas shall have a compacted subgrade consisting of at least the top 6 inches scarified and compacted to 95% of the maximum density based on the modified proctor test (ASTM D-1557) density. Backfill for all embankments, non-supportive and unpaved areas shall be compacted to at least 90% of the maximum density based on the modified proctor test (ASTM D-1557) in 6-inch lifts, except trench fill and fill beneath roads shall be compacted to 95% of the maximum density based on the modified proctor test (ASTM D-1557).

3.2.6 Erosion Control

During project construction, erosion and sediment control measures shall be implemented by the Contractor to prevent sediment-laden runoff from leaving the site. An Erosion and Sediment Control Plan shall be developed by the Engineer in conjunction with the Stormwater Management Plan developed by the Engineer for the construction phase of the project. During this phase, the constructed stormwater management basin shall be used as a sediment basin. Construction runoff shall be directed to this basin where sediment will settle out before being discharged off site. In addition to the sediment basin, the plan shall include the incorporation of silt fencing, straw bale dikes, storm inlet protection, swales, piping, and other measures to promote sediment and erosion control. The Contractor shall prepare a final version of these plans based on the preliminary plans submitted by the applicant to the city official/CBO.

3.2.7 Stormwater Management

A Stormwater Management Plan shall be developed by the Engineer for the final stabilized site. The intent of the stormwater management plan shall be to preserve the existing pre-development drainage patterns to the extent possible. The plan shall include a stormwater collection system consisting of a detention/retention facility, swales, ditches, culverts, catch basins, and piping.

3.2.8 Roads and Parking

Asphalt site roads and parking shall be provided for access, operation and maintenance as shown on the General Arrangement provided as Figure 2.1-1. Alternative access, if required by local regulations, shall be provided as shown on the General Arrangement provided as Figure 2.1-1.
3.2.9 Site Area Paving

Areas within the power block shall be surfaced with concrete or gravel as shown on the General Arrangement provided as Figure 2.1-1. All roads shall be paved with asphalt unless specifically shown otherwise on the General Arrangement. Asphalt shall be a minimum of 4 inches thick and shall be placed in no less than 2 lifts. A minimum of 6 inches of 1.5 inch clean, uniformly graded, crushed stone over a geotextile fabric shall be used in areas so designated on the General Arrangement drawing (provided as Figure 2.1-1). **Local conditions may warrant the crushed stone layer to be thicker than 6”, but in no case shall it be greater than 10 inches.** Concrete aprons shown in the crane lift areas of the combustion turbines shall be designed to support the crane loads during maintenance activities.

Site roads shall be provided that conform to the following:

- Operating speed of 10 miles per hour.
- Minimum road width of 20 feet, with 2-foot shoulders.
- Minimum radius of curvature of 50 feet (centerline) unless restricted.
- AASHTO HS-20-44 loading conditions (minimum requirement).
- Maximum longitudinal slope of 5 percent (except as required for short distances for site entrance and exit roads in which case 8% shall not be exceeded).
- Maximum transverse gradient of 2 percent.
- The road to the CT Generator from the plant loop road shall be flat (0% slope) for a minimum distance of 70 feet from the face of the generator.

3.2.10 Wetlands Protection

The Contractor shall comply with requirements specified by any laws, codes, and permits.

3.2.11 Landscaping and Fencing

Any detailed landscape design, fine grading, furnishing and placement of trees, shrubbery, and/or grass, will be provided by Owner. Any embankment area around the perimeter of the power block and any unpaved areas on site shall be gravel.

Contractor shall hydoseed and restore to its original contours any offsite area that is disturbed during construction.

Contractor shall furnish and install a single chain-link fence (8 feet of fabric topped with three strands of barbed wire angled outward) around the site boundary, with a single 24-
A foot-wide automatic slide main gate, with a keypad for vehicle use, located at the main entrance. One manually operated vehicle gate located at another access point around the site shall also be provided if an additional vehicle entrance is shown on the Site General Arrangement. See Section 4.0 for additional security and access control measures and equipment. The centerline of fence shall be at least 6” inside of the property line to assure construction on Owner’s property.

3.3 Civil/Structural Design Requirements

3.3.1 Geotechnical Report

The Geotechnical Report(s) to be utilized in the project design are as specified in Appendix 5.4.

3.3.2 Codes and Standards

The governing building code identified in Section 1.11 and local/state-building codes shall be incorporated into the design of buildings and structures. Steel structures shall be designed in accordance with the design specifications for structural steel buildings published by the American Institute of Steel Construction (AISC). Reinforced concrete structures shall be designed in accordance with the design requirements for concrete buildings and structures published by the American Concrete Institute (ACI).

Allowable variances and applicable local code interpretations shall be established before project commencement.

Additionally all plant areas and structures shall be designed and configured to meet OSHA requirements contained in Part 1910 of the U.S. Code of Federal Regulations.

3.3.3 Combustion Turbine Support Structure

The combustion turbine support foundation shall be designed in accordance with the manufacturer’s recommendations and the Geotechnical Report. Both static and dynamic loading criteria set forth by the manufacturer shall be considered. Site specific seismic and wind conditions shall be reviewed and compared to the seismic and wind conditions that govern the manufacturer’s loading criteria. The Engineer shall factor the manufacturer’s loads if applicable. In general, the structure shall be a reinforced concrete mat foundation to support the equipment anchorages.

3.3.4 SCR Structure

The SCR structures and related equipment shall be supported on reinforced concrete mat foundations. Foundation loads shall be supplied by the SCR manufacturer. The design shall be based on the final Geotechnical Report.
3.3.5 Tank Foundations

The cylindrical vertical tanks shall be supported on suitable foundations consisting of a ring-wall foundation or a mat foundation depending on the size of the tank.

3.3.6 Transformer Foundations and Protection

Transformer foundations shall be designed and constructed in accordance with manufacturer’s recommendations.

Spill containment shall be provided for the generator step-up transformer and unit auxiliary transformers, and shall be topped with galvanized steel grating. Reinforced concrete retention pits, with a low point sump, shall be provided for the transformers and shall be sized to contain at least the full oil volume of the transformer. Transformer firewalls shall be provided between oil-filled transformers and adjacent structures and equipment as required. The walls shall be constructed of reinforced concrete. The transformer pits shall have a manually operated outlet valve and drain line routed to the oily water separator. The valve shall be a PIV type, but of a different color than fire system PIVs to provide needed differentiation.

Smaller (oil volume < 500gals) oil filled transformers shall be located in bermed areas to facilitate containment of any oil. The bermed area shall be of sufficient volume to contain 110% of the transformer oil volume. The height of each berm shall be limited to 8 inches. A valved drain shall be located in the berm wall to allow drainage of rain and ground water from the bermed area. The drain shall lead to the OWS sump.

3.3.7 Stack

Self-supporting steel stacks and platforms shall be provided adjacent to each SCR. The stacks shall be supported by a reinforced concrete foundation. If required, precast concrete piles or other equally suitable pile design shall be utilized only if specified in Section 1.

3.3.8 Spill Containment Structures

Spill containment structures shall be provided for any chemical injection skid and chemical storage areas including the ammonia storage tank. Chemical injection and storage areas shall have local containment designs without means for drains to external sumps, however these shall include a sump area 24” x 24” x 12” deep. Spill containment at the chemical unloading areas shall be provided to contain small spills at hose connection points.

Containment areas shall be adequate for the particular fluids being contained, and provide retainage capacity for 110% of the maximum storage. The ammonia unloading area shall be bermed.
A berm (for containment) shall enclose the area comprising the CT auxiliary skid. The containment design shall include a sump and drain line to the OWS Sump.

3.3.9 Loads and Load Combinations

**Dead Loads**

Dead loads shall consist of the weight of all permanent construction including, but not limited to, fixed equipment, framing, piping, floors, walls, roofs, partitions, stairs, ductwork, cable tray, and any other structures, contents of tanks, bins, etc.

**Live Load**

Live load is the load superimposed by facility use. It does not include wind load, snow load, earthquake load, or dead load. The minimum live load design basis shall be as follows:

- **Platforms and walkways**
  - Uniform Load, 60 pounds per square foot
  - Concentrated Load, 1,000 pounds on support beams

- **Stairs**
  - Uniform Load, 100 pounds per square foot
  - Concentrated Load, 1,000 pounds on support beams

- **Equipment and piping (other than dead load)**

- **Supports for equipment and members to which supports are attached shall, as a minimum, be designed for the following load cases:**
  - Normal operating loads of equipment (excess over dead load)
  - Test loads of equipment and piping (excess over dead load). Supports for equipment and piping may be stressed to 1.2 times the allowable under hydrotest loads.
  - Thermal force caused by thermal expansion of equipment and piping under all operating conditions.

**Dynamic loads**

These loads shall be considered and applied in accordance with the manufacturer’s specifications, criteria, or recommendations, and industry standards. Rotating parts shall be considered as a vibrating mass.
Vehicle loads

Underground piping, conduits, trenches, sumps, and foundations accessible to truck traffic shall be designed for HS-20-44 truck wheel loads per the AASHTO Standard Specification for Highway Bridges.

Seismic loads

All equipment shall be designed to withstand the seismic loading requirement specified in the governing building code for the seismic zone defined in Section 1.

In addition, equipment anchorages and supports shall be designed to prevent overturning, displacement and dislocation in accordance with governing building code requirements. Piping, cable tray and ductwork shall be investigated to determine if stops or other restraints are required.

Wind Loads

Wind pressures and shape factors shall be applied to all system components and exposed equipment in accordance with governing building code.

Allowances shall not be made for the effect of shielding by other structures.

The overturning moment calculated from wind pressure shall not exceed two thirds of the dead load resisting moment. The uplifting forces calculated from the wind pressure shall not exceed two-thirds of the resisting dead loads and adequate structure-foundation ties shall be designed to resist wind forces.

Other Loads

Other expected loads (water hammer, dynamic loads from operating equipment, system modulation, etc.) required to predict the response of structures shall be considered where appropriate.

Proper load combinations shall be used for structural steel and reinforced concrete to comply with applicable codes and standards and with vendor requirements.

3.3.10 Structural Steel

Structural steel shall conform to ASTM A 36, ASTM A 992, ASTM A 572 Grade 50, or other materials as required and accepted by AISC, and shall be detailed and fabricated in accordance with the AISC Code of Standard Practice and the AISC Specification for Structural Steel Buildings.

High-strength bolts shall conform to ASTM A 325 or ASTM A 490. Other bolts shall conform to ASTM A 307, Grade A. All bolts shall be resistant to rusting for a minimum of 30 years.
Nonheaded anchor bolts shall conform to ASTM A 1554 Grade 36, unless higher strength bolting materials are required by design. Exterior exposed anchor bolts that are not high-grade fine thread shall be hot-dipped galvanized.

Welded structural members shall meet the requirements of AWS D1.1.

All outdoor structural steel shall be hot-dipped galvanized. Galvanizing shall be in accordance with the requirements of ASTM A 123, ASTM A 153, and/or ASTM A 653. Galvanized nuts and bolts shall conform to ASTM B 695.

3.3.11 Steel Grating and Steel Grating Stair Treads

The steel to be used for grating and grating treads shall conform to either ASTM A 36 or ASTM A 570.

Stair treads shall have non-slip abrasive nosings. The treads shall have end plates for attaching to stringers.

Grating shall be rectangular and consist of welded steel construction. Grating shall be hot-dipped galvanized after fabrication in accordance with ASTM A 123. All grating ends and openings larger than 8” shall be banded. Grating in the areas subject to chemical attack shall be fiberglass for walking surfaces, and cast or ductile iron with epoxy coated imbeds for trench grating (i.e. ABT Trench Systems).

Floor or platform openings around the exhaust duct, pressure vessels, piping, and equipment necessitated by expansion and movement requirements shall be protected in accordance with OSHA standards, as applicable. One such requirement is that the largest allowable gap shall be four (4) inches between the floor or platform opening and the structure.

3.3.12 Stairs and Ladders

Stairs shall be provided between varying elevations. Vertical ladders may only be used where personnel access is infrequent.

Safety cages and/or other devices shall be provided for fixed ladders as required by applicable codes and regulations. At a minimum, ladders that may expose a person to a fall of greater than twenty (20) feet shall have a cage.

Gates shall be installed as fall protection to protect all ladder openings. The gates shall fall into two categories: a single bar gate and a gate that is equal to a guardrail (i.e. top rail, mid rail and equal strength).

A single bar gate may be used:

For offset platforms between fixed ladders used only for passing through (not a work area).
Caged ladders to a pass through area.

A guardrail equivalent gate is required as follows:

- A work platform that is accessed by a fixed ladder without a cage must be guarded by a guardrail or gate equivalent to a guardrail system so offset that a person cannot walk directly into the opening.

- A work platform this is accessed by a floor opening ladder way must be protected on all sides except that a gate equivalent guardrail system may be used.

- An open sided work platform that is accessed by a caged fixed ladder on the side of the platform, where the ladder’s cage is at least as high as the guardrail system protecting the work platform, must have a guardrail equivalent gate.

Stairs, ladders and safety cages shall be hot dipped galvanized. Ladder rungs shall be of a non-slip design.

3.3.13 Structural Concrete

Concrete shall comply with ACI 301 and ASTM C94. Materials shall be handled and stored as recommended in ACI 304. Mixes shall be formulated to produce durable concrete of the required strength for the anticipated exposure conditions.

Admixtures may be added at the discretion of the Contractor with the consent of the Engineer, provided that qualifying mix designs are made accordingly.

Where concrete is to be placed by pumping, special consideration shall be given to the concrete mix to provide workability, quality, and strength required for the pumping operation.

Calcium chloride or admixtures containing calcium chloride shall not be used.

3.3.14 Reinforcing Steel

Concrete reinforcing shall be deformed bars of intermediate grade, billet steel conforming to ASTM A 615, Grade 60. Welded wire fabric shall conform to ASTM A 185.

3.3.15 Concrete Finishing

Permanently exposed vertical concrete surfaces shall receive a “smooth form finish” meaning that all tie holes and surface defects shall be patched and all fins exceeding 1/8” shall be removed.

Horizontal surfaces shall be finished as outlined in specification 03300, “Cast-in-Place Concrete.”
Concrete surfaces, both vertical and horizontal, that are to receive a protective coating (i.e., containment areas, and chemical treatment areas) shall be finished in accordance with the applicable coating manufacturers recommendation.

3.4 Enclosures

3.4.1 General

Construction materials used in enclosures shall meet the definition of noncombustible or limited combustible, except roof coverings which should be Class A in accordance with NFPA 256, Standard Methods of Fire Tests of Roof Coverings. Metal roof deck construction, where used, should be “Class I” or “fire classified.” Particular attention shall be focused on sloping floors and adding drains around equipment to preclude any pooling of water.

Enclosure loads shall take into consideration added dead load for items including but not limited to cable trays, pipe, and other items hung from the structure. The Engineer shall provide this information to the Contractor where required.

Two-hour fire barriers shall be provided for the following enclosures:

- Power Distribution Center (PDC)
- Fire Pump Enclosure (if supplied)
- Other as required by Code or local fire authority.

3.4.2 Control Building

The electrical switchgear, MCCs, SCS panels, metering, protective relaying, batteries and other miscellaneous equipment shall be housed in a single-story, insulated Power Distribution Center (PDC). The PDC shall be a factory assembled. The PDC shall have a controlled environment, both heated and cooled. See Section 3 for all HVAC requirements. There shall be a minimum of (2) separate entries into the PDC. Consideration shall be given in the PDC layout and construction to facilitate equipment maintenance and replacement.

3.4.3 Fire Pumphouse Module (if supplied)

The fire pumphouse module, including a jockey pump and one electric fire water pump shall be located adjacent to the fire/service water tank. Suitable access doors shall be provided for maintenance of the pumps.

3.4.4 CEMS Enclosure

The CEMS enclosure shall be single-story, insulated, pre-fabricated shop-assembled (modular) metal building supported on a reinforced concrete foundation. The enclosure shall be located at ground level. The building shall contain continuous emissions.
monitoring equipment and other miscellaneous electrical equipment such as lighting panels. The building shall be provided with HVAC equipment to maintain proper temperature control for the electronic equipment. Door access shall be provided for installation and maintenance of equipment.

Concrete Masonry

Hollow load bearing or nonload-bearing concrete masonry unit (CMU) partitions may be used as fire boundaries where required by code in accordance with the UL Fire Resistance Directory. CMU’s shall be either hollow, normal weight, nonload bearing Type I conforming to ASTM C 129, or load-bearing Grade N, Type I conforming to ASTM C 90.4. CMU’s shall be filled with mortar and shall conform to ASTM C 270, Type M. CMU’s shall be reinforced as required to meet load capacity.

Pre-Formed Metal Siding

Exterior siding shall be an insulated field-assembled siding system. Exterior face panels shall be 24-gauge minimum; interior liner panels shall be 24-gauge minimum standard sheets of galvanized steel. Exposed panel surfaces shall have the manufacturer’s standard baked-on finish.

The wall system shall be designed to withstand the specified wind loading, with practical and equally spaced support girts.

Exterior panel surfaces exposed to weather shall be oil coated with Hylar/Kynar 500 or equivalent finish. The interior surface of the exterior panels shall be finished with the manufacturer’s standard baked-on enamel finish.

The siding finish color shall be selected by Owner from the manufacturer’s standard colors.

Wall insulation shall be noncombustible glass fiber or mineral wool to produce a minimum U-factor of 0.08 Btu/hr/ft²/°F. Insulated metal panels shall contain noncombustible insulation or listed as Class 1 or Class A per Factory Mutual Guide or UL listing.

Doors, Frames, and Hardware

Exterior personnel doors shall be flush, hollow metal on pressed steel doorframes complete with windows, hinges, locksets, closers, weather-stripping, and accessory hardware. Fire doors and frames shall conform to NFPA No. 80 for the class of door furnished.
3.5 **Painting and Coatings**

3.5.1 **Equipment Painting**

The painting and coatings shall be applied by a contractor that is SSPC – QP1 qualified. The Contractor shall perform coating or painting of all areas intended for coating or paint application as described below.

The following equipment and structures shall be finish painted following installation except those that are indicated as shop finished below:

- Power island equipment; main and unit auxiliary transformers (shop finished)
- All field erected tanks (bolted tanks are shop finished)
- Uninsulated shop fabricated tanks (shop finished)
- Electrical cabinets and panels (shop finished)
- All carbon steel, such as valves, shop coated tanks, electrical junction boxes, etc.
- All uninsulated carbon steel pipes shall be primed and final coated.
- Concrete secondary containment surfaces (including over curb edges)

Off the shelf components such as motor control centers, control boxes, motors, fans, valves, hangers, etc. shall receive vendor’s “Standard Shop Finish”. CTG shall have compatible alkyd enamel finish over supplier standard primer after touch up in the field.

**ITEMS NOT PAINTED OR COATED:**

- Galvanized
- Aluminum
- Stainless Steel
- Special Alloys
- Machined Surfaces
- Surfaces to be insulated
- Resinous Materials
- Glass
- Ceramic
- Labels and Nameplates
- Interior Structural Steel (factory applied primer only per Specification 13121)

Structural and miscellaneous steel, including pipe supports located outdoors, shall be hot dipped galvanized. Field touch-up shall be performed after erection.

Final color selections for all locations shall be subject to approval of the Owner.

3.5.2 **Coating System Applications – See Specification 09900**

Acceptable Materials for Tank Lining and Exterior Coating (Field Applied Coatings)
Interior Lining

Demineralized Water and Reverse Osmosis Tanks (as applicable) shall be lined with Plasite 7156 or equal.

Exterior Coating

The exterior of the tanks shall be coated with a factory-applied system with an acrylic enamel finish.

Tanks that are lined or coated shall have surface preparation and application in accordance with the instructions of the lining manufacturer. All linings shall be free from holidays when tested with a low voltage (67.5 v) wet sponge holiday detector such as a Tinker-Rasor Model M-1 Holiday Detector. Lining shall be selected based on the liquid that is stored with respect to the tank material. Minimum lining application shall be a 2-coat process with a minimum of 4.0 mils lining per coat.

Scheme

The enclosure colors shall be subject to approval of the Owner. Plant Equipment ( uninsulated pipes, tanks, etc.) shall be painted a non-reflective medium gray, with the exception that exposed fire system piping shall be painted red and exposed natural gas and ammonia piping shall be painted yellow. Color samples for enclosures and plant equipment shall be submitted to the Owner for approval.

3.5.3 Signage

Safety signs shall be provided and installed throughout the facility in accordance with OSHA guidelines and general industrial practice. Identification for all exits and fire protection equipment shall also be provided. Traffic marking and signs shall be provided as necessary to assure proper traffic flow, control and safety. All requirements of the Fire Marshall having jurisdiction shall be followed.

3.6 Testing

The services of an independent qualified materials testing laboratory shall be engaged to sample, test and certify that the following construction work and materials are installed as specified:

- Earthwork materials and compaction
- Asphalt paving compaction
- Concrete slump
- Concrete strength
- Concrete air entrainment
- Grout strength
- Masonry Grout & Mortar
- Structural Steel Installation
The results of all samples and tests shall be provided to Owner in a timely fashion.

A minimum of four concrete test cylinders shall be taken for each 100 cubic yards (or portion thereof) of concrete placed at any one time. Cylinders shall be taken in accordance with ASTM C-31 and tested in accordance with ASTM C-39, except the fourth cylinder, which shall be held for use at the discretion of the Contractor.

4 MECHANICAL SYSTEMS AND EQUIPMENT

This section describes the primary mechanical equipment and systems, their functions, and the criteria upon which their design shall be based for the MMC Chula Vista Energy Efficiency Upgrade Project.

Refer to the Process Flow Diagrams for further information on BOP system design.

4.1 Combustion Turbine Generator

Each CTG shall be supplied with a metal acoustical enclosure suitable for outdoor installation. The CTG shall use either Dry Low NOx combustors or a water injection system to control exhaust gas NOx. The CTG shall also have Sprint water injection performance enhancement capabilities.

The generator is an air-cooled direct-drive, 2-pole, 60 Hz synchronous machine operating at 13,800 volts.

Auxiliary systems for the CTG, which are to be supplied as part of the CTG supplier scope, shall be as follows:

- Baseplate support system
- Lubricating and hydraulic oil system
- Oil-to-air lube oil coolers
- Fuel gas system, including fuel gas metering valve
- Inlet air filtration (static filters) system
- Fire protection and detection system for the CTG
- Starter System (Starting Motor and fluid drive for GE CTG)
- Turbine compartment vent fans
- Generator compartment vent fans
- Lube oil filtration system
- Turbine controls
- Generator controls (protection, excitation, power system stabilizer, and automatic governor control)
- Neutral grounding and surge protection equipment
- 125 VDC battery system
- Online/offline water wash system
- Sprint System
• Water Injection System.

CTG inlet air conditioning shall be accomplished via an inlet fogging system. The fogging system shall be provided by a third party vendor, retrofitting the OEM-supplied inlet equipment where necessary. The fogging system shall be designed to achieve a compressor inlet temperature that is within 2 deg F of the wet bulb temperature. The fogging system shall be complete with pumps, nozzles, interconnecting piping, valves, controls, and other equipment necessary to function across typical load and ambient range.

Equipment shall be designed for outdoor installation in ambient conditions.

4.2 Selective Catalytic Reduction and CO Oxidation Catalyst System

4.2.1 SCR/CO Catalyst Description

Selective catalytic reduction (NOx) and CO catalysts in a common casing will be purchased by the Owner and are used to meet the required stack emissions limits. The SCR/CO system includes the following equipment:

• Inlet expansion joint
• Structure and ductwork
• SCR (NOx) catalyst
• Ammonia injection grid
• CO catalyst
• Ammonia injection skid
• Stack / silencer assembly
• Ladders and platforms
• Tempering air fans, 2x100%
• PLC control system
• Manways for access to the upstream and downstream side of each catalyst
• Interconnecting piping between the vaporization skid and ammonia injection grid
• Testing ports and connections

4.2.2

Noise attenuation features include stack silencers and an acoustic shroud in the inlet section of the casing, in order to meet overall project required noise limits of 60 dB(A) at property line. Aircraft warning lights will not be provided. Lightning protection will not be required.

SCR system shall be provided with catalyst modules designed to facilitate eventual replacement. The NOx and CO catalyst modules shall be loaded and removed via roof or side access panels.

The SCR scope of supply shall include the ammonia vaporization skid which includes:
1. Electric heater with redundant capacity heating elements
2. 100% capacity dilution air fans
3. Vaporization chamber with two (2) 100% capacity atomizing nozzles

An ammonia storage tank, forwarding pumps and interconnecting piping provide ammonia to the ammonia vaporization skids of each SCR catalyst system. The existing ammonia tank having a capacity of 12,000 gallons shall be retained. New forwarding pumps and interconnecting ammonia supply and return lines shall be installed as part of the Contractor’s scope.

4.3 Water Systems

4.3.1 Demineralized Water

Demineralized water shall be required for Sprint water injection, fogger inlet cooling, water wash of the CT compressor section, and potentially water injection for NOx control. Rental demineralizer equipment such as trailers or portable demineralizer skids shall be used to supply demineralized water for the plant. The equipment shall include a number of cation, anion and mixed bed ion exchanger vessels. The demineralizer equipment shall not include RO units, and all demineralizer equipment shall have offsite regeneration, therefore, there shall be no demineralizer waste stream. The system feedwater shall be provided by municipal water.

Demineralized water quality shall meet the following water purity requirements:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total dissolved solids</td>
<td>ppm</td>
<td>5</td>
</tr>
<tr>
<td>Silica as SiO₂</td>
<td>ppm</td>
<td>0.1</td>
</tr>
<tr>
<td>Conductivity</td>
<td>micromho/cm</td>
<td>&lt; 0.1 at 25°C</td>
</tr>
<tr>
<td>pH</td>
<td>SU</td>
<td>6.0-8.0</td>
</tr>
<tr>
<td>Sodium + potassium max</td>
<td>ppm</td>
<td>TBD</td>
</tr>
<tr>
<td>Chlorides max</td>
<td>mg/L</td>
<td>.5</td>
</tr>
<tr>
<td>Sulfates max</td>
<td>mg/L</td>
<td>.5</td>
</tr>
</tbody>
</table>

The product water from the demineralizer system shall be stored in a bolted, carbon steel, field erected, factory epoxy coated demineralized water tank. The tank shall be sized for 100,000 gallons which is nominally 12 hours of plant demineralized water usage.

The demineralized water system shall be sized to produce approximately 100 gpm which shall refill the demineralized water storage tank in 16 hours or less.
4.3.2 **Potable Water System**

The source of potable water shall be from the municipal supply as specified in Section 1. The potable water main shall run through the facility and branch at convenient locations to supply safety showers, the demineralized water system and hose bib connections.

Emergency showers and eyewash stations shall be located in the vicinity of the ammonia tank area, demineralized water equipment area, and any other area with chemicals or hazardous materials.

4.4 **Wastewater Collection and Treatment System**

The wastewater system shall collect and process equipment drainage, spills, floor washdowns, and containment flows. The storm water system shall collect storm water runoff from the plant site.

4.4.1 **Industrial Wastewater and Oily Waste Treatment System**

The equipment and miscellaneous plant drain system shall collect and treat wastewater from plant and equipment drains that may contain small quantities of oil (including the plant area washdown floor drains and equipment drains). The drainage shall be designed for gravity flow to sumps for pumping to the treatment area. Sumps shall be centrally located and shall use submersible pumps. The system shall remove oil, grease, gross suspended solids, emulsified oils, etc by processing through an oil/water separator designed for outdoor, above ground service and for 10-15 ppm effluent oil concentration. Oil is to be collected in the attached storage compartment and disposed of off-site.

4.4.2 **Sanitary Sewage System**

Sanitary sewage from the plant shall be collected and discharged to the existing utility sanitary sewer connection.

4.4.3 **Stormwater Drain System**

The stormwater drain system may include swales/ditches (that don’t impede access) and/or catch basins and underground piping designed to carry off yard stormwater.

Stormwater collected in transformer pit drains and other oil storage / contact areas shall be contained and routed to the oil/water separator.

4.4.4 **Spill Prevention and Control**

**Ammonia Tank**

The existing ammonia tank containment shall be retained. Wastewater piping from the existing containment shall be revised to tie in to the new waste water system.
Oil Reservoirs

Curbs shall be provided around the CTG lube oil package reservoirs to provide secondary containment. Additionally, containment around the CTG equipment as described in Section 2 (Civil) shall be provided for protection in this area. A curb shall also be provided around the Fuel Gas Compressor to provide secondary containment.

Oil-Filled Transformers

Each oil-filled transformer containing more than 500 gallons of oil shall be mounted in containment, although some transformers may share a common containment. Rainwater that collects in the containment shall drain to a corner sump with a normally closed and locked valve. The plant operator shall be able to check the accumulated rainwater for gross oil contamination and open the valve to drain it to the oil/water separator. The containment shall be sized to contain the total oil volume of the transformer, plus sufficient freeboard to accommodate accumulated rainwater.

Liquid Fuels/Chemicals

Spill containment control measures shall also include containment around any liquid fuel tanks and chemical unloading areas.

4.5 Fire Protection System

4.5.1 General

NFPA 850 and the applicable fire code shall provide the general guidance for the fire protection considerations of the facility. The Engineer shall prepare a Fire Risk Evaluation plan to detail the site-specific fire protection features of the facility.

Fire prevention and protection for the facility, including the Fire Risk Evaluation Plan, all drawings, calculations, and related system details, shall be reviewed and must receive approval from the local Fire Marshal and Owner’s insurance representative.

Automatic and manual fire protection systems employing detection and extinguishing equipment shall be provided at all locations having potential fire hazard due to the presence of combustible materials or where major property damage could result. Yard hydrants and portable extinguishers shall provide additional incipient fire extinguishing capability and overall protection throughout the plant site.

The fire protection water supply shall be taken from the existing municipal fire water line that enters the site. A new underground firewater loop with necessary hydrants shall be provided which shall replace the existing firewater piping and hydrants. Hose houses shall not be installed around the yard since plant-operating personnel shall only be trained to extinguish incipient fires and local fire department personnel shall only use their own hose.

The fire water flow requirement shall be determined per the applicable code.
4.5.2 Fire Protection System

As a minimum, the fire protection system shall include:

<table>
<thead>
<tr>
<th>Area</th>
<th>Standard</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Extinguishers Site Wide</td>
<td>NFPA 10</td>
<td>Use Dry Chemical only if it is best option</td>
</tr>
<tr>
<td>Fire Water Supply / Distribution</td>
<td>NFPA 24</td>
<td>Emergency fire department water supply connections shall be provided adjacent to the plant loop road.</td>
</tr>
<tr>
<td>Underground piping/loop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire Hydrants</td>
<td>NFPA 24</td>
<td>Hydrants shall be spaced &lt;300 ft apart</td>
</tr>
<tr>
<td>Combustion Turbine Generator</td>
<td>NFPA TBD</td>
<td>Provided by OEM</td>
</tr>
<tr>
<td>Turbine Enclosure</td>
<td>NFPA TBD</td>
<td>Provided by OEM</td>
</tr>
<tr>
<td>Generator Enclosure</td>
<td>NFPA TBD</td>
<td>Provided by OEM</td>
</tr>
<tr>
<td>Power Distribution Center</td>
<td>NFPA 72</td>
<td>Smoke detection throughout</td>
</tr>
</tbody>
</table>

4.5.3 Additional Fire Protection Features

Additional features of fire protection/detection include:

- One central fire detection control panel to monitor status of zones, with visual indications, audible alarm, and test provisions; and/or a remotely located fire detection control panel in a location where there is 24/7 manned coverage

- Area fire/smoke detectors where required for automatic suppression systems

- Fire alarm horns (audible throughout the site)

- Manual pull stations

- Interconnecting cabling

- Natural gas and ammonia leak detection

4.6 Compressed Air System

The compressed air system shall be designed to supply service and instrument air for the facility. Dry, oil-free instrument air shall be provided for pneumatic operators and devices throughout the plant. Compressed service air shall be provided to appropriate areas of the plant as utility stations.

The instrument air system shall be given demand priority over the service air system. A pressure control valve shall be set at approximately 85 psi to cut off the air supply to the service air header once the system pressure falls below that set point.

Two (2), 100 percent capacity, oil free rotary screw, packaged air-cooled air compressors shall supply compressed air to the service and instrument air systems. The control system shall be designed to allow either air compressor to become the “lead” and shall provide
instrument air system pressure indication and a low-pressure alarm. The instrument air system shall include two parallel duplex instrument air dryers, a compressed air storage receiver, stainless steel piping, valves, instrumentation and controls.

4.6.1 Instrument/Service Air Requirements

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Compressors</td>
<td>2 x 100%</td>
</tr>
<tr>
<td>Total Flow, Each (scfm)</td>
<td>250 Minimum</td>
</tr>
<tr>
<td>Type</td>
<td>Rotary Screw-Oil-Free</td>
</tr>
<tr>
<td>Discharge Pressure (psig)</td>
<td>125 Minimum</td>
</tr>
<tr>
<td>Aftercoolers and Moisture Separators</td>
<td>Included</td>
</tr>
<tr>
<td>Air Receiver</td>
<td>2 x 100%, 500 gallons each (minimum)</td>
</tr>
<tr>
<td>Air Dryer</td>
<td>2 x 100%, Heat-Less Regenerative Type</td>
</tr>
</tbody>
</table>

The total instrument air flow capacity is based on the total quantity of air users, capacity of each air user, an average load factor of 25 percent, plus an additional 50 percent margin to account for air leakage. All instrument air shall pass through the air dryers. Instrument air shall be dried to a dew point of -40°F.

4.6.2 Service Air Requirements

Service air requirements shall be based on providing a minimum of 50 scfm at 125 psig. Utility hose stations shall be located as necessary throughout the plant to allow all equipment to be accessed via air hose. Each hose station shall have with a ball valve, an anti whip valve and a quick disconnect coupling.

4.6.3 Emergency Air Compressor Connection

An emergency air compressor connection consisting of a ball valve and a 2-inch RF flange connection shall be located in the air header ahead of the compressor discharge air receiver, and in a location reachable by a 25 foot long portable air compressor air hose. This connector shall be sized for at least the same flow rate as one of the plant air compressors. An oil trap shall be supplied at the emergency connection to prevent oil from the emergency air compressor entering the instrument air system.

4.7 Compressed Gas Systems

All compressed gas tanks/cylinders and pressure regulators required to operate and maintain the facility will be provided by Owner’s gas suppliers. All interconnecting piping, valves, instrumentation and controls shall be part of design.

4.7.1 Carbon Dioxide

A carbon dioxide system shall be provided for fire protection at the CTG.
### Heating, Ventilating, and Air-Conditioning System

The design basis for sizing the system shall be as follows:

<table>
<thead>
<tr>
<th>Area</th>
<th>Summer</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate controlled areas (Power Distribution Center, CEMS enclosures, etc)</td>
<td>75°F, 50% R.H.</td>
<td>70°F</td>
</tr>
<tr>
<td>Other areas</td>
<td>100°F, ventilated</td>
<td>50°F</td>
</tr>
</tbody>
</table>

The HVAC system shall consist of building heating, building ventilation for fresh air makeup and cooling, and air-conditioning as required and shall include:

- Multiple HVAC units for the Power Distribution Center (supplied as part of the package)
- HVAC Unit for the CEMS Package (supplied as part of the package)
- Ventilation fans for the turbine enclosure (supplied as part of the package)

### Fuel System

#### 4.9.1 Fuel Gas

The fuel gas system treats and delivers fuel gas to equipment at the desired conditions. The scope of the fuel gas system extends from the interface with the utility natural gas connection at the plant property boundary to the gas interfaces for the CTGs. The fuel gas system currently in place has a combination of piping, regulators, other valving and instrumentation. The fuel gas system shall be redesigned to accommodate the reciprocating gas compressors and fuel gas requirements of the LM6000 CTG’s, while connecting to the existing utility supply now in use. Portions of the existing fuel gas system that are proposed to be carried over to the new system design must be approved by Owner.

The fuel gas supply system includes 3 x 50% fuel gas compressor packages which shall control gas pressure and temperature to CTG manufacturer requirements. Each compressor is sized to provide the natural gas needed for one LM6000 unit. The compressor package includes inlet-side scrubber(s) to remove coarse sludge from the incoming gas, discharge coalescing filter(s), and discharge cooler(s). The inlet scrubber and discharge coalescing filters shall be located on either the gas compressor package skid or on a separate skid. The discharge cooler shall be a separate skid package. The compressor package shall include a recycle system to control discharge pressure across all CTG operating conditions.

A regulating station shall reduce the utility supply gas pressure to nominally 300 psig to match design conditions at the inlet of the gas compressor. The design shall include the capability to increase the setpoint of the regulating station and manually adjust the
volume pockets of the gas compressor in order to minimize electric power consumption of the compressor.

The fuel gas system shall have provision to bypass the gas compressor for unusual situations where the gas compressor is unavailable and utility line pressure is sufficient to run the CTG at low loads. In such bypass situations, the fuel gas must flow through the inlet scrubber and discharge coalescing filter in the gas compressor area.

A duplex filter/coalescer shall be located downstream of the gas compressor equipment near each CTG unit. Carbon steel interconnecting piping shall be provided from the gas compressor area to the final filter/coalescer. All piping after the final filter/coalescer shall be stainless steel. Condensate and other waste drained from the filter/coalescer shall be routed to the waste water collection system.

4.10 Lubricating Oil Systems

Lubricating oil systems shall be provided with the CTG including all lubricating oil pressure and drain piping, as well as all valves, devices, and controls needed for an operable system. Lube oil pipe shall be stainless steel.

The CTG lube oil is cooled by an oil to air fin fan heat exchanger. Oil piping with containment shall be routed between the CTG auxiliary skid and the fin fan skid.

4.11 Cranes/Monorails

Equipment shall be arranged to allow maintenance to be performed via mobile crane access to the CTG and other major equipment. The CTG shall include a monorail lifting beam and hoist for turbine removal.

4.12 Pumps

4.12.1 General Service Pumps (50 HP and Smaller)

Pumps shall be sized for maximum efficiency at the normal operating point. Pumps shall be free from excessive vibration throughout their operating range.

Pumps shall operate satisfactorily at various flow rates up to maximum pump output. Pump motors shall be sized so the selected pump impeller shall not overload the motor at any point on the pump head-capacity curve. Wear rings shall be provided as appropriate.

Vent and drain valves shall be fitted at high and low points on the pump casing. Pumps rated 25 hp and above typically have a recirculation line for protection. The recirculation line shall normally be routed to the source from which the system takes suction. Restriction orifices shall be used as appropriate.

Horizontal split-case pumps shall allow the removable casing half and impeller to be withdrawn without disturbing any of the process piping or valves. Horizontal end-
suction pumps shall allow the impeller to be withdrawn without disturbing the motor or discharge piping.

Pumps shall have expansion joints between the inlet and outlet side and piping connected to them as required by good engineering practice.

Strainers (startup or permanent) shall be installed in the suction piping of horizontal pumps or sets of pumps. The driver shall be mounted on an extension of the pump bedplate and shall drive the pump through a flexible coupling.

Pumps shall have mechanical seals (25,000-hr life if available), if appropriate for the application. In general, major pumps shall be specified to have mechanical seals. Pumps with mechanical seals shall be arranged to facilitate seal removal. Shaft slingers shall be specified to prevent packing gland leakage water from entering bearing housings.

Couplings and any intermediate shafting shall be provided with OSHA approved guards. Bedplates shall be of ample proportions and stiffness to withstand the loads likely to be experienced in shipment and service.

4.13 Tanks

Overflow connections and drop downs to grade lines shall be provided. Maintenance drain connections shall be provided for complete tank drainage.

Manholes, where provided, shall be at least 24 inches in diameter and hinged to facilitate removal. Storage tanks shall have ladders and cleanout doors as required to facilitate access/maintenance. Provisions shall be included for proper tank ventilation during internal maintenance. Ladders and platforms shall be galvanized and designed in accordance with OSHA standards.

Local level indication shall be provided with level transmitters for remote monitoring and a float system for local monitoring.

Tanks shall be designed using the following criteria:

<table>
<thead>
<tr>
<th>Tank</th>
<th>Quantity</th>
<th>Description</th>
<th>Size in Gallons (see note)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demineralized Water Storage</td>
<td>1</td>
<td>Carbon Steel Bolted Fab &amp; Erect AWWA D103-97 with factory applied exterior and interior coating</td>
<td>100,000</td>
</tr>
<tr>
<td>Water Wash Drain Tank</td>
<td>1</td>
<td>Horizontal, Cylindrical Double Wall Tank, Fiberglass</td>
<td>2000</td>
</tr>
<tr>
<td>Gas Turbine Waste Oil Drain Tank</td>
<td>1</td>
<td>Horizontal, Cylindrical Double Wall Tank, Fiberglass</td>
<td>1,000</td>
</tr>
<tr>
<td>Oil/Water Separator</td>
<td>1</td>
<td>Above Ground Carbon Steel</td>
<td>500</td>
</tr>
</tbody>
</table>

Refer to Section 2.5 for interior lining and exterior coating requirements.
4.14 Pressure Vessels

Pressure vessels shall be ASME stamped and shall include, at minimum, the following features/appurtenances:

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Quantity</th>
<th>Description</th>
<th>Capacity (gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia Tank</td>
<td>1</td>
<td>Existing Equipment</td>
<td>12,000</td>
</tr>
<tr>
<td>Compressed Air Receiver</td>
<td>2</td>
<td>Vertical, Carbon Steel per ASME Section VIII</td>
<td>500 minimum</td>
</tr>
</tbody>
</table>

- Process, vent, and drain connections for startup, operation, and maintenance.
- Materials compatible with the fluid being handled.
- A minimum of one manhole and one air ventilation opening (e.g., handhole) where required for maintenance or cleaning access.
- Relief valves in accordance with the applicable codes.

4.15 Heat Exchangers

Heat exchangers shall be shell-and-tube or plate type and shall be designed in accordance with Tubular Exchanger Manufacturers Association (TEMA) or manufacturer’s standards. Fouling factors shall be specified in accordance with TEMA. Cooling duty and fluid characteristics shall be considered in determining fabrication materials, wall thickness, etc.

4.16 Piping and Piping Supports

4.16.1 Piping Standards

Piping standards are listed in the following table, which identifies proper pipe material and usage based on service. Should there be any conflict between the piping standards listed below and any other provision of this document, except code, the piping standards shall have priority. Non-standard pipe sizes shall not be used. Direct buried flanges shall not be used except for underground fire water systems which shall use flanges with stainless steel bolts for connections to fire hydrants and to ductile iron transition pieces to above grade piping.

<table>
<thead>
<tr>
<th>Service</th>
<th>Media</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressed Air Piping</td>
<td>Air Headers</td>
<td>AG - ASTM A312, Type 304</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UG – ASTM A312, Type 304</td>
</tr>
<tr>
<td>Compressed Air (Instrument Tubing 3/8&quot;, 1/4&quot;)</td>
<td>Air</td>
<td>ASTM A213, Type 316</td>
</tr>
</tbody>
</table>
### Service, Media, and Material

<table>
<thead>
<tr>
<th>Service</th>
<th>Media</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demineralized Water</td>
<td>Water</td>
<td>AG – ASTM A312, Type 304</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UG – PE3408 HDPE</td>
</tr>
<tr>
<td>Potable Water</td>
<td>Water</td>
<td>UG – PE3408 HDPE</td>
</tr>
<tr>
<td>Fire Water</td>
<td>Water</td>
<td>AG - ASTM A53 Gr B / A106 Gr B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UG – PE3408 HDPE (see Note 1)</td>
</tr>
<tr>
<td>Lube Oil (Supply and Return Piping)</td>
<td>Oil</td>
<td>ASTM A312 TP 304 L (Seam Welded),</td>
</tr>
<tr>
<td>Drain Lines</td>
<td>Water</td>
<td>AG – ASTM A53 Gr B / A106 Gr B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UG - HDPE Below 140°F, ASTM A53Gr B / A106 B (coated and wrapped) above 140°F</td>
</tr>
<tr>
<td>Ammonia</td>
<td>Ammonia</td>
<td>AG – ASTM A106 B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UG – Double wall pipe, internal ASTM A106 B, external A53, with leak detection.</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Natural Gas</td>
<td>Upstream of final filter/separator A106 Gr B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Downstream of final filter/separator A312 TP 304</td>
</tr>
</tbody>
</table>

Note 1. HDPE fire system pipe shall transition to ductile iron prior to penetrating floor slabs, equipment foundations, or grade to avoid exposed above-grade HDPE fire pipe.

### 4.16.2 Design Temperature and Pressures

1. The design pressures of piping systems shall generally be based on the maximum sustained pressure plus 5% or 20 psig, whichever is greater. Design pressures shall be rounded to next highest 10 psi.

2. The design temperature of piping systems shall generally be based on the maximum sustained temperature which may act on the system plus 10°F, except where specific design guides dictate otherwise. The piping design temperature shall be rounded to the next highest 10°F.

### 4.16.3 Piping Design and Selection Criteria

1. Piping shall be designed in accordance with the requirements of the Code for Pressure Vessel Piping, ASME B31.1 – Power Piping.

2. Piping which is $1^{1/4}$, $3^{1/2}$, 5, or 7 inches nominal pipe size shall not be used for general piping system design; although short segments may be required at connections to equipment.

3. Allowable fluid velocities shall be based on the following:

<table>
<thead>
<tr>
<th>Service</th>
<th>Velocity</th>
<th>DP (psi)/100 ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Water – Ferrous pipe</td>
<td>1-10 fps</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Service</td>
<td>Velocity</td>
<td>DP (psi)/100 ft</td>
</tr>
<tr>
<td>------------------------------------</td>
<td>----------</td>
<td>-----------------</td>
</tr>
<tr>
<td>General Water - Non-ferrous pipe</td>
<td>1-7 fps</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Pump Suction - low NPSH</td>
<td>3-6 fps</td>
<td>-</td>
</tr>
<tr>
<td>Pump Suction – high NPSH</td>
<td>6-10 fps</td>
<td>-</td>
</tr>
<tr>
<td>Compressed Air (100 psig)</td>
<td>900-4,500 fpm</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>3,000-5,000 fpm</td>
<td>-</td>
</tr>
<tr>
<td>Gravity Drains</td>
<td>1 to 10 fps</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

Lines shall be sized on either velocity or DP/100 ft limitations, whichever govern. Values shown are for general line sizing purposes only and shall be superseded when other constraints, such as the available pressure, require a more detailed sizing analysis.

4.16.4 Piping Supports

All pipe supports and anchors shall be in accordance with the requirements of the Power Piping Codes and other codes and standards as applicable.

4.17 Valves

4.17.1 Valve General Requirements

Valves shall be arranged for convenient operation from floor level where possible (e.g., hand wheels no greater than 7'-0” above operator’s feet), and if required, shall have extension spindles, chain operators (with Owner approval), or gearing. Manually operated valves that are normally operated during facility operation, and manual block valves that are required for normal plant start-up and shut down, shall be located such that operation can be performed either from grade, platform, or by extended stem operator. Hand-actuated valves shall be operable by one person.

4.17.2 Valve Materials

Valve bodies shall generally be constructed of materials equivalent to the pipe with which they are used. Valve body and trim materials of construction shall be in accordance with applicable ASTM standards.

Valves in throttling service shall be selected with design characteristics and of materials that resist erosion of valve seats when the valves are operated partly closed.

4.17.3 End Connections

Steel flanges shall be raised-face type, unless otherwise required.

Cast iron and bronze flanges shall be flat-faced type.
4.17.4 Low Pressure Water Valves

Fire protection valves shall be UL listed or FM approved for fire service. Curb box valves shall only be used for lead-ins to fire hydrants. Post Indicating Valves shall be provided on the fire main loop at intervals such that no more than five hydrants or fire systems would be impaired in the event of a main break. Fire system control valves shall be PIV, OS & Y, or butterfly type and shall be located outside of the fire hazard area they control.

Resilient seated carbon steel butterfly valves shall be limited to use with piping systems having a design temperature of 180°F or less.

4.17.5 Instrument Air Valves

Instrument air valves shall be bronze ball type, with valve face and seat of approved wear-resistant alloy. Needle valves shall be bronze.

4.17.6 Valve Operators

Manual operators shall be lever, hand wheel, or gear type, with the use of lever operators to be limited to valves requiring a maximum of 90° stem rotation from full open to full closed position on valve sizes 6 inches and smaller. All operators shall be sized to operate the valve with the valve exposed to maximum differential pressure.

4.17.7 Electric Valve Actuators

The electric actuator shall be designed specifically for the operating speeds, differential and static process line pressures, process line flow rates, operating environment, and frequency of operation for the application.

All motors shall be designed for full voltage starting. Motor starting torque shall not be less than 500 percent of rated full load torque. The motor time rating for normal opening and closing service shall not be less than the greatest requirement of 1) three successive open-close operations in a 50°C ambient, 2) 15 minutes at maximum driven equipment torque in a 50°C ambient temperature, 3) as required for the service. Sufficient torque shall be provided to open or close the valve against maximum differential pressure, and seating or unseating torque at any voltage between 90 and 110 of rated voltage.

The electric actuator shall be furnished with an integral starter and manual disconnect switch.

Electric actuators shall be placed in a position relative to the valve that prevents leakage of liquid, steam, or corrosive gas from valve joints onto the motor or control equipment.

4.17.8 Safety and Relief Valves

Safety valves and/or relief valves shall be provided as required by code for pressure vessels and heaters. Safety and relief valves shall be installed vertically and vented to a
safe location. Piping systems that can be over pressurized by a higher-pressure source shall also be protected by pressure relief valves. Equipment or parts of equipment that can be over pressurized by thermal expansion of the contained liquid shall also have thermal relief valves provided. At commercial operation all relief and safety valves shall have current seals in place.

4.17.9 Instrument Root Valves

Instrument root valves shall be specified for operation at the working pressure and temperature of the piping to which they are connected. Personnel access to instrument root valves may be from grade, platforms, stairs, ladders, man lifts, or other appropriate.

4.17.10 Valve Special Features

Valves shall be provided with locking devices, hand wheel extensions, vacuum service packings, limit switches, and other special features, as required. Locking devices, when furnished, shall allow the valve to be locked either open or closed with a standard padlock. Limit switches, when furnished, shall be provided for the open and closed position of the valve.

4.17.11 Control Valves

Refer to Section 5.0 “Control Systems” for information on control valves.

4.18 Insulation and Cladding

Thermal insulation shall be provided as appropriate to conserve energy, afford personnel safety, provide freeze protection, prevent condensation, and attenuate noise. Piping operating above 140°F shall be insulated in areas required for personnel protection. All pipe sections that are insulated for freeze protection shall have insulation placed in and around the pipe support.

Thermal insulation shall be provided in accordance with Specification PPSD-A-TS-15107 and shall consist of pre-formed slabs or blankets, where feasible. Asbestos containing materials are strictly prohibited. An embossed aluminum jacket shall be provided on the outside surface of the insulation. Insulation system materials, including jacketing, shall have a flame spread rating of 25 or less when tested in accordance with ASTM E 84.

Insulation at valves, pipe joints, or other points to which access may be required for maintenance shall be removable soft covers. At each flanged joint, the material shall terminate on the pipe at a distance from the flange equal to the overall length of the flange bolts to permit their removal without damaging the insulation.

Design temperature limits for thermal insulation shall be based on system operating temperature during normal operation.
4.19 Lubrication

Types of lubrication specified for facility equipment shall be suited to the operating conditions and shall comply with the recommendations of equipment manufacturers.

The startup charge of flushing oil shall be the manufacturer’s standard lubricant for the intended service. Subsequently, such flushing oil will be sampled and analyzed by Owner to determine whether it can also be used for normal operation or must be replaced by Owner in accordance with the equipment supplier’s recommendations.

Rotating equipment shall be splash lubricated, force lubricated, or self-lubricated. Oil cups shall be provided as necessary. Where automatic lubricators are fitted to equipment, provision for emergency hand lubrication shall also be specified. Where applicable, equipment shall be designed to be manually lubricated while in operation without the removal of protective guards. Lubrication filling and drain points shall be readily accessible.

5 ELECTRICAL SYSTEMS AND EQUIPMENT

This section describes the facility’s principal electrical equipment and systems, their functions, and the general criteria upon which their design shall be based. An overview is shown on the main single-line diagram provided in Section 2.14.

5.1 Interconnections to Electrical Utilities

Power generated shall be delivered to the utility transmission system through an existing 69kV breaker on the high voltage side of the generator step-up transformer. Startup power shall be backfed through this same interconnect from the utility system. The interface point between the plant and the utility at the plant side of the existing 69kV breaker. Protection, control and communication interface shall be at the utility plant fence line. The Engineer shall be responsible for designing the high voltage interface facilities associated with the plant protection, control and communication as well as all related design, such as grounding, cabling, and raceway.

5.2 Electric Power System – General

Power shall be generated by the two LM6000 Combustion Turbine Generators (CTG) and stepped up through a 3-winding generator step-up transformer to the utility high voltage system. The generator shall be connected to the 13.8kV generator breaker with 15kV cable. The line side of the generator breaker shall be connected to the step-up transformer by cable or cable bus.

The following general criteria shall be used to design the electrical system:
• The electrical systems, equipment, materials, and their installation shall be designed in accordance with applicable industry codes and standards, project design criteria, and other requirements as specified.

• Facility power shall be supplied through one (1) 13.8-4.16kV unit auxiliary transformer connected to the 13.8kV switchgear. The facility shall be “black start” capable via a Contractor supplied black-start generator. This generator shall provide power to feed plant auxiliary electric loads in the event of a loss of the 69kV system. During normal startup, power required for auxiliaries shall be supplied from the utility through the generator step-up transformer to the 13.8-4.16kV unit auxiliary transformers.

• The 4160V system shall be fed from the 4160V unit auxiliary transformer. The 4160V switchgear shall be single-ended, low-resistance grounded, and located in the furnished PDC.

• The 480V system shall be fed from a 4.16-480kV secondary unit substation transformer. The 480V low-voltage switchgear shall be single-ended and high-resistance grounded. The 480V motor control centers shall be fed from the 480V low-voltage switchgear. The black start emergency generator shall be connected to the 480V switchgear to provide black-start capability to the plant in event of a loss the 69kV system.

• Equipment shall be sized to handle the maximum required current. The unit auxiliary transformers, 4160V equipment, and 480V switchgear shall all be sized to handle the load of the entire plant configuration.

• Equipment short-circuit ratings shall be based on the maximum short-circuit currents under all operating conditions and shall take into account equipment design margins and the standby generator testing. There are no provisions for future loads.

• Motors greater than 200 hp shall be supplied from the 4160V system. Motor-operated valves and motors from ¼ hp up to and including 200 hp shall be supplied from the 480V system. Motors less than ¼ hp shall be fed from the 120V system.

• The electrical power distribution system design and cable sizing shall be selected to limit the cable voltage drop from source to load to not more than 5 percent. The allowable voltage variation at the load equipment shall be limited to ±10 percent of the load nominal voltage rating under normal continuous operating conditions. The electrical system design shall also be based on motor starting and system capability requirements.

• Electrical and controls equipment requiring access for normal operation and/or maintenance shall be accessible from permanent floors or platforms without scaffolding, portable ladders, or lifts. Access space and clearance for electrical
equipment shall be per manufacturer’s recommendation and in accordance with NEC requirements.

- The protective relaying, metering, and controls for all electrical equipment shall be according to the Engineer’s design schematic diagrams, connection diagrams, and metering & relaying one-lines.

5.3 Plant DC Power Systems

Plant DC shall be supplied from 125VDC and 24VDC battery systems. Emergency power for the CTG critical loads shall be supplied by the 125VDC battery system supplied with the CTG. Control power for the plant electrical equipment, e.g. switchgear shall be supplied by the station 125VDC battery system.

The station 125VDC system shall consist of one (1), 100% capacity battery bank, two 100% capacity battery chargers, battery management system, a switchboard, and the required 125VDC panelboards. The batteries shall be lead-acid. This system shall supply DC power requirements for the uninterruptible power supply (UPS) system, medium and low voltage switchgear, balance of plant, and any critical DC loads. The station 125VDC system shall be sized to supply the plant emergency loads for a period long enough to allow a safe shutdown of all plant equipment including the CTG, gas compressor, etc. The battery shall be sized in accordance with IEEE 485. Battery racks shall be designed to applicable project specific seismic zone requirements.

Each battery charger shall be sized to supply the normal DC loads while simultaneously recharging a fully discharged battery in twelve (12) hours or less. Each charger shall be designed such that it may be operated as a battery eliminator with the battery disconnected.

The batteries shall be connected to the DC switchboard through a disconnect switch. The switchboard and panelboards shall be designed for indoor installation and constructed in accordance with NEMA PB-1 and PB-2. Each panelboard shall be provided with 20 percent spare breakers and shall be fully equipped.

The following 125VDC typical loads shall be fed from the station battery:

- MV and LV switchgear control power
- BOP SCS Power Supply
- CTG control system
- Plant UPS Power System

5.4 Uninterruptible Power Supply (UPS) System

Single UPS inverters shall supply 120VAC single-phase power to the UPS panelboards that supply critical AC loads. The UPS inverter shall be fed from the station 125VDC battery. The UPS system shall include one 100% ferroresonant inverter, one alternate source transformer, one static transfer switch, one manual bypass switch, and required
The manual bypass switch shall operate to completely bypass either inverter while continuing to provide power to all panelboards. In the case of an inverter failure, the alternate 480 VAC source shall supply power to the AC panelboard via the alternate source transformer and the associated static transfer switch. The alternate source transformer shall be shielded and non-regulating.

The following loads shall be supplied from the UPS:
- SCS operator stations
- CEMS PLC and DAS computer
- Solenoid operated valves (via SCS)
- Communication equipment
- Revenue metering SCADA equipment
- CTG UPS loads
- Fire Protection Alarm System

5.5 Main Generators

The gas turbine generators shall be an air-cooled design. Each combustion turbine generator shall be synchronized to the utility’s transmission system using the associated low side (13.8kV) generator breaker.

The CTG shall be capable of remote automatic generator control and shall be supplied with metering quality CTs, PTs and meters capable of supplying signals to the SCS and performance monitoring systems.

5.6 Generator Step-up Transformer (GSUT)

A single three winding, delta-wye, ONAN/ONAF/ONAF 65°C rise GSU transformer shall connect both CTG’s to the 69kV system. The neutral point of the HV winding shall be solidly grounded. The GSU transformer shall have metal oxide surge arresters adjacent to the HV terminals.

Accessories shall include a magnetic liquid-level gauge, pressure-relief device, buckholz relay, oil preservation device, valves for top and bottom filter press connections, drain/sampling valves, grounding pads, bushing-mounted current transformers, combustible gas detector, and hot spot winding temperature elements.

The GSUT shall include a manual de-energized tap changer located in the HV winding with taps ranging from 5 percent above normal to 5 percent below normal in 2.5 percent increments. The tap changer shall have manual locking provisions.

GSU transformer auxiliaries shall be powered from a 480V, three-phase, three wire source.
5.7 Unit Auxiliary Transformers (UAT)

One (1) 13.8-4.16kV two-winding delta-wye ONAN/ONAF 65°C UAT shall be provided to serve all plant auxiliary electric loads. The UAT shall be rated to supply facility startup and maximum operating power requirements. The neutral point of the 4160V UAT shall be low-resistance grounded.

Accessories shall include a magnetic liquid-level gauge, pressure-relief device, sudden pressure relay, oil preservation device, valves for top and bottom filter press connections, drain/sampling valves, grounding pads, bushing-mounted current transformers, and hot spot winding temperature elements.

The UAT shall include a manual de-energized tap changer located in the HV winding with taps ranging from 5 percent above normal to 5 percent below normal in 2.5 percent increments.

5.8 Secondary Unit Substation Transformer (SUS)

One (1) 4.16-0.48kV two-winding delta-wye ONAN/ONAF 55°/65°C SUS transformer shall be provided to serve the 480V switchgear and all 480V plant auxiliary electric loads. The SUS transformer shall be rated to supply facility startup and maximum operating power requirements. The neutral point of the 480V SUS transformer shall be high-resistance grounded with a ground fault detection scheme consisting of a pulsing contactor in the neutral circuit to aid in identifying ground faults.

Accessories shall include a magnetic liquid-level gauge, pressure-relief device, sudden pressure relay, oil preservation device, valves for top and bottom filter press connections, drain/sampling valves, grounding pads, bushing-mounted current transformers, and hot spot winding temperature elements.

The SUS transformer shall include a manual de-energized tap changer located in the HV winding with taps ranging from 5 percent above normal to 5 percent below normal in 2.5 percent increments.

5.9 Power Distribution Center (PDC)

The PDC shall house all 13.8kV switchgear, 4.16kV switchgear and motor control centers, 480V voltage switchgear, low voltage MCCs, SCS panels, power and lighting panels, revenue metering, protective relaying, station batteries, CAISO RIG and other miscellaneous equipment.

The PDC shall be shipped to site with all wiring completed between all internal components.
5.10 Medium Voltage Switchgear

Three lineups of medium voltage switchgear shall be provided including two 13.8kV medium voltage switchgear lineups, one for each generator breaker. This switchgear shall be 15kV class nominal, three-phase, three-wire with ratings not to exceed 3000A continuous and 50kA fault current duty. This 13.8kV switchgear shall be connected between the CTG generator terminals and the low-voltage windings of the GSUT. The 13.8kV medium voltage system shall be high-resistance grounded via the CTG neutral grounding transformer when the generator breaker is closed, and shall be ungrounded when the generator breaker is open. A set of zero-sequence PT’s and ground fault protection are required for each 13.8kV switchgear bus to monitor for bus ground faults prior to closing the generator breaker.

The medium voltage switchgear shall be located outdoors, shall use vacuum interrupters, and shall be rated to continuously distribute the full auxiliary load. Each lineup shall contain voltage transformers, protective relaying for the GSUT, UAT, and feeder breakers and other load distribution equipment. All medium voltage breakers shall be electrically operated from the SCS and equipped with a stored energy mechanism.

5.11 Medium Voltage Motor Controllers

The medium voltage motor controller lineup shall be rated 4.16kV nominal, three-phase, three-wire with bus ratings not to exceed 1200 amps continuous and 250MVA fault current duty. The MV MCC shall be NEMA Class E2 rated equipment. The MV MCC shall be double high construction and drawout where possible. The MV MCC shall contain vacuum and control power shall be via an internal control power transformer. All motor controllers shall be controlled from the SCS. The medium voltage motor controller lineup shall consist of motor controllers and a main load-break switch.

The 4160V medium voltage switchgear shall be rated 4.16V nominal, three-phase, three-wire switchgear with ratings not to exceed 3000A continuous and 50kA fault current duty. This MV switchgear shall receive power from the 13.8-4.16kV unit auxiliary transformer through a cable connection.

5.12 Low Voltage Switchgear

The low voltage switchgear shall be rated 480V nominal, three-phase, three-wire with ratings not to exceed 4000 amps continuous and 100 kA fault current duty. The low voltage switchgear shall use electrically operated air-break power circuit breakers controlled from the SCS. Each power circuit breaker shall have a solid-state trip device. If an electric fire pump is required, its feeder shall be mechanically operated only. The low voltage switchgear shall supply power to the low-voltage MCCs. The low voltage switchgear shall be located indoors. The low-voltage switchgear shall receive 480V power from the 13.8-0.480kV transformer through non-segregated phase bus duct.

A multimeter shall be mounted on the front of each low-voltage switchgear to display bus voltage and current, kW, and kVAR for the incoming feed to that low-voltage switchgear.
Each low voltage switchgear shall be designed with an integral high resistance grounding system with a self-contained annunciator and pulsing contactor. Ground fault detection shall be provided with an alarm indication to the SCS.

All low voltage switchgear shall have provisions and to accommodate a future vertical section.

5.13 Low Voltage Motor Control Centers

Low voltage motor control centers (MCCs) shall be rated 480V nominal, three-phase, three-wire and shall supply 480V non-motor loads, motors from ¾ hp up to and including 200 hp, motor-operated valves, and lighting and distribution panels. Thermal magnetic molded-case circuit breakers shall be used for non-motor loads. Each motor starter shall consist of a padlockable motor circuit protector; three-phase overload protection; three-pole contactor; hand-off-auto switch; stopped and running indication lights; and control power transformer. Control power transformers shall be sized to handle each individual motor space heater load. The MCC bus bracing and starter interrupting ratings shall be consistent with the short-circuit currents calculated during detail design. All motor control centers shall be installed indoors.

A minimum of 10% spare starters shall be provided for the following: size 1 FVNR starters, size 2 FVNR starters, 150A breakers, 225A breakers in each lineup.

Placards shall be placed on each motor control center starter to warn that operation of the equipment in “hand” position bypasses all permissives.

All motor control centers shall have provisions and space to be extended a minimum of 1 vertical section.

5.14 Motors

This section addresses motors for BOP equipment. Motors shall be the squirrel-cage induction type suitable for full-voltage across the line starting. The motor nameplate at service factor load shall not be less than 1.15 times the maximum brake horsepower (KW) of the driven load. Motors shall be provided with Class F insulation with Class B rise. Motor locked-rotor current shall be limited to 650% of full load current at rated voltage. All medium voltage motors shall be suitable for starting at 80% of the motor nameplate voltage.

All motors rated above 200 hp shall be rated 4000 V, shall be weather-protected Type II (outdoor), Type I (indoor only), totally enclosed fan cooled (TEFC), or totally enclosed water air cooled (TEWAC), depending on application. Motors rated 4000 V shall include two resistance temperature detectors (RTDs) per stator winding and one RTD for each sleeve bearing wired to a terminal block.
All motors rated ¾ to 200 hp and fractional horsepower reversing motors (e.g. electric actuators) shall be rated 460V, totally-enclosed fan-cooled (TEFC), and shall be designed in accordance with the IEEE 841 standard.

Motors less than ¾ hp and smaller shall be rated 110 VAC.

Motors rated 25 hp and above shall have space heaters. The space heater shall be serviceable or replaceable without disassembly of the motor. The space heater terminal box shall be separate from the motor termination box. Where possible, the motor space heaters shall be rated for 240 VAC but sized and energized at 120 VAC. Space heaters rated for 120VAC shall also be allowed if 240VAC rated heaters are not available.

Motors shall be furnished with oversized cast iron terminal boxes and shall be capable of rotation in 90-degree steps. 4000 V motors shall be provided with two grounding pads. Antifriction bearings shall be grease lubricated, self-lubricating, and regreaseable. Antifriction bearings shall have a L10 bearing life of 100,000 hours. 4000 V motors shall be equipped with vibration switches or probes when specified and wired out to a terminal box for customer wiring.

Motor data sheets shall be provided for all three-phase motors, including those contained in vendor package equipment.

Routine tests shall be performed on motors in accordance with NEMA MG-1 and IEEE 112.

5.15 Electrical Protection

Protective devices shall be coordinated to the extent feasible to interrupt electric disturbances (fault, overload, abnormal operating condition, etc.) at the point nearest the fault, with the next upstream protective device providing back-up protection.

Protective devices shall operate through a lockout relay (86) or equivalent latching device or circuit to prevent automatic restart/reclose of the equipment.

The settings of the 69kV breaker and generator protective devices shall be fully coordinated with the utility system protection.

In general, relays shall be micro-processor based, multi-function type. Drawout protective relays shall have provisions for their removal without tripping their associated circuit breakers. Protective relays and lockout relays shall be provided with ABB FT-1 type external test switches to allow for the functional testing of the protective relaying and their associated circuits. The test switches shall be provided for voltage and current inputs as well as relay trip outputs (normally-open contacts on lockout relays).

As a minimum, the following protection shall be provided for:

- CTG (provided by the turbine generator supplier)
- Generator differential (87)
- Negative sequence (46)
- Loss of excitation (40)
- Reverse power (32)
- Stator ground (64G or 59GN)
- Volts/hertz (24)
- Overvoltage (59)
- Overfrequency and underfrequency (81)
- System Distance Backup (21)
- Voltage balance (60 FL)
- Field ground (alarm only)
- Out of Step (78)
- Breaker failure (50BF) (For generators with low-side breakers)
- Accidental Energization (50/27)

- Power transformers (each GSU and UAT)
  - Transformer differential relay (87T) or overall unit differential (87U)
  - Transformer neutral overcurrent (51TN)
  - Transformer phase instantaneous overcurrent (50)
  - Transformer phase time overcurrent (51), other than main step-up transformers
  - Restricted ground fault protection (87GD) – Unit auxiliary transformer low voltage windings only.
  - Transformer fault pressure relay (63)
  - Oil level switch (71Q) (alarm only)
  - Oil temperature (26Q) (alarm only)
  - Winding temperature (49) (alarm only)
  - Overpressure (alarm only)
  - Main step-up and unit auxiliary transformer protection relays shall be SEL-387E or equal.

- MV buses (13.8kV and 4.16 kV)
  - Bus under voltage for alarm (27) and blown secondary VT fuse indication (60)
- Incoming phase time overcurrent (51)
- Incoming residual ground time overcurrent (51G)
- Bus ground fault detection (59G) on the 13.8kV busses to detect bus faults prior to closing the generator breaker.
- Main incoming protection relay shall be Schweitzer SEL-351A or equal.

- 4.16-0.480kV transformers (protection located in the 4.16kV switchgear)
  - Phase time overcurrent (51)
  - Phase instantaneous overcurrent (50G – zero sequence)
  - Feeder protection relay shall be Schweitzer SEL-351A

- 4000 V motors
  - Thermal overload (49)
  - Phase overcurrent (51)
  - Phase instantaneous overcurrent (50 – provided by contactor fuse)
  - Ground overcurrent (50G – zero sequence)
  - Phase reversal (47)
  - Stator overtemperature (when required by the P&IDs) (alarm and trip)
  - Bearing overtemperature (when required by the P&IDs) (alarm only)
  - Phase current unbalance (provided through thermal overload protection)
  - Vibration (when required by the P&IDs) (alarm and/or trip as indicated by P&IDs)
  - Motor and feeder protection relay shall be Schweitzer SEL-701

- LV switchgear buses (480 V)
  - Bus under voltage for alarm and blown secondary VT fuse indication
  - LT/ST protection on main, tie, and MCC feeder breakers
  - LT/ST/I protection on motor feeders
  - Ground fault alarm

- 480 V motors fed from MCCs
  - Thermal overload and motor circuit protector

- Panels, transformers, heaters and miscellaneous loads fed from MCCs
  - Thermal-magnetic molded-case circuit breaker
5.16 Metering

5.16.1 Metering - General

Separate revenue metering for each CTG shall be provided to allow independent dispatch of each unit into the ancillary services markets. Metering class CT’s & PT’s shall be provided in the 13.8kV switchgear lineup associated with each CTG’s 13.8kV generator circuit breaker. Space for the revenue metering should be provided in the PDC, but may be approved for outdoor installation if approved by CAISO and SDG&E revenue metering representatives.

Metering of plant auxiliary power during standby shall be provided by an SDG&E revenue metering installation on the 13.8-4.16kV transformer. This revenue meter installation shall be configured to monitor auxiliary power consumption when both generator breakers are open and the plant is in a standby mode. This meter shall be enabled when both generator breakers are open and disabled if either one or both of the generator breakers are closed. The final aux electric metering configuration, metering instrument transformers and test switches shall must be reviewed and approved by the local utility prior to installation.

Relaying class accuracy voltage and current transformers are acceptable for panel indication meter applications.

ABB FT-1 type test switches shall be provided for the voltage and current inputs to each meter.

5.16.2 Metering Locations

Indication metering shall be provided in the following locations:

- Each generator (voltage, current, kW, kVAR, kWHr, kVARHr, pf, and freq)
- Each 13.8kV breaker (voltage, current, kW, and kVAR) – SATEC PM172P Series Multimeter
- The 4.16kV main breaker (voltage, current, kW, and kVAR) – SATEC PM172P Series Multimeter
- Each low voltage main breaker (voltage, current, kW, and kVAR) – SATEC PM172P Series Multimeter
- Each medium voltage motor (current) – provided through SEL-701 motor protection relays
- Low-voltage motor control centers (voltage, current, kW, and kVAR) – SATEC PM172P Series Multimeter
• 125 VDC BOP systems:
  − Battery amperes (at DC switchboard)
  − Bus voltage (at DC switchboard)
  − Negative to ground (at DC switchboard)
  − Positive to ground (at DC switchboard)
  − Blown Fuse (at each fused switch in DC switchboard)
  − Each charger output volts and amperes

• 120 VAC UPS system
  − Each inverter input volts and amperes
  − Each inverter output amperes, voltage, and frequency

5.17 **Annunciation to Plant Computer System**

The following points at a minimum shall be wired to the plant computer system for indication:

• Revenue meters: (through datalink)
  − MW export (if applicable)
  − MW import (if applicable)
  − MVAR import
  − MWHr export
  − MWHr import (if applicable)
  − MVARh export
  − MVARh import
  − System voltage

• Generators (either through the datalink with the turbine control system, if available, or hard-wired directly to BOP SCS).
  − Generator gross watts
  − Generator gross watt-hours
  − Generator gross amperes (each phase)
  − Generator gross vars
  − Generator gross var-hours
  − Generator volts (each phase)

• Generator Step-Up Transformer (GSUT):
  − Common trouble alarm (DI)
  − Transformer temperature (4-20mA)
  − Water concentration (4-20mA)
  − Hydrogen concentration (4-20mA)

• Unit Auxiliary Transformer (UAT):
  − Common trouble alarm (DI)
  − Transformer temperature (4-20mA)
• Each 4.16kV-480V Transformer:
  – Common trouble alarm (DI)

• Each Medium Voltage Switchgear Lineup:
  – Bus voltage (through datalink)
  – Main breaker current, kW, and kVAR (through datalink)
  – Transformer and MCC feeders current, kW, and kVAR (through datalink)
  – Motor feeders current (through datalink)
  – Bus undervoltage indication (DI)
  – Instrument voltage transformer blown fuse indication (through datalink)
  – I/O as defined on standard schematics

• Each 480V Switchgear:
  – Ground fault alarm
  – Bus phase A-to-B voltage (4-20mA)
  – Main breaker phase B current (4-20mA)

• 125VDC System:
  – One common trouble alarm from each battery charger
  – One common trouble alarm from each 125VDC switchboard
  – One common alarm from each battery management system

• 120VAC UPS System:
  – One common trouble alarm from the UPS inverter
  – Position of each main breaker/switch on each UPS panelboard
  – Manual bypass switch position

5.18 Controls

5.18.1 Synchronizing

The CTG shall be synchronized automatically from the balance of plant SCS through the units respective synchronizing system, which is included as part of each generator package. In addition, the CTG shall also be complete with vendor supplied controls to allow the CTG to be synchronized from the local CTG control room. The synchronizing system shall control turbine speed/generator frequency, generator voltage, and breaker closure (factoring in breaker historical closure time). No remote manual synchronizing capability is required. Synchronizing breaker selection shall be performed through the turbine control system.

5.18.2 Automatic Generation Control

Automatic Generation Control and Monitoring shall be provided. The control shall be by the plant SCS system via a CAISO Remote Intelligent Gateway (RIG) or DPG installed in the PDC.
5.18.3 Medium Voltage Breaker Control

All medium voltage breakers and contactors when in the “in service” position shall be controlled through the SCS. Local closing shall only be allowed when the breaker or contactor is in the test position. Local opening shall be allowed in either the “in service” or “test” position.

Control schemes for all medium voltage switchgear and motor controllers shall be submitted for Owner’s review prior to release for manufacturing.

5.18.4 480V Control

All 480V electrically operated switchgear breakers when in the “in service” position shall be controlled through the SCS. Local closing shall only be allowed when the breaker is in the test position. Local opening shall be allowed in either the “connected” or “test” position.

480V starters that control process loads shall be controlled from the control room through the SCS. Equipment such as HVAC, air compressors, small sump pumps, CEM, etc., shall be locally controlled only, with no remote control.

Non-reversing motor control from the SCS shall be via a maintained start/stop contact. Reversing motor control from the SCS shall be via open/close contacts.

Control schemes for all low voltage switchgear and motor controllers shall be submitted for Owner’s review prior to release for manufacturing.

5.19 Communications and Security Systems

The telephone system and security system shall be provided as discussed in the following subsections.

5.19.1 Telephone Communication System

The in plant telephone system shall consist of a dedicated telephone exchange with an integrated voice mail system. The main switching termination and isolation equipment shall be located in the PCM. Nineteen inch rack(s) shall be provided and installed by the Contractor for this equipment. No wood products are permitted. This shall also be the termination point for the two 50 pair offsite telephone lines coming into the site.

The standard telephone system capacity shall be as follows:

- One local T-1 with 200 DID block.
- One dedicated long distance T-1
- 4 – Centrex Lines
- 1- ISDN line for WAN back-up
• 6 – Copper backup PBX trunks (4 DID, and 4 COT)
• 1 Analog fax line

Underground raceway for the incoming (offsite) telephone lines from the plant boundary to the PDC, and all underground raceway inside the plant battery limit required for plant telephone shall be designed by the Engineer and provided and installed by the Contractor. Above ground raceway shall be provided and installed by the Contractor for routing and installation of telephone extensions throughout the site from the PDC.

All wire and cable except for the incoming telephone lines and building premises cable and wire shall be furnished and installed by the Contractor. A minimum of 20% spare pairs shall be provided to each location designated by the Owner during the detailed design phase. Termination of telephone cable and installation of equipment will be by others. Cable and wire shall be specified by the Engineer.

5.19.2 Computer Network System

The in plant computer system shall consist of a local area network with the main switching, termination and isolation equipment located in the electronics room adjacent to the control room as described in Section 5.3.

All raceway for in the plant computer and computer network systems shall be designed by the Engineer and provided and installed by the Contractor. Above ground raceway shall be provided and installed by the Contractor. Raceway shall be provided by the Contractor for routing and installation of computer extensions throughout the plant including the following areas:

• CEMS
• PDC

All cable and wire except for that included with prepackaged systems (e.g. PDC) shall be furnished and installed by the Contractor. A minimum of 20% spare pairs shall be provided to each location. Cable and wire shall be specified by the Engineer.

5.19.3 Security System

The plant security system shall consist of a surveillance camera at the main gate and one monitor in the PDC.

The main gate shall be controlled from a programmable keypad at the gate, from the PDC. An intercom system shall be provided from the main gate to the control room and to the PDC. Automatic opening/closing features of the gate shall be provided for vehicles exiting the plant.
5.20 Cable and Raceway

In general, equipment at grade not located near overhead pipe or cable tray racks shall be fed from underground ducts with other equipment generally connected using above grade cable tray and conduit systems. Where cable tray is routed in pipe rack with piping, the cable tray shall be routed at the top elevation of the pipe rack above all piping. Covers shall be provided if considered necessary for protection against welding slag or other debris.

Unless otherwise approved by the Owner, all cables routed underground shall be installed in marked concrete or cement slurry encased duct bank. Above ground circuits shall be installed in conduit or tray. Grouped electrical cables should be routed away from exposure hazards or protected as required by the Fire Risk Evaluation Plan. In particular, care should be taken to avoid routing cable trays near sources of ignition or flammable and combustible liquids. Where such routing is unavoidable, cable trays should be designed and arranged to prevent the spread of fire.

The final design shall provide a minimum of 10 percent spare conduits in each duct bank for Owner’s future use, plus sufficient ducts and associated spares. In no case shall there be less than one spare conduit provided for each application utilized in that duct bank, (power, control, instrumentation).

Cable trays shall be designed for 35% fill. Cable tray shall be aluminum unless otherwise required due to environmental or corrosion issues.

Separation of voltage levels in all raceways shall be maintained to meet the CTG manufacturers cable separation requirements or industry codes and standards whichever is more conservative. Rigid galvanized steel conduit shall be used in duct banks when required for signal separation. Otherwise, conduit in ductbank shall be PVC. All above ground conduit shall be RGS (rigid galvanized steel).

Manholes shall be provided as required for cable installation. Each manhole shall be provided with a sloped floor to a 2’X2’X2’ deep sump for pumping out water with a portable submersible pump. Duct banks shall be sloped toward manholes where possible. The slope determination shall be made to suit site conditions.

Hazardous area classifications and fire rated barrier requirements shall be identified by the Engineer.

5.21 Grounding

The facility grounding grid system shall consist of buried stranded copper conductors and ground rods, and ground wells as required. The buried grounding conductors shall be sized on actual maximum available fault current in the switchyard. Exothermal welded type connectors that meet the requirements of IEEE 837 shall be used for the buried ground grid connections. Exothermal welded connectors shall be used above ground for
connection of the ground grid to building steel. NEMA approved crimp on cable lugs shall be used for connection of the ground grid to equipment.

The ground resistivity shall be measured in accordance with IEEE 81 or ASTM G57. The ground grid shall be designed so that the step, touch, and mesh potentials are within acceptable levels per IEEE 80 and IEEE 695. The calculated ground grid resistance shall be verified by measuring final grounding resistance by Fall-of-Potential method per IEEE 81. The ground grid design shall take into account the nearby substation and shall be tied into the grid of the substation in at least 2 places.

Equipment and electrical systems in the plant power block area shall be grounded in accordance with the Owner’s standard grounding details, the National Electrical Code (NEC) and IEEE 142. All major electrical equipment shall be grounded directly to the ground grid. The communication, instruments, and control cable shields shall be grounded per the Owner’s standard grounding details, IEEE 789, the turbine supplier’s requirements, and the SCS supplier requirements as applicable.

5.22 Cathodic Protection

Because of the potential hazard in case of a leak, cathodic protection shall be provided for all buried, coated-carbon-steel pipe including natural gas pipes. The cathodic protection system for buried pipes shall be sacrificial galvanic anode system unless soil conditions or pipe size require the use of an impressed current system. Cathodic protection shall be designed to meet NACE RP-01-69.

All underground piping systems, tanks, large heat exchangers, condensers shall be reviewed for cathodic protection by the Owner prior for release for manufacturing on installation.

Field-erected storage tank bottoms shall be set on a concrete ring-wall or slab foundation. Cathodic protection shall be provided if required.

5.23 Lightning Protection

It is not expected that lightning protection shall be required for any plant site or structure located at any plant site. However, lightning protection shall be provided as required by the Owner in specialized locations such as near the high voltage side of the GSUT.

5.24 Lighting Systems

As a minimum, lighting shall be provided in the following areas:
- Building interiors.
- Building exterior entrances.
- Outdoor equipment within the power block and tank area.
- Power transformers.
- Power plant roadways.
- Parking areas within the power block area.
• Entrance gate.

Lighting levels shall be as recommended in IES standards.

Suitable fixtures shall be specified and installed according to the hazardous area classification.

Emergency lighting shall be provided by integral battery packs and shall not be connected to UPS system or 125 VDC station battery. Emergency lighting shall be provided for safe egress from all plant areas. Emergency lighting shall be provided with battery packs as well as connected to the plant 120V system.

If specified in Section 1, Stack aviation warning lighting shall be installed per FAA advisory circular AC 70/7460-1.

The lighting circuits shall consist of minimum #12 AWG stranded copper conductor. Cables used for lighting circuits shall be XHHW-2. In outdoor areas, the circuits shall be provided with rigid steel galvanized conduits with weatherproof fittings.

Outdoor lighting shall be switched and photocell controlled through contactor’s that feeds/controls the outdoor lighting. Light poles shall be galvanized steel or aluminum. To reduce the visual impact created by outdoor lighting, the following mitigation measures shall be adopted:

Lighting on the project site shall be limited to areas required for safety and shall be shielded from public view to the extent possible.

Lights shall be directed on site so that significant light or glare shall not be created. Highly directional, high-pressure sodium vapor fixtures shall be used.

Nighttime backscatter illumination shall be avoided by directional shielding of lights and providing on/off switch at the bottom of the ladders and stairways. All light switches shall be clearly identified.

LV distribution panelboards for lighting and receptacles shall be sized to distribute the capacity of the supplying transformer and shall be located near the loads connected to each panel. Such panels shall include a minimum of 20 percent spare breakers and all spaces shall be equipped. Panels shall include a main breaker as required by the NEC. All plant lighting panelboards shall be located indoors, to the extent practical.

Distribution transformers shall be sized to supply the expected continuous load, with approximately 20 percent margin for future load growth. The transformers shall be air-cooled, dry type, with a 150° C rise. When it is required that the panelboard and/or transformer are located outdoors, the panelboard shall have a minimum 3R rating and the transformer shall be equipped with drip shields.
5.25 Freeze Protection / Electric Heat Tracing

The following paragraphs are intended to serve only as a guideline for defining freeze protection, heat tracing and insulation of systems that could potentially be damaged by freezing. Freeze protection methods shall consist of the use of self limiting, insulated electric heating cables for low temperature lines and mineral-insulated (MI) for high temperature lines, heated “doghouses,” insulation, sparging with heated water, etc. Although pipe or equipment insulation is referenced in Section 3, it shall be considered an integral part of the freeze protection system.

For items located outdoors, the heat tracing system shall be provided for freeze protection at site minimum ambient temperature and weather conditions. Freeze protection shall be provided for all piping systems indoors or outdoors which are subject to freezing during plant operation and shutdown. Sufficient cable shall be provided for all flanges, valves and piping specialty items to permit maintenance of these items. The heat tracing system shall provide a controlled amount of heat to maintain the temperature above the freezing point, or, in the case of process protection, maintain proper viscosity, temperature or other parameters required for process operation. Lines requiring freeze protection normally include (but shall not be limited to) water lines, instrument lines, instrument transmitter housings, safety showers, eyewash stations, and condensate lines.

Where freeze protection is required on fire protection, the design shall be in accordance with NFPA standards.

Freeze protection shall be provided in accordance with the P&IDs for all piping systems, equipment, tubing, gages and instrumentation that contain fluids subject to freezing. All tubing requiring heat trace shall be thermostatically controlled to prevent boil off of the sensing fluid. Above grade, freeze protected piping that continues below grade shall be insulated and heat traced below frost depth.

Space heaters or heated enclosures shall be used for items where heating cables and insulation is not practical. Power for the heating cable circuits shall be supplied from distribution panels similar to those used for the lighting circuits and shall be controlled by locally mounted individual thermostats. The freeze protection system shall provide local status and alarm indication for each circuit. Each circuit shall be provided with electronic monitoring that indicates heat trace proper operation, failure or damage conditions.

Where required, instruments shall be freeze protected by utilizing heated “soft-pack” type enclosures. Heaters shall be centrally located within the enclosures and rated for extreme plant ambient temperature and wind speed. All process tubing shall be continuously heat traced and insulated through the enclosure wall up to the base of the instrument.

The Engineer shall be responsible for indicating all items that require freeze protection on P&IDs. In the event any vendor supplied packaged unit equipment includes factory or shop installed freeze protection, the Engineer shall be responsible for providing continuity and interface with the balance of plant freeze protection.
5.26 Welding and Convenience Receptacles

Welding receptacles with local disconnects (480 V, 60 amp) shall be provided in convenient locations throughout the plant. This includes two at the bottom of each SCR on opposite sides, two near each CTG, one near the gas compressor area, and one near the PDC.

Convenience receptacles (120 V) shall be provided around the plant as follows:

- PDC per the manufacturer’s standard scope of supply, but no less than three (3).
- Mechanical and Electrical Enclosures. One duplex receptacle for each enclosure
- General Plant Area to allow a 100-foot extension cord to reach all areas that require power for maintenance.
- Inside the CEMS enclosure and near the gas compressor area.

Outdoor convenience receptacles shall be the weather proof GFCI type.

5.27 Temporary Construction Power

Construction Power requirements shall be arranged for by the Contractor to meet construction needs including service to Construction Offices, Vendors, Engineers, and Sub-Contractors, plus 250 KW of start-up loads until back feed is available. The Contractor is responsible for the entire temporary power system design, supply, installation, safety inspection, maintenance, and removal.

Temporary power shall be supplied by the Contractor for space heaters, motor heaters, temporary heaters, and lighting as required for proper storage of material or equipment supplied by the Contractor, Owner or others.

5.28 Temporary/Construction Telephone Service

The Contractor shall provide telephone lines and T-1 (data) lines as required to a service pedestal at the site boundary that shall serve as temporary telephone lines.

Each user shall arrange for their own telephone service and installation from the service pedestal.

6 CONTROL SYSTEMS AND EQUIPMENT

6.1 General

The complete plant will be monitored and controlled by a Supervisory Control System (SCS) furnished by the Owner.
The plant shall be appropriately automated to allow remotely located operators to start-up, operate, and shut down the entire plant.

Auxiliaries such as small sump pumps that need not be in continuous operation for electric power production shall be monitored, controlled, and protected locally, with limited SCS monitoring and control.

6.2 Automatic Generation Control (AGC)

The plant shall be capable of set point remote block Automatic Generation Control (AGC) from CA-ISO. The reference point for the AGC shall be the net plant revenue meter(s) on the generator step-up transformer(s).

Plant data shall be communicated to San Diego Gas & Electric (SDG&E) and CAISO. The inputs required must be provided by SDG&E/CAISO and an example is indicated in the table below:

<table>
<thead>
<tr>
<th>Item</th>
<th>Status/Units</th>
<th>MW</th>
<th>MVAR</th>
<th>MW-HR</th>
<th>MVAR-HR</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-Line Revenue Metering Point (each)</td>
<td>OK/trouble</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>GSUT High Side voltage</td>
<td>kV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GSUT High Side Frequency</td>
<td>Hz</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Voltage Circuit Breaker(s)</td>
<td>Open/close/trip</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGC Set Point</td>
<td>MW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Feed back</td>
</tr>
<tr>
<td>AGC High and Low Limits</td>
<td>MW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generator Circuit Breaker (CTG)</td>
<td>Open/Close/Trip</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generating Unit (each)</td>
<td>On/Off, AGC enabled</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>High Temperature Control Limit</td>
<td>°F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas Turbine Inlet Air Temperature</td>
<td>°F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambient Air Temperature</td>
<td>°F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Plant Fuel Flow</td>
<td>MMBTU/Hr and Standard Cu-ft/hr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auxiliary Power Transformers</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

6.3 Supervisory Control System (SCS)

The SCS shall provide for control of the balance of plant equipment. The balance of plant control system shall interface with the CTG Turbine Control Panel (TCP), Gas
Compressor PLC, CEMS PLC, Ammonia System PLC, Air Compressor PLC, and CO/SCR PLC to provide routine operator control including start-up, shut down, synchronizing, and set point load control from the balance of plant console.

In addition to the control interface provided by the balance of plant control system, the primary equipment to produce electric power, the CTG and related auxiliaries, shall also be monitored, controlled, and protected via the Turbine Control Panel provided by the turbine supplier.

The SCS processors and I/O racks shall be centrally located in the Power Distribution Center (PDC).

Packaged systems (where applicable), except as noted herein, shall be programmed into, and controlled by the SCS. Control of the continuous emissions monitoring system (CEMS), CO/SCR, gas compressor, ammonia delivery system, and air compressor shall be by stand-alone programmable logic controller (PLC) systems. These PLCs shall include an RS-485 link to the SCS, unless approved otherwise by the Owner, for transfer of process monitoring and status information. Air compressor and dryer packages shall utilize their manufacturers’ standard stand-alone control system(s) with a data link to the plant SCS. Signals for start/stop, lead/lag, and status (running, trouble, etc.) shall be hard wired to/from the SCS unless otherwise provided by the OEM. All PLC program software licenses shall become the property of the Owner at the time of plant start-up.

A consistent control and instrumentation philosophy shall apply throughout the plant to minimize diversity of equipment type and manufacturer.

There shall be no hardwired discrete control and monitoring operator stations to back up the LCD’s and keyboards. However, individual emergency pushbuttons or switches shall be provided for hardwired shutdown of major equipment (CTG and fuel gas shut off). These push buttons shall be mounted in the Power Distribution Center (PDC).

6.3.1 SCS Equipment

**Operator Workstation**

The balance of plant SCS shall include one operator workstation. The workstation shall be equipped with one keyboard and one 19” LCD Flat Panel Monitor. The monitor shall be located on the work desk provided in the Power Distribution Center (PDC).

**Printers**

One color inkjet printer shall be provided and shall be located on the work desk in the Power Distribution Center (PDC).
6.3.2 SCS Processors, I/O Cabinets and Hardware

Processors, power supplies, communication modules, input and output modules shall be mounted in a freestanding cabinet with front access. Redundant circuits in separate raceways shall provide 125 VDC power to the SCS processors. The operator workstation and printer shall be powered from the plant UPS system.

The system shall be provided with 10 percent spare wired I/O and 10 percent spare slots in each cabinet at system shipment.

Equipment and termination blocks shall be identified either with laminated phenolic nameplates or stamped metal tags.

6.3.3 SCS Functionality

The control system located in the Power Distribution Center (PDC) shall show an overview and grouped or detailed information to assist the operator in required control actions. Functional logic diagrams or ladder logic diagrams shall be provided to the SCS supplier.

Motor control logic shall be coordinated to offer consistent functionality for all balance of plant equipment. Likewise, the operator interface for such logic shall also be consistent. Permissive displays shall be provided for applicable motors and valves identifying all system interlocks. Permissive displays shall be developed either as a paged display associated with a given graphic or a pop-up display.

All alarm annunciation shall be done in the balance of plant SCS. The Engineer shall provide all alarm set points for the balance of plant points to the SCS supplier for implementation prior to the software freeze date. The sequence of events (SOE) function shall have a resolution of not more than 1 millisecond and shall be an integral part of the SCS. The Engineer shall supply the SOE point list to GE for implementation into a separate DFR. The CTG sequence of events shall be synchronized with the same time stamp as the BOP or hard wired points to the BOP SCS to allow comprehensive SOE reports to be generated by the BOP SCS.

6.3.4 Graphics

A maximum of ten process graphics with an ISA-based symbol set, 10 trend displays, and 10 permissive displays that show the status of system interlocks shall be included in the BOP portions of the SCS. Graphic and trend displays associated with the GE-supplied equipment shall be provided by GE. Faceplates shall be included as pop-up windows on the process graphic displays. SOE trip logs shall be included.

6.3.5 Input/Output

The Engineer shall provide an I/O database with a minimum of 85% of the information complete to the SCS supplier to initiate the SCS manufacturing schedule. This
information shall be provided in the Access database format required by the SCS supplier. The Engineer shall be responsible to provide all analog ranges in engineering values to the SCS supplier. Pure alarms shall open-to-alarm and fail in the open position. Alarms used for control shall close-to-alarm and fail in the open position.

Field Wiring

Field wiring to the SCS shall land on compression type terminal blocks in the processor or remote I/O cabinets. The SCS shall accept both field powered and dry contact inputs. The normal wetting voltage for digital inputs shall be 24 VDC supplied by the SCS from redundant power supplies. Motor run/stop status contacts shall be 120 VAC powered from the motor control center. Solenoid-operated valves shall generally be 120VAC powered from the SCS.

Sequence of Events

One millisecond resolution time stamped points (SOE) shall be provided for the following:

- Generator circuit breakers (52b contacts)
- The unit auxiliary transformer 13.8kV volt main breakers (52b contacts)
- The 13.8kV volt main breakers to secondary unit substation transformers (13.8kV to 480 volt) (52b contacts)
- The 480 volt secondary unit substation main breakers (52b contacts)
- All lockout relays combined into a single “protection tripped” signal (normally-open contact)
- No other points than those listed above shall be connected as SOE

6.3.6 Foreign Device Interface (FDI)

The SCS shall be capable of interfacing with other foreign devices through Ethernet, RS232, or RS485 interfaces using a MODBUS or TCP/IP protocol (where applicable). Data links to the SCS shall be provided for switchgear relays, fuel gas metering station, ammonia delivery system, CEMS, CO/SCR, air compressor, and gas compressors. A Serial MODBUS link shall be utilized for interfacing to the CT TCP.

6.3.7 Factory Acceptance Test

The SCS shall include a supplier-supported factory acceptance test, which shall provide a thorough demonstration of all functional features of the SCS. The system shall be demonstrated using software simulation, but shall include sufficient hardware testing to
confirm proper system integration. A test procedure shall be developed by the system supplier to support the factory acceptance test.

6.4 Local Controls

SCS start/stop functions shall not be provided for self-contained components/equipment packages that do not require constant operator control or intervention (e.g., lubricating oil pumps, sump pumps, vent fans, etc).

Hard wired local controls for equipment shall be limited to hand-off-auto switches in the MCC’s for 480 volt motors and those provided by the equipment/skid manufacturer.

6.5 Analytical Equipment

6.5.1 Continuous Emissions Monitoring System

A continuous emissions monitoring system (CEMS) and data acquisition and reporting system (DARS) shall be provided for the CT/SCR trains in accordance with the air permit. The CEMS shall consist of sampling devices connected via sample lines to emissions rack mounted analytical measurement devices and CEMS control equipment located in the CEMS enclosure near the base of one of the stacks.

Adequate rack space shall be provided to allow future analyzers if required.

Calibration gases in cylinders shall be furnished by the Owner. The building containing the CEMS equipment shall have an exterior weather shield to protect the bolted racks, gas cylinders and regulators for connection of the calibration gases.

The CEMS shall be controlled by a PLC and shall monitor NOx, CO, O2, and NH3.

Inputs for fuel flow, power generation, and all other required process conditions shall be hard wired from the plant SCS. Emissions shall be calculated based on plant fuel flows, analyzer readings, and surrogate calculations based on fuel analysis.

The primary operator interface with the CEMS shall be through a personal computer workstation (PC) located in the CEMS building. The PC shall provide operator access via a Windows-NT environment to acknowledge alarms, retrieve data, and generate all required emissions reports and shall include exceedance/fault codes as appropriate. System reports shall be modifiable by site personnel, and emission alarms shall be adjustable through the PC interface. All appropriate equations and coefficients used by the systems shall be capable of being modified by authorized plant personnel (via password protection).

The CEMS hardware and reporting package software shall meet the requirements of applicable permits. System reports shall be able to include a daily summary of the average plant generation in megawatts, the average fuel flows, and any other plant data available to the system.
All corrected emissions data and a common alarm shall be hard wired to the SCS system.

UPS power shall be provided for the CEMS analyzers, controller, and PC to ensure proper surge protection, power conditioning, and protection in the event of a momentary loss of power.

The local control unit located with the CEMS equipment shall allow access to the operational status of the CEMS and provide the capability to initiate both automatic and manual calibrations. Such features shall also be available from the PC in the CEMS building.

The complete system shall be factory tested using NIST traceable calibration gases to confirm the function of all required features. After installation, tests shall be performed by the Owner as necessary to verify the CEMS meets all permit criteria. These tests shall include an accuracy test, a zero drift test, a calibration drift test, a stratification test, and an operational period test.

6.6 **Instrumentation Design Criteria/General Requirements**

6.6.1 **General**

The instrumentation and control equipment/systems and materials and their installation shall be designed in accordance with applicable codes, industry standards, this scope document, and material selection specified in this section. Instruments and valves shall be pre-calibrated, tagged and/or programmed by the supplier. The Engineer’s standard tagging procedure shall be used to identify all instrumentation. All instruments, control valves, switches and process control philosophy shall be shown on the piping and instrument diagrams (P&IDs) in sufficient detail to fully illustrate each instrument loop and its components. Process control and alarms shall be shown on the Engineer’s BOP P&ID’s but shall not include any permissives, overrides, or interlocks. Process control shall not be shown on those systems that are in a vendor’s scope of design.

Pneumatic signal levels, where used, shall be 3-15 psig for pneumatic transmitter outputs, controller outputs, electric-to-pneumatic converter outputs, valve positioner inputs, etc. Signal levels of electric to pneumatic converters may also be 6 to 30 psig, depending on application.

Electronic transmitters and controllers shall be designed for proportional output of 4-20 mA DC with 24V DC power supply from the SCS into 600 OHM maximum loop resistance.

No primary sensor full-scale signal level, other than thermocouples, shall be less than 10 mV or greater than 125 V. Transmitters requiring an external power supply shall be connected to 115 VAC.
Electronic transmitters shall be Rosemount smart type and shall have local digital indication as indicated on the P&IDs.

An identification tag showing the purchaser’s identifying tag number as per the data sheets shall be attached to each field instrument. The tag shall be a minimum of 20 gage stainless steel wired to the transmitter with a minimum letter height of 0.25”, 85 characters maximum or permanently stamped on the instrument with 65 characters maximum. As a minimum the tag should have the manufacturer name, model number and purchase order number. For safety, tag wired ends shall be curled.

Each field instrument shall be installed as per construction installation drawings. Interchanging instruments during construction is prohibited.

Instruments and transmitters shall be wired back individually to the SCS (without the use of field buses or similar communication protocol).

Field instruments, digital indicators, SCS, PLC, etc. shall be configured for the following engineering units:

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Degrees F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure</td>
<td></td>
</tr>
<tr>
<td>Near Atmos.</td>
<td>In. of water</td>
</tr>
<tr>
<td>Above Atmos.</td>
<td>PSIG</td>
</tr>
<tr>
<td>Below Atmos.</td>
<td>In. of Hg Absolute</td>
</tr>
<tr>
<td>Absolute</td>
<td>PSIA</td>
</tr>
<tr>
<td>Level</td>
<td>Percent of range for process</td>
</tr>
<tr>
<td>Flow</td>
<td></td>
</tr>
<tr>
<td>Liquids</td>
<td>GPM</td>
</tr>
<tr>
<td>Water</td>
<td>GPM</td>
</tr>
<tr>
<td>Gas or Vapor</td>
<td>SCFH*</td>
</tr>
<tr>
<td>Air &amp; Nitrogen</td>
<td>SCFH*</td>
</tr>
<tr>
<td>Analyzers</td>
<td>Ph, %, us</td>
</tr>
</tbody>
</table>

* Defined at 60°F and 14.69 PSIA

6.6.2 Pressure Instruments

Where necessary for operation, either industrial-type 4-1/2-inch-diameter pressure gauges with white faces and black scale markings, or indicating pressure transmitters shall be provided. Pneumatic receiver gauges shall be 3-1/2 inch oval size. In general, pressure instruments shall have linear scales with units of measurement in pounds per square inch.
gauge. Pressure gauge accuracy shall be ±0.5 percent of full range per ANSI Specification B40.1, Grade 2A. Pressure instruments shall generally have screwed connections. Pressure gauge stem connection shall generally be ½” NPT.

Pressure gauges shall have either a blowout disk or a blowout back and an acrylic or shatterproof glass face.

Pressure gauges on process piping shall generally be visible 10 feet from an operator’s normal stance at floor level and shall be resistant to plant atmospheres.

Connections to piping or equipment shall be in accordance with piping specification and instrument installation details.

Pressure test points shall have isolation valves and caps or plugs. Pressure devices on pulsating services shall have pulsation dampers.

Fire protection system pressure gauges shall be designed in accordance with UL standards.

“Face” gauges in high vibration areas shall be liquid filled and include a vibration snubber. “Face” gauges used for measuring high pressure or temperature process media shall be fitted with an isolation diaphragm.

6.6.3 Temperature Instruments

In general, temperature instruments shall have scales with temperature units in degrees Fahrenheit. Exceptions to this are electrical machinery RTDs and transformer winding temperatures, which are in degrees Celsius.

Dial thermometers shall have 4-1/2 inch-diameter (minimum) dials and white faces with black scale markings and shall be every-angle type and bimetal actuated. Dial thermometers shall generally be visible 10 feet from an operator’s normal stance at floor level (viewing area) and shall be resistant to plant atmospheres.

Temperature elements and dial thermometers shall be protected by thermowells except when measuring gas or air temperatures at atmospheric pressure. Temperature test points shall have thermowells and caps or plugs.

Thermowells for dial thermometers and filled system instruments shall be purchased with the instruments to assure proper fit. Thermowells shall be constructed of stainless steel except where conditions warrant the use of main line class material.

All thermowells shall be drilled barstock (not built-up type).

Threaded and socket weld thermowells shall have lagging extensions when used with insulation for high temperature. Consideration shall be given to thicker insulation in cold services.
In general, RTDs shall be dual 100-ohm platinum three-wire circuits \((R_{100}/R_0=1.385)\). The element shall be spring-loaded, mounted in a thermowell, and connected to a cast iron head assembly. However, RTDs associated with multi-variable transmitters shall be four-wire.

Thermocouples shall be type K dual element, ungrounded, and spring-loaded. For general service, the materials of construction shall be dictated by service temperatures. Thermocouple heads shall be the cast type with an internal grounding screw. If a thermocouple is inaccessible, the leads shall be brought to an accessible junction box.

“Face” gauges in high vibration areas shall be liquid filled and include a vibration snubber.

6.6.4 Level Instruments

Reflex-glass or magnetic level gauges shall be used. Level indication for corrosive service (if required) shall use devices other than reflex-glass gauges. Level gauges for high-pressure service shall have suitable personnel protection. Transparent type gauge glasses shall be used up to 600 PSIG.

Gauge glasses used in conjunction with level instruments shall cover a range that includes the highest and lowest trip/alarm set points.

Level transmitters for measuring the level in storage tanks vented to atmosphere (e.g., condensate storage tank) shall generally be the flanged differential pressure type and shall have local and main control room indication. Differential pressure type level instruments shall normally be furnished for pressure vessels in level ranges which exceed 48 inches. External displacer type level transmitters and controllers shall be normally furnished for all pressure vessels in level ranges equal to or less than 48 inches. Guided wave, internal displacer or ball float level instruments shall be furnished for open sumps and tanks and for services where draining of the tank for maintenance can be easily accomplished.

6.6.5 Flow Instruments

Primary Elements

Concentric type orifice plates shall be used as the primary elements for flow measurement. In general, 316 SS orifice plates shall be provided. For clean fluids the square edge orifice shall be used. The orifice plates shall be in accordance with API 2530, Chapter 14, Section 3, orifice metering of natural gas and other related hydrocarbon fluids. Each orifice plate shall be stamped with the tag number. Primary element calculations shall confirm to the requirements established in “Principles and Practices of Flow Meter Engineering” by L.K. Spink, and the “Flow Measurement Engineering Handbook” by R.W. Miller.
Orifice meter differential range shall be selected for a beta ratio (d/D) of between 0.3 and 0.7 for flow control elements and between 0.4 and 0.6 for other critical flow measurements.

**Meter Runs**

Orifice runs shall utilize orifice flange taps and shall be installed in a horizontal line if possible. Integral orifice meters, variable area meters (armored rotameters) should be installed in lines less than 2 inches.

Flow transmitters shall be the differential pressure type with the range matching (as closely as practical) the primary element. All flow differential pressure transmitters shall be furnished and shipped with integral three or five valve manifolds. In general, flow transmitters shall be Rosemount 3095 MV with external RTDs. The pressure, temperature compensation, when utilized, and element differential pressure shall be brought back to the SCS via a superimposed Hart signal on the corrected 4-20 ma flow signal.

**6.6.6 Control Valves**

Control valves in throttling service shall be the globe-body cage type with body materials, pressure rating, and valve trim suitable for the service involved. Other style valve bodies may also be used when suitable for the intended service. No split-body valves or separable flange styles shall be used without specific approval. Butterfly valves shall be of the lug body type.

Each control valve shall be sized using the methods and equations described in the standard ISA-75.01. Each control valve shall be sized and selected, including trim and plug design, actuators, valve materials, and valve accessories to properly satisfy all operating and design conditions of each application as listed in the Data Sheets.

The valve body size shall not be less than two pipe sizes smaller than the nominal inlet pipeline size, unless otherwise specified.

Bellow seal bonnets shall be used for highly toxic or volatile fluids. Teflon or approved non-asbestos alternate packing material may be used for temperatures between -40°F and 450°F. Grafoil packing shall be used as a minimum for temperatures 450°F and above.

Solenoid valves supplied with the control valves shall have Class H coils 120 VAC UPS powered. The coil enclosure shall normally be a minimum of NEMA 4 but shall be suitable for the area of installation. Terminations shall typically be by pigtail wires.

Manual bypasses with isolation valves for on-line maintenance shall be provided for control valves as indicated on the P&IDs.
End Connections

Steel valves with flanged ends shall be in accordance with ASME B16.5. End to end dimension of each valve shall be in accordance with the appropriate ISA Standards (i.e. ISA S75.03 and S75.04).

All welding connections for valves 2-1/2 inches and larger in nominal size shall be butt-welded. All welding connections for valves 2 inches and smaller in nominal size shall be socket welded. All welding ends shall be in accordance with ASME B16.34 and B16.25.

Control valves in 300# class service and below shall be flanged, except for Hydrogen, Natural Gas, Ammonia, steam and vacuum service. Where flanged valves are used the flange rating shall match the pipe class specifications.

All control valves 600# and greater shall be furnished with weld end connections.

For butterfly, ball, and similar body types, lugged or flanged bodies to permit dead end service shall be provided unless otherwise specified. Wafer types that cannot be independently fastened to the field piping at both ends of the valve body shall not be provided.

End extensions and Reducers:

If the size of a welded end valve is different than the field pipe size, the valve shall be furnished with shop welded concentric reducers matching the upstream and downstream pipe size, material and wall thickness. Shop welded end extensions shall be provided for valves with body material that is different than the field piping material (such as alloy valve bodies to be welded into carbon steel pipelines or vice versa). End extensions shall be a pipe section at least 6 inches (150 mm) long. End extensions and reducers shall be factory installed on the valve body and stress relieved in accordance with ASME B31.1. End extensions and reducers shall be shown on the valve drawing and included in the shop end-to-end or center-to-face dimensions.

Valve Actuators

All control valves shall be furnished with pneumatic spring opposed diaphragm actuators where possible. Pneumatic piston, electric or other actuators can be provided if better suited for the application or called out on the data sheets.

Valves shall be designed to fail in a safe position.

Valve actuators with valve action "fail open" or "fail closed", shall be provided with a mechanical spring or a trip valve and volume tank to fully open or close the valve as applicable on loss of air pressure. Valve actuators with valve action "fail in place" shall be provided with a mechanism to hold the valve in position on loss of air pressure. Actuators shall be sized sufficiently to achieve the desired "fail" position while the valve is operating at maximum differential pressure.
All actuator tubing shall be a minimum of 3/8” AISI 316 stainless steel. Tubing fittings shall be either Swagelok or Parker A-Lok compression type.

Hand wheels shall be furnished only on those valves that can be manually set and controlled during system operation (to maintain plant operation) and do not have manual bypasses. Flow direction shall be clearly indicated by arrow on the body as part of casting or permanently attached plate.

Volume Tanks

Volume tanks shall be designed to withstand a minimum pressure of 125 psig.

All volume tanks shall be constructed in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 (stamped UM).

Sound Control Requirements

For all valves, the equivalent "A" weighted sound level, measured three feet downstream of the valve outlet and one meter from the un-insulated pipe surface, shall not exceed 85 dBA unless noted otherwise on the valve Data Sheets. Noise reduction shall be accomplished by source treatment, utilizing trim specifically designed for the service. Calculations of noise shall be done in accordance with the International Standard IEC 534-8-3 and submitted with valve specifications and sizing information.

Positioners

Positioners shall be the Fisher DVC6000 Series, electro-pneumatic type utilizing the HART communication protocol and shall be provided with pressure gauges for indicating the air supply, valve actuator, and control signal pressures. Input signal shall be loop powered by the SCS. Positioners shall be designed for a control signal input range of 4-20 mA. Positioners shall provide an output signal from 0 psig to the full supply air pressure to the valve actuator. Positioners shall not be provided with bypasses.

Control valve accessories shall be mounted on the valve actuator unless severe vibration is expected. Control valves with a positioner shall not be equipped with a pneumatic valves unloader.

When valve position feedback is required for SCS information (i.e. non-control use) only, Fisher digital valve controllers (DVC’s) shall be utilized to provide a Hart signal back to the SCS superimposed on the valve analog output. Valve position feedback for process control use shall be hard wired. Valve position feedback shall be provided as shown on the P&ID’s.
6.6.7 Instrument Tubing and Installation

Tubing used to connect instruments to the process line shall generally be 1/2 inch diameter, 0.049 inch wall (minimum) seamless 316 stainless steel for primary instruments and sampling systems.

Instrument tubing fittings shall be the compression type. One manufacturer shall be selected for use and shall be standardized as much as practical throughout the plant.

Differential pressure (flow) instruments shall be fitted with five-valve manifolds. Three-valve or two-valve manifolds shall be specified for other instruments as appropriate.

Instrument installation shall be designed to correctly sense the process variable. Taps on process lines shall be located so that sensing lines do not trap air in liquid service or liquid in gas service. Taps on process lines shall be fitted with a shutoff (root or gauge valve) close to the process line. Root and gauge valves shall be main-line class valves.

Instrument tubing shall be supported in both horizontal and vertical runs as necessary. Expansion loops shall be provided in tubing runs subject to high temperatures. The instrument tubing support design shall allow for movement of the main process line.

6.6.8 Field-Mounted Instruments

Field-mounting instruments shall be of a design suitable for the area in which they are located. They shall be mounted in areas accessible for maintenance and relatively free of vibration and shall not block walkways or prevent maintenance of other equipment.

Field-mounted instruments shall be grouped on racks. Supports for individual instruments shall be a prefabricated, off-the-shelf, 2-inch pipe stand. Instrument racks and individual supports shall be mounted to concrete floors, to platforms, or on support steel in locations not subject to excessive vibration.

Instruments shall be freeze protected by utilizing heated “hard box” type enclosures (reference Section 3.0 Mechanical Systems & Equipment, paragraph 3.18, Insulation and Cladding).

Individual field instrument sensing lines shall be sloped or pitched in such a manner and be of such length, routing, and configuration that signal response is not adversely affected.

Liquid level controllers shall generally be the non-indicating, displacement type with external cages.

6.6.9 Instrument Air System

Branch headers shall have a shutoff valve at the takeoff from the main header. The branch headers shall be sized for the air usage of the instruments served, but shall be no
smaller than 3/8 inch. Each instrument air user shall have a shutoff valve, filter, and regulator (where appropriate) at the instrument.

7 CONSTRUCTION / ERECTION AND INSTALLATION

7.1 Introduction

The requirements listed herein are not necessarily all of the requirements that apply to the Contractor’s scope of work, but rather are intended to provide the general intent of the Contractor’s responsibility to furnish a safe and quality built, timely, complete, functional facility.

7.2 General

The Contractor shall install and erect the equipment and systems to meet the designed plant operating life of 30 years. In addition, the Contractor is required to keep the site clean and to utilize safe work practices throughout the plant’s construction.

Contractor shall provide experienced construction and project management personnel and other support staff as necessary to assist the subcontractors in interpretation of the Contract Documents, witness and monitor the performance and quality of the work, verify status, coordinate the activities of any Owner’s equipment vendors, assist in document control, and help resolve any problems or issues which may arise.

Contractor shall schedule the work so as to effectively utilize the TFA time the Owner has obtained as part of the purchase of the Owner supplied equipment.

All installation and instruction manuals that are provided by the equipment manufactures shall be strictly followed.

The Owner will make provision for a representative from the Engineer to be on-site to address technical questions during construction.

The Contractor’s basic scope of work for construction, erection and installation includes the purchase of all components (Balance of Plant) not specified as being supplied by Owner. This includes, but is not necessarily limited to the site preparation, foundations and all other civil work (except final landscaping), installation of all equipment, all electrical work, lighting, grounding, lightning protection, instrumentation, mechanical work, structural steel, piping (including pipe racks), all underground utilities, stacks, tanks, cooling towers, buildings (complete), bridges and supports, insulation, heat tracing, wastewater system, certain portions of the water treatment system, painting, inspection and testing, tagging of all equipment and components according to Contractor’s approved tagging procedure, and all related work comprising a completed functional facility.

The work is to be completed in accordance with the technical specifications, drawings, and other documents relative to this project and according to all applicable codes,
standards, and regulations as may apply to this project. Applicable codes and standards shall be the latest revision which is issued and in force on the date of contract award. The technical specifications and drawings provide technical requirements and details.

The Contractor shall provide all tools, cranes and rigging, construction equipment, scaffolding, construction materials, competent craft and other personnel, adequate supervision, services, etc., as necessary for performance of all activities required to accomplish the work outlined herein and as may be otherwise specified in the Contract Documents.

The Contractor shall maintain all applicable construction equipment fitted with working mufflers, silencers or other noise limiting devices to minimize any significant noise impact during construction, as well as adhere to all other regulatory conditions (e.g., OSHA mandated safe work practices) required of the facility being built.

Except for the specific items of major equipment being supplied by Owner, the Contractor is responsible for providing a complete plant installation. This responsibility includes providing miscellaneous items not specifically called for but which are required by good quality construction practice (e.g. temporary components, supports, cleaning supplies, shims, gaskets, nuts, bolts, etc). Owner will issue clarifications for Owner purchased equipment and material as information becomes available. Such clarifications shall not be cause for increases in contract price unless the clarification results in a clear substantial increase in work scope not normally included in a standard merchant power plant facility.

7.2.1 Mobilization

Contractor shall be responsible for mobilization of their forces and facilities at the construction site, including provision and setup of field construction offices, sanitary facilities, distribution of temporary utility services including power, telephone service, LAN services, potable and service water, an area lighting system, and 24/7 site security. Such facilities shall be sufficient to accommodate Contractor’s, Owner’s, Engineer’s, and Vendor’s construction and commissioning personnel. The Contractor is also responsible for the preparation and locating of off-loading and laydown areas, storage facilities and other necessary facilities as may be required and/or otherwise outlined in the Contract Documents.

7.2.2 Project Controls Program

Contractor shall establish, implement, and maintain a Project Controls program subject to Owner’s approval. The project controls program shall include invoicing, scheduling, administration and project correspondence, including the complete and timely submittal of schedules, drawings, and other documentation per the Documentation and Submittals in Section 9. This includes a full time on-site Project Controls Manager, at least one full time scheduler, and sufficient qualified support staff located on-site for the duration of the work.
7.2.3 Notification

The Contractor shall keep Owner informed of the progress of all work, and notify Owner’s Project Manager a minimum of five (5) days, and again within approximately one (1) hour in advance of any delivery, inspection and/or testing and all critical or major activities, and provide immediate notification of any situation that warrants Owner’s knowledge or involvement. Any work that is covered without Owner’s inspection (or sufficient opportunity of inspection), shall be un-covered by Contractor for verification at the discretion of the Owner.

7.2.4 Site Conditions

Contractor shall maintain surface water control, erosion control, and dust control, throughout the site and other areas where Contractor is engaged in work associated with the Project (including laydown areas, project access roads and parking areas). This scope includes keeping public roads and streets, as well as adjacent and other neighboring properties free and clear of any construction generated materials.

7.2.5 Surveying

Contractor shall perform all surveying required to locate and construct the work based on the on-site benchmarks provided by Owner. (Owner will furnish a minimum of two (2) project base lines and two (2) elevation bench marks one time, which shall then after be protected and maintained by the Contractor).

Prior to proceeding with any work, the Contractor shall verify that all interface work involving subcontractors, utilities, pipelines, rights-of-way, streets and highways, adjacent properties, existing lines and grades, foundation locations, elevations, sizes, location of anchor bolts, embeds, conduit stub-ups, materials, pipe thickness, flanges, etc. conform to the engineering design drawings and other Contract Documents. Conditions differing from those shown on the engineering design drawings or other Contract Documents shall be reported immediately to Owner, and followed-up in writing. The Contractor shall verify location and conditions and make the necessary final adjustments or corrections to conform the work. Owner reserves the right to engage the services of an independent surveyor or survey consultant to work together with the Contractor to resolve any disputed issue.

7.2.6 Receiving Program

Contractor shall establish, implement, and maintain a complete receiving and inventory control program subject to Owner’s approval. This includes a full time on-site Materials Control Manager and a sufficient, qualified, support staff for the duration of on-site work.

All equipment located in lay-down or staging areas, warehouses, or installed shall be protected from damage by Contractor according to manufacturer’s recommendations until formally turned over to Owner. This includes providing any temporary power for
motor heaters, temperature and humidity control, temporary lubrication, periodic rotating of equipment, or any other manufacturer’s requirement or industry standard.

7.2.7 Lifting, Rigging, and Transporting

Contractor is responsible for lifting, rigging, and transporting (from designated delivery point for Owner furnished equipment) all materials and equipment associated with the Project. Contractor shall submit a “Lift, Rigging, and Transport Plan” for each major component proposed for the project. As a minimum, each plan shall include drawings (indicating set-up and crane swing radius, boom angle, and connections), load chart(s) for each crane(s) or other proposed equipment, equipment and rigging certifications, operator certifications, and relative calculations.

Examples of items requiring “Lift, Rigging, and Transport Plans” are as follows:

- CT Components
- CT Generators
- Transformers
- SCR
- Tanks or Tank Components
- Stacks or Stack Components
- Any equipment with weight over 50 tons.
- Any lift that exceeds 90% of the applicable lift chart for the equipment being used.

**Additionally, any lift over 50 tons or higher than 100 ft. shall require a (specific jurisdiction) registered PE stamp.**

Submittals shall be made to Owner sufficiently prior to any proposed lift or transport to allow time for review and possible equipment or rigging changes, but in no case less than five (5) days prior to the proposed activity.

No equipment shall be operated on, or associated with the Project by anyone other than properly trained, experienced, licensed and/or certified equipment operators.

7.2.8 General Cleaning

Throughout the construction period Contractor shall maintain the site in a clean and orderly state and particularly immediately prior to commissioning activities, the Contractor shall inspect, clean and vacuum out all electrical enclosures, structures and equipment. The Contractor shall remove all excess materials and ensure that all work and maintenance areas, as well as all paths, remain unobstructed at all times.

7.2.9 Final Terminations

Final connections for all interface points associated with equipment, components, electrical systems, piping, instrumentation, utilities, or services installed on or associated with this project, are the responsibility the Contractor (except final electrical power
7.2.10 Demobilization

Upon completion of all required work including completion or resolution of all system punch list items and having received a written demobilization release from Owner, the Contractor shall completely demobilize trailers, equipment and other construction facilities, remove all temporary service connections (unless otherwise instructed), remove all hazardous and non-hazardous construction debris, chemical wastes, etc. in accordance with applicable local, state, and federal codes and regulations, clean up the site, and turn over the site to the satisfaction of Owner.

7.3 Safety

Preventing accidents and losses during construction is the Number 1 Priority on the project as well as being critical to maintaining project schedule.

Contractor shall establish, implement, and maintain a complete site-specific safety program to prevent accidents, losses, or damage to personnel, equipment, and structures and shall be subject to Owner’s approval. This includes a full time on-site Safety Manager at the start of the project and a sufficient, qualified, support staff for the duration of on-site work.

The site-specific program shall follow the applicable laws, ordinances, regulations and standards for such programs and shall include: code of safe practices, fire protection, spill prevention, emergency situations, procedures, hazardous material control and training. The plan shall be coordinated with local authorities as required. The Site Safety Plan shall comply with applicable QA/QC procedures. The Contractor shall submit to Owner for review the OSHA 200 log for the previous three years for each site subcontractor.

At least 45 days prior to the start of construction, or a date agreed to by Owner, Contractor shall submit to Owner a copy of the Project Construction Safety and Health Program and the Personal Protective Equipment Program.

7.3.1 Safety and Health Orientation

Each new or reassigned employee shall receive a thorough safety and health orientation, which gives the employee the basic information about the Contractor’s safety program, Federal OSHA and other applicable safety rules and regulations. If necessary, the Contractor shall provide additional safety instructions during the scope of the normal daily activities for the performance of hazardous or unfamiliar tasks. Employee attendance to the orientation shall be required and appropriate records shall be maintained on file in the Contractor’s office. Such records shall be available for review by the Owner [or authorized State or Federal agency personnel].
The Contractor’s safety orientation shall include, but is not limited to, the following topics as required by the assigned tasks:
- Employer/employee responsibilities under federal/state Occupational Safety and Health Act (OSHA).
- Code of safe practices
- Eye protection
- Head protection (hard hats)
- Foot protection
- Hearing protection (mandatory, where designated)
- Respiratory protection (where required)
- Fall protection and associated equipment.
- Scaffolding.
- Perimeter guarding.
- Housekeeping.
- Fire protection.
- Injury/illness reporting.
- Hazard communication (Right-to-know)
- Emergency procedures.
- Evacuation.
- Site lockout/tag out briefing.
- Site Confined Space entry.
- Suitable work clothing [(including fire retardant clothing where required)].
- Trenching and excavations.
- Material handling, rigging procedures and crane safety.
- Electrical safety.
- Apparel requirements- no mesh shirts, tank tops, shorts or tennis shoes.

7.3.2 Supervisor’s Safety Orientation

Contractor shall familiarize their supervisory personnel with the Contractor’s safety and health responsibilities by conducting a safety and health orientation with each supervisor upon promotion or assignment. Orientation records shall be maintained on file in the Contractor’s office.

7.3.3 Weekly Tool Box Meetings

Contractor shall conduct weekly toolbox meetings to provide their employees with up-to-date safety and health information. Employee attendance shall be mandatory and attendance records shall be maintained on file in the Contractor’s office. Such records shall be made available upon request by the Owner for review.

7.3.4 General Safety Requirements

- Barricades: Contractor shall erect and maintain all required barricades that may be required to protect personnel from their work operations as required by OSHA.
• Safety Signs: Contractor shall post any signs or posters that may be needed to advise employees of unsafe areas or conditions as required by OSHA.

• Scaffolds: Contractor shall erect all scaffolds in conformance with OSHA standards.

• Floor and Roof Openings: Contractor shall barricade or cover all floor and roof openings, to protect employees from falls as required by OSHA.

Contractor shall designate in writing to Owner, a qualified safety representative with authority to administer Contractor’s Site Safety Plan. Vendor supplied service organizations shall each be required to implement a safety program commensurate with the Work to be performed and in compliance with Contractor’s Site Safety Plan. Contractor is responsible for subcontractor’s and Contractor’s compliance with the Site Safety Plan.

It is imperative that loss prevention be incorporated into construction and as a minimum, the following must be provided by the Contractor:

• Approved Safety Program

• Safe workplace for all employees

• On-site First Aid Facility

• Fire prevention program in accordance with NFPA 241, the Standard for Safeguarding Construction, Alteration, and Demolition Operations.

• Ensure no equipment shall be operated unless it is safe to operate, protective equipment is in service, and that operators are verified as sufficiently trained and properly licensed or certified for the particular equipment being operated.

• Ensure hazards shall not be introduced unless protective equipment is in service, and appropriate notice and documentation has been achieved.

• Conduct regular safety meetings and training.

• Adhere to all OSHA and other applicable safety requirements

7.3.5 Noncompliance with Safety, Health or Fire Requirements

The Owner will monitor the safety performance of the Contractor working on the site. All Contractor’s employees shall be required to comply with safety obligations as established in the contract. Noncompliance with safety, health or fire requirements which could result in the threat to life, limb, or property may result in cessation of work operations, until items (persons) in noncompliance are corrected.
Employee Sanctions: Contractor shall advise its employees that any employee who jeopardizes his or her safety and health, or the safety of others, shall be subjected to disciplinary action, including immediate removal from the site.

7.3.6 Occupational Health

Contractor shall take all reasonable steps and precautions to protect the health of their employees and other site personnel. Contractor shall conduct occupational health monitoring and/or sampling as required by OSHA to determine the levels of exposure of its employees to hazardous or toxic substances or environmental conditions. Copies of employee sampling results shall be provided to the Owner.

- Hazard Communication: Contractor shall develop and implement a hazard communications program that complies with federal, state and local requirements. Material Safety Data Sheets (MSDS) shall be maintained for each such substance used/stored at the site. Copies of all MSDS’s shall be provided to Owner.

- Hazardous Waste: Contractor shall develop a plan to properly handle and dispose of all hazardous waste they generate. Such plans shall comply with Environmental Protection Agency, state, and local requirements.

- Confined Spaces: Contractor shall develop and implement a confined space entry procedure as required. Such procedures shall comply with OSHA and Owner standards.

- Respiratory Protection: Contractor shall develop and implement a respiratory protection program that complies with OSHA, and Owner requirements.

- Hearing Protection: Contractor shall assess their work areas, post signs, and issue hearing protection to employees as required.

7.3.7 Fire Protection and Prevention

Fire Extinguishers: Contractor shall provide fire extinguishers that are adequate for potential hazards that may be encountered during their operations and shall instruct employees in the proper use of such equipment.

Materials: Contractor shall insure that the material it proposes to use at the site conforms to contract requirements, insofar as flame-resistant or fireproof characteristics are concerned. Specific materials in this category include fuels, solvents and coatings, plastic-covering materials, construction lumber, scaffold plans, paper, boxes and crating materials.

7.3.8 Crane and Material Handling

Contractor shall comply with the rules, regulations and standards associated with crane safety and material handling. Contractor shall not bring equipment or machinery,
intended for material or personnel handling, on-site without having written proof of a current inspection and crane operator certification. Contractor shall renew any inspection report prior to expiration. Failure to maintain current inspection reports may result in shutdown of the equipment.

7.3.9 Radiography

Contractor, if involved in radiography, shall implement safe operating procedures for radiological activities as required by applicable regulations and standards.

7.3.10 Safety Inspections

Contractor shall conduct periodic (at least once per week) documented safety inspections of their work areas and operations during which the Owner reserves the right of representation. During these inspections, the Contractor shall identify and correct safety discrepancies. Contractor shall participate in general safety inspections conducted by the Owner.

7.3.11 Accident/Incident Reporting

Contractor shall cooperate with the Owner in analyzing any accident/incident. Additionally, the Contractor shall immediately investigate and submit to the Owner written reports of any accident/incident wherein injuries or fatalities occur, or which results in property damage or fire loss in excess of five hundred dollars. These reports shall be submitted to the Owner within twenty-four hours of occurrence. The Owner’s Project Manager shall be notified immediately of any injuries/incident on site.

7.3.12 Record Keeping

Contractor shall maintain all records required by federal and state agencies, which pertain to work related injuries or illness.

7.4 Quality Assurance/Quality Control

7.4.1 Quality Control Program

Contractor shall establish, implement, and maintain a complete Quality Control Program subject to Owner’s approval. This includes the furnishing of a full time on-site QA/QC Manager and a sufficient, qualified, support staff for the duration of on-site work.

The program shall clearly establish the QA/QC Manager and staff as being independent and separate from the Contractor’s supervisory, production, or craft personnel, and that they have the responsibility and authority to enforce quality requirements and to verify the effectiveness of problem solutions and corrective actions.

The program shall be capable of assuring that the design, construction, purchasing, manufacturing, shipping, storage, testing, inspection and examination of all equipment,
materials, procedures, and services shall comply to the requirements of the Contract Documents.

Contractor shall provide all equipment, materials, and labor required to perform all required inspection and testing, temporary isolation or closure of systems and other relative functions and activities as may be required, including providing certified testing personnel and laboratory work as necessary for testing or inspecting soil density, concrete, welding, bolting, alignment, flushing, pressure testing, megger, hypot, grounding resistance, coatings, HVAC, final cleanup, and other work required to support the quality control program and/or requirements or recommendations of applicable equipment manufacturers.

Certain inspections and testing procedures require that the Contractor engage the services of a third party certified testing company to fulfill these obligations. As a minimum this applies to soil density, concrete, asphalt, radiography, mag particle, lube oil and any laboratory tests. As with all subcontractors, Owner reserves the right of approval of their involvement with the Project.

**All the above notwithstanding, Owner reserves the right of refusal or acceptance of any and all work performed on, or in conjunction with the Project.**

7.4.2 Quality Assurance Manual

The QA/QC program shall consist or one or more permanently bound set of documents comprising a single quality assurance manual. The form and format of the quality assurance manual is at the discretion of the Contractor and it’s subcontractors, is subject to final approval by the Owner, and must be singularly used by the Contractor and all it’s subcontractors as the guide for quality performance of all work associated with the Project. The content of the quality assurance manual may be in the form of written descriptions of QA/QC policies, procedures, methods, instructions, exhibits, or other quality assurance method descriptions.

The Contractor’s quality assurance manual shall include at a minimum, control procedures or methods to assure the following:

- Establishment of an independent, on site QA/QC staff.
- Describe the authority and responsibilities of the persons in charge of the quality assurance program.
- Design documents, drawings, specifications, quality assurance procedures, records, inspection procedures, and purchase control documents are maintained current and accurate.
Purchased materials, equipment and services conform to the requirements of these documents.

Receipt and in-process inspections as well as equipment examinations, testing and checkout procedures are properly performed.

The adequate inspection and quality of all Contractor’s subcontracted work and shop fabricated components is included.

That the quality of all special processes such as welding, heat-treating, hot forming and nondestructive testing is properly inspected, verified and documented.

That the proper methods are employed for qualifying all personnel performing welding and non-destructive testing.

Owner’s Project Manager or designee shall have access and, if necessary, copies of all QA/QC documentation.

7.5 Civil/Structural/Architecture

7.5.1 Sitework, Excavation, Fill, and Grading

Contractor shall furnish all equipment, labor, etc. required to complete all excavation, compaction, backfill, imported fill, and grading required for the general sitework, and for the placement of all underground utilities, circ/water piping, etc. This scope includes the import of suitable fill and the off-site disposal of any excess material excavated as required to achieve a balanced site. This includes but is not limited to import of fill necessary to replace on-site material that does not meet the specification criteria for its use. Contractor shall also restore to original condition any roads, ditches, grades, or properties, etc. damaged during the course of work associated with the Project.

7.5.2 Concrete

Contractor shall furnish all materials, equipment, labor, etc. necessary to complete the delivery, forming, placing, finishing, and curing of all concrete foundations and slabs including finish grading and paving wherever specified for the entire site. Contractor is required to obtain Owner sign-off on Pour Cards prior to concrete placement. Scope includes the detailing, furnishing, fabrication, delivery, unloading and placing of all reinforcing steel and embedded items required for all concrete work. This scope includes, but is not limited to, major foundations for the CTG’s, SCR, and stacks as well as all grade and elevated slabs, stair and ladder landings, pump and motor foundations, tank foundations, and foundations for vendor supplied skids, all building foundations, several sumps, electrical equipment foundations, and other such equipment as required by the contract documents. The mix design of any concrete may not be altered to increase its ability to be pumped without the consent of the Owner and the Engineer.
7.5.3 Grouting

Contractor shall furnish all materials, equipment, labor, etc. necessary to complete all grouting required in association with the Project.

Precautions shall be taken to ensure the complete filling of all spaces to be grouted by ramming, puddling or vibrating. The Contractor shall also take measures to prevent pressurizing against a head in a standpipe or accumulating excess grout at any vents, drains, or edges. Vent holes to prevent air pockets in isolated sections such as corners of a stiffened or built-up frame, and in large enclosed or covered areas may be utilized when authorized by the manufacturer’s installation instructions.

Concrete foundations shall be bush hammered and saturated with clean water for 24 hours prior to grouting. All free water shall be removed from the surface to be grouted by controlled jetting or absorption with rags.

7.5.4 Grout Mixes

Proprietary epoxy non-shrink grout shall be used for all bearing purposes. Grout for equipment shall meet the requirements of ASTM C-1107 Grade C for column baseplates. Commercial grout mixes, such as Masterflow 928 and Five Star Grout (U.S. Grout Corp.) or equal (in accordance with OEM’s requirements) shall be used where appropriate. The mix shall be placed and cured in strict accordance with the manufacturer’s recommendations.

Iron powder, aluminum powder additives or chemical grouts using cementing materials other than Portland cement and natural mineral aggregates shall not be permitted.

7.5.5 Structural and Misc. Steel

Contractor shall furnish and/or fabricate (except as otherwise specified in Scope of Supply documentation) and install all structural and miscellaneous steel. Included in, but not necessarily limited to the scope are the main power block structure, inlet air structures, pipe racks, bridges, crane rails, ladders, platforms, stairs, walkways, steel decking, grating, handrails, monorails, and all other structural and miscellaneous steel items required by the contract documents including all components required for assembly such as nuts, bolts, washers, shims, etc.

7.5.6 Steel Erection

The Contractor shall follow standards for steel erection per 29 CFR 1926 Subpart R effective July 18, 2001, and detailed construction specifications. Bolt torque shall be accomplished by the “Turn of the nut” method or by use of compression washers. A minimum of 10% of bolts shall be checked by a calibrated torque wrench.
7.5.7 Buildings

Contractor shall furnish and construct all buildings on the project site as shown on the General Arrangement and described in Section 2. This includes complete installation including foundations, structural steel, plumbing, lighting, HVAC, interior and exterior walls (with acoustical and thermal control treatment as specified in the Contractor’s Engineer’s performance specifications), painting, insulation, fire protection and detection, electrical wiring, building and room I.D. signs, exit signs, etc., as required by the Contract Documents. Contractor shall provide detailed design for all pre-engineered buildings based on Owner’s standardized designs.

7.6 Mechanical

7.6.1 Mechanical Equipment

Contractor’s scope includes receiving, unloading, handling, setting, assembly, alignment, coupling, erection, etc., of all Owner and Contractor furnished equipment including the installation of combustion turbine generators (CTG’s), SCR, air inlet structures with filter media, and all associated equipment including generators, partial or pre-assembled skids, interconnecting piping, valves, fittings, blowers, pumps, ductwork, expansion joints, and other related equipment.

7.6.2 Foundation Preparation

Prior to the setting of any plates or equipment all surfaces that are to receive grout or topping shall be cleaned and checked to be free of any material that may inhibit surface bonding. This verification shall include confirmation that all paint or protective coatings, as required by either the equipment vendor or drawings, have been applied and are dry and that all bolt sleeves are clean. Approval is required by OEM Technical Advisors before setting major pieces of rotating equipment. A pre-pour and post-pour anchor bolt survey is required and must be submitted to Owner for review.

7.6.3 Initial Setting Requirements

All equipment shall be set, aligned and leveled at the position and elevation indicated on the applicable drawings. The equipment shall be set within the identified tolerances necessary for the attachment of all connecting piping and material associated with its assembly.

Allowances shall be made to account for any differential thermal expansion and/or shaft sag of all equipment. This shall allow the Contractor to align the equipment without reducing the built-in adjustability of the mounting hardware (i.e. shim stacks, etc.).

Just prior to grouting, the Contractor shall verify and confirm, using calibrated torque wrenches or extensometers, the correct and even tensioning of all equipment anchor bolts. In addition, the Contractor shall perform a final inspection to ensure any and all shaft alignments.
7.6.4 Alignment of Equipment

All couplings shall be left loose after setting and any connecting pipe flanges shall be unbolted prior to alignment. If a piece of equipment and its driver have been shipped as a complete assembled unit, the coupling shall be loosened before field alignment.

Equipment shall be assembled with proper allowances for end float, seal and wear rings, thrust collar clearances, relation of magnetic center to rest position, up or down thrust, coupling spacing and all other clearances required by the manufacturer or generic to the installation. The Contractor shall match all external markings of disassembled components during equipment final assembly. This shall include all markings identifying the factory balanced rotating parts such as coupling spacers.

After all piping or ducts have been connected to the equipment, a final check shall be made to verify the equipment alignment. Prior to any rotational tests, all halves of motor couplings shall be safely secured.

During testing and preliminary operation, Contractor shall take measurements of the vibration amplitude, acceleration, and frequency on rotating equipment rated at 5 hp and above. This includes drivers as well as driven equipment. These readings shall be one of the determining criteria for equipment final acceptance. In the event that the measurements exceed the vibration tolerances identified by the manufacturer or applicable codes and standards, the Contractor shall take corrective action to meet the specified criteria.

In all cases, after initial run-in and warm-up of equipment, shaft and coupling alignment shall be rechecked with the couplings disconnected as required by the manufacturer. In some cases, when recommended by the manufacturer, readings shall be taken immediately after shutdown while equipment is close to its operating temperature.

7.6.5 Lubrication

Contractor is responsible for supplying the lubricant for the first fill and subsequent fills of lubricants for equipment and is responsible for placing initial and subsequent fills up to Mechanical Completion.

7.6.6 Doweling of Equipment

After the installed equipment has operated at its normal operating temperature for a period of time, alignment shall be rechecked at the equipment’s operating temperature. If alignment is determined to be satisfactory, dowel pins shall be installed in the designated equipment, drivers, and baseplates.

Dowel pins used for final positioning of equipment on baseplates shall conform to the requirements of the Standard for Threaded Taper Pins of The American Society of Tool Purchasers and shall be furnished with threaded tops and fitted with backing out nuts to facilitate pin removal.
7.6.7 Insulation

Furnish, fabricate and install insulation and lagging for all equipment, piping, instruments and tubing, etc. as required by the Contract Documents.

7.6.8 Fire Protection, Detection, and Suppression

Contractor shall provide detailed design (based on Engineer’s performance specification), furnish, fabricate, and install complete fire protection, detection and suppression systems, including local power and control wiring and terminal boxes, etc., as required in each system. Contractor shall furnish and install main plant fire protection panel and any other panels for a complete installation. Contractor shall be licensed per state and local regulations or engage an approved licensed subcontractor for fire system installation and provide all required certifications (including UL and FM approvals and post installation test reports).

7.7 Piping and Supports

7.7.1 General

Contractor shall be responsible for the erection of all large and small bore piping specified in the engineering drawings, otherwise called for in the Contract Documents, and any interconnecting pipe not required to be provided by others.

All large-bore and small-bore alloy and carbon steel pipe shall be furnished and fabricated by the Contractor.

7.7.2 Hangers and Supports

Contractor shall be responsible for the erection of all pipe hangers and supports specified in the engineering drawings, otherwise called for in the Contract Documents or required by code.

Pipe supports for all pipe other than alloy or carbon steel material shall be designed, furnished and fabricated by the Contractor.

Unless noted otherwise in this section, all fabrication, bending, welding and inspection of pressure piping shall be completed in accordance with the Owner’s Specification CHUL-0-TS-15062, Piping.

No unistrut shall be used for pipe supports, including small bore pipe.

7.7.3 Piping Appurtenances

Contractor shall furnish and install all piping appurtenances (strainers, isolation valves, control valves, flow nozzles, flow orifices, restriction orifices, thermowells, venturis, expansion joints, etc.) that are integral to the piping systems. (Note: Some of these items
(materials only) may be furnished by others, but fall within the Contractor’s scope for installation. Refer to the engineering and/or vendors drawings for details).

7.7.4 Bending and Forming

Bending and forming shall be in accordance with the requirements of ANSI B31.1. Bends shall meet all requirements of PFI ES-24. However, the difference between the maximum and minimum diameters shall not exceed 8 percent of the nominal outside diameter of the pipe before bending. Ovality shall be within the limits established by the applicable ASME piping code.

Girth butt welds shall not be located within a pipe bend.

Fabrication tolerances and minimum bending radii shall comply with the requirements of PFI Standards ES-3 and ES-24.

7.7.5 Protection for Shipment

All flange faces, machined surfaces and threads shall be clean and protected from damage during shipment. Flange faces and machined surfaces shall be protected with wood, plastic, or metal covers as appropriate. Couplings, orifices, and threads shall be protected by steel pipe plugs, tape, or by plastic protectors.

7.7.6 Inspection

The Contractor shall be responsible for the inspection of all shop-fabricated piping material. The Contractor shall maintain qualified personnel to check shop and field fabrication of all piping systems for compliance to both material specifications and dimensional accuracy, including weld integrity.

7.7.7 Partial Data Reports

For boiler external piping as defined in Paragraph 100.1.2A of ANSI B31.1, all welding shall be inspected in the Manufacturer’s shop by an authorized inspector representing the Inspection Agency or Insurance Company qualified for this service. Inspections shall be performed as required to ensure an adequate check on the work done and the quality of workmanship.

7.7.8 Fabrication and Installation

Pipe containing longitudinal or seam welds shall not be permitted for feedwater process applications. Threaded joints shall not be permitted in piping systems used for water/steam (design temperature above 175°F), lubricating oil, and CTG natural gas service. Natural gas piping components shall not use synthetic lubricants. Where feasible, Victaulic or equivalent couplings, including crimp-type fittings, shall be used for low-energy aboveground piping.
7.7.9 Welding

In general, welding controls, inspections, examinations, welding procedure content and qualification (including welder qualifications) shall be in accordance with ASME B31.1 for BOP piping and ASME Section 1 for Boiler and Pressure Code Piping.

7.7.10 Backing Rings

Weld backing rings shall not be used.

7.7.11 Slope

Steam piping systems in the plant shall be sloped in the direction of steam flow. Where feasible, the minimum pipe slope shall be 1 percent. Condensate collection in piping systems shall be avoided by installing automatic and manual drain devices as appropriate.

All steam drain lines shall be sloped at 2 percent. Contractor may modify this general design requirement if it becomes impractical to maintain strict adherence; however, provisions for proper drainage shall be maintained.

7.7.12 Dissimilar Metal Joints

In all cases (except for air systems) when a piping connection is made between steel and aluminum or copper, the mating surfaces shall be electrically isolated. Piping that is 2 ½ “ or larger shall incorporate flanges with a non-conductive gasket. These flanges shall use flange bolts fitted with plastic ferrules and plastic washers under the bolt heads. 2” and smaller dissimilar piping connections may be made using the same flange arrangement stated above, or with dielectric-type couplings, bushings or unions.

For alloy steel piping, all trim pipe connections and welded instrument attachments, including thermowells, shall be of the same material and P-number as the main pipe. Thermowells shall not be welded directly into the pipe pressure wall.

7.7.13 Instruments

Installation and orientation of all gauges, site glasses, controllers, thermometers, thermocouples, pressure gauges, etc. shall be maintained to provide ease of maintenance and adherence to industry standards.

7.7.14 Instrument and Branch Connections

Piping branch connections to the first shutoff valve including instrument and sampling takeoffs and flow and pressure connections shall conform to the applicable piping class and shall not be less than ¾ inch nominal size unless the source pipe is ½ inch or smaller. If the source pipe is ½” or smaller the root connection shall be the same size as the line.
7.7.15 General-Pressure Piping Systems

Intersections and branch connections may be made using direct pipe insertion (branch to run), or by employing fittings, tees, couplings, laterals, crosses, weld-o-lets fittings, weld-o-lets, elbow-lets, etc. Regardless of the methods specified, pipe intersections shall conform to the requirements of ANSI/ASME B31.1 Power Piping Code, and shall be sufficiently reinforced to maintain system design pressures. Direct pipe insertion shall not be permitted on thin-wall stainless steel piping systems.

7.7.16 Root Connections

Root connections on horizontal or sloping lines shall not be located below the center of the line. Root valves shall be, unless otherwise specified, of a standard globe pattern, mounted with the stem upright or horizontal. The following guidelines shall be observed:

- Root connections for service on steam, condensable vapors or wet gas shall be taken from the top or side of the pipe or from any point in between.

- Root connections for service on liquids shall only be taken from the side of the pipe utilizing a root nipple horizontal.

- Root connections for service on dry gases shall be taken from the top of the pipe.

7.7.17 Drains, Vents and Traps

All piping systems shall have high point vents and low point drains. Drains with restricting orifices or steam traps with startup and blowdown drains and strainers/crud traps shall be installed in the low points of steam lines. Personnel access to vent and drain valves shall be provided to facilitate proper system operation and may be from grade, stairs, platforms, adders, man-lifts, or other appropriate means based on the frequency of valve operation. Personnel access to vents and drains provided for hydrostatic testing is not considered a normal plant operation activity. Vents 2 (two) inches and larger shall be equipped with bird screens.

The Contractor shall install vent and drain connections at all high and low points on the piping whether or not such connections are shown on the piping drawings. These connections shall be ½ inch for ½ inch piping and not less than ¾ inch for larger piping.

7.7.18 Orifices

Lines fitted with restricting devices, such as orifices in the process runs shall include adequate drainage upstream of the device to prevent water from collecting in lines.
7.7.19 Pipe Sleeves

All pipes passing through masonry walls or floors shall have sleeves provided. Sleeves shall be sized and have clearances to allow for packing and sealant installation. At a minimum, sleeves shall be 18-gauge carbon steel (hot dipped galvanized). Where required, the annular space between the pipe and sleeve shall be packed with fiberglass or special materials as required for fire or air pressure barriers.

7.7.20 Hydrostatic Testing

Hydrostatic testing, when required, shall be conducted prior to field painting, coating or insulating and shall be witnessed by representatives of the Contractor and Owner. Hydrostatic testing shall be performed to meet all relevant code requirements and acceptance criteria.

ASME B31.1 requires a hydrostatic test for Boiler External and Non Boiler External piping. Owner does waive hydro in cases where the test is impractical (circulating water lines) and on some water lines with a design temperature rating under 140 deg F with prior approval from Owner. Under no condition other than those stated above shall hydro be waived. Waiving hydro in lieu of in-service testing shall require a system review and walk down by Owner’s QA.

All welds regardless of material and including HDPE piping except those large bore circulating water lines and welds specifically exempted by Owner shall be exposed for visual examination during hydro.

7.8 Electrical

Contractor shall install all electrical equipment and components, including but not necessarily limited to motors, motor control centers, switchgear, SCS GSU/Auxiliary Transformers, all other transformers, generator circuit breakers, panels, electrical cable, conduit and other raceway, lighting, grounding, lightning protection, fire protection and detection, and other related components as may be required by the Contract Documents. Contractor’s scope also includes installation of all electrical materials provided by Owner’s major equipment vendors. The Contractor shall furnish all items required to provide a complete functional operating facility.

The Contractor shall handle, set, level, assemble, check, connect, ground, clean and perform preliminary tests to all electrical equipment as defined in the contract document.

7.8.1 General

The Engineer and major equipment suppliers shall define hazardous location types, locations, and boundaries as applicable to their respective scope of work. The Contractor shall install and erect all equipment in accordance with the National Electrical Code and NFPA 70.
Panelboards

Panelboards shall be installed level and plumb and shall utilize all provided mounting holes. Conduits shall be connected and all wiring shall be pulled before any panelboard internal hardware is mounted. Wiring shall be symmetrically arranged in the gutters with all unnecessary conductor lengths eliminated. The panelboard shall be covered prior to the installation of its faceplate. This shall protect the unit from contamination and damage until the permanent cover is installed. In addition, all panelboards shall contain a complete typed directory detailing the exact location of all loads served from each associated circuit.

Control Panels and Consoles

All external connections to any control panel, unless prefabricated, shall be terminated on screw type terminal blocks. All panels shall be mounted level and plumb and shall meet all NEC requirements. In addition, unless otherwise noted all junction and terminal boxes shall possess gasketed screwed covers. Where necessary to provide rigidity, heavier steel plate or stiffening members shall be used.

Fire Alarm

Contractor shall design (based on Engineer’s performance specifications), fabricate, furnish and install all fire alarm systems including local power and control wiring, panels, devices, terminal boxes, enclosures, etc., as required. Means to trip/isolate all HVAC during fire condition shall be provided.

Lightning Protection

Contractor shall design (based on Engineer’s performance specifications), fabricate, furnish and install all lightning protection systems including local power and control wiring, panels, devices, terminal boxes, enclosures, etc., as required.

Heat Tracing

Contractor shall design (based on Engineer’s performance specifications), fabricate, furnish and install all heat tracing systems including local power and control wiring, panels, devices, terminal boxes, enclosures, etc., as required in each heat traced area. Heat tracing scope includes heat tracing for all instrument tubing, piping, equipment, and similar items provided or installed by the Contractor and/or others (Vendors).

Instruments shall be freeze protected by utilizing soft, reusable type enclosures (reference Section 3.0 Mechanical Systems & Equipment, paragraph 3.18, Insulation and Cladding).

Cathodic Protection

Contractor shall design (based on Engineer’s performance specifications), fabricate, furnish and install all cathodic protection systems including local power and control wiring, panels, devices, terminal boxes, enclosures, etc., as required.
Motors

When practical, motors shall be stored in their permanent locations. Wherever stored, the motors shall be protected, maintained and periodically inspected to meet the motor manufacturer’s recommendations. After installation, each motor’s internal heater shall be connected to its permanent power source. If the permanent source is not available within 10 days the Contractor shall supply a temporary source to energize the motor heater. Additional motor wiring shall be completed and terminated in accordance with manufacturer’s instructions.

7.8.2 Conduit

General Requirements

The Contractor shall furnish and install a complete conduit system including all support hardware (i.e. hangers, brackets, inserts, anchors, turn-ups, markers and steel structures).

All metal conduit and fittings shall be industrial grade electrical products and shall bear the label of the “Underwriter Laboratories.” These products shall also meet the requirements of ANSI C80.1 and ANSI C80.4.

Electrical metal tubing including enameled and aluminum EMT shall not be used for power, control, instrument or signal wiring. In addition, aluminum conduit shall be used on the cooling tower. All conduit fittings and reducers required shall be provided by the Contractor and shall be of the threaded type. All metal conduits shall be grounded and ground bushings shall be utilized on all isolated conduits or conduit systems.

All conduits entering indoor equipment enclosures, terminal boxes, pull boxes, etc. through drilled or punched holes shall be terminated with a sealing lock nut. Outdoor conduit penetrations shall use Meyer’s hubs in lieu of a sealing locking nut.

The Contractor shall strictly follow all hazardous area requirements. All conduit seals shall be poured after Owner’s approval. Fire stops shall be installed in all fire-rated walls and all conduits entering or leaving buildings and underground vaults shall be sealed to prevent moisture transfer.

Above Ground Conduit

Conduit runs shall be installed to avoid conflicts with passageways and the operation and/or maintenance of equipment. Wherever practical, conduit runs shall be run parallel or perpendicular to the dominant surface. All exposed open-ended conduits shall be sealed (i.e. where cables leave a conduit and enter a tray). Low point drains shall be provided for all conduit systems.

Conduit connections to vibrating or moving equipment such as motors, motor operated valves, belt driven equipment or equipment requiring ready removal for maintenance
shall be made with galvanized steel jacketed flexible conduit with external bonding jumpers.

**Underground Conduit**

Unless Owner approves otherwise, all underground conduits shall be encased in concrete as required by the table below.

<table>
<thead>
<tr>
<th>Location</th>
<th>Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within 36” of manhole, vault, or other at grade or below grade structure.</td>
<td>3,000 psi concrete with XYPEX waterproof admixture.</td>
</tr>
<tr>
<td>With cover less than 24” to finish grade</td>
<td>2,000 psi concrete</td>
</tr>
<tr>
<td>All other locations</td>
<td>2-sack sand/cement slurry</td>
</tr>
</tbody>
</table>

In all cases a red dye marking or electric service designation tape must be placed on top. Reinforcing steel is not required but may be used to tie or support the duct during construction. The Contractor shall slope all underground conduit ducts toward manholes where possible for drainage. Underground conduit shall either be rigid non-metallic schedule 40 conduit PVC or galvanized rigid metal conduit as required to meet cable separation criteria. Transitions from plastic to metal conduit shall be made by the use of approved watertight adapters. Conduit turn-ups for termination into building walls, equipment foundations or elsewhere shall employ steel galvanized conduit elbows. The underground portion of all metal conduit elbows shall be taped or painted with asphaltum and each conduit turn-up or trench penetration shall be identified with a non-ferrous tag.

The Contractor shall ensure that all conduit turn-ups are plumb and perpendicular to the horizontal floor plane. To meet these criteria, the Contractor shall install temporary extensions to each stub-up to verify that they are plumb using a 4° level.

**7.8.3 Cable Tray**

Cable tray design loading (including the tray), at a minimum, shall support 50lbs/ft and shall take into account the appropriate seismic loading for the site. In addition, the Tray System shall be capable of temporarily supporting a 200 lb static load.

Per NEMA VE-1, all “Cable Tray Systems shall be made corrosion-resistant material.” Acceptable tray materials include aluminum, stainless steel or hot dipped galvanized steel.

Fiberglass cable tray shall be used at the cooling tower and areas subject to cooling tower water spray. Stainless steel hardware shall be used for support.

The Contractor shall use the manufacturer’s standard fittings, connectors, hangers, clamps, etc., in the construction of the cable tray system. The cable tray system shall be completely grounded and the top tray of all outdoor trays shall be covered. Cable tray
fittings shall be as provided by the cable tray manufacturer. Field fabricated fittings or direction changes with out fittings shall not be accepted.

All rough edges shall be ground smooth and all damaged or nicked galvanized surfaces shall be coated with zinc-rich paint.

7.8.4 Cable Installation

General Requirements

All cables and conductors shall be installed continuous from end to end with out splices. Cables shall be supported inside of all electrical raceways, equipment and junction boxes to prevent distortion of the insulation jacket. Power cables in horizontal runs shall be secured to the tray in intervals not exceeding 10’ while all cables in vertical runs shall be attached to their corresponding raceway or tray every 4’. Cables shall be arranged to minimize cable stresses at all bushings and end bells.

All conductors and cables that are exposed behind control or instrument panels shall be bundled together with either linen cord or nylon ties in a nest and orderly fashion. Splices shall not be made to utilize cables or wires that were cut to short for the service for which they were originally intended.

High temperature cable shall be used in all areas potentially exceeding 90 degrees Celsius.

Cable Installation in Conduit and Duct

All conduits shall be clean and dry when cable is pulled. To meet these criteria, each run shall be blown out (except those with turn downs at both ends) and visually inspected for internal obstructions and debris. In addition, any conduit or duct showing a significant amount of internal dirt or moisture at either end shall be cleaned by pulling a mandrel or brush through the associated run. Manholes, hand-holes and underground duct shall be pumped dry and cleaned before any cable is routed through the structure. A nylon pull string shall be left in every spare conduit.

Before starting a pull, the Contractor shall inspect both conduit ends for irregularities or burrs that could damage the cable. Cables shall be feed into conduits and ducts by hand, flexible feed tubing or large radius feed-in fittings. Cables in vertical conduit runs shall be supported by approved clamp type fittings or basket type cable grips that meet the requirements of Article 300-19 of the National Electric Code. If necessary, the Contractor may use manufacturer approved cable lubricants while performing these pulls.

Wherever possible, the Contractor shall pull cables into or through duct banks or manholes directly from their associated cable reels. These cables shall not be dragged over the ground, obstructions or the sharp corners of manhole frames and shall have all slack necessary to fasten each cable to its final position. Particular care shall be used in
duct line installations to guarantee that cable ends are not submerged in water and that the integrity of their associated seals are maintained.

Cable Installation in Tray

Cables shall not be pulled over the sharp corners of trays and/or supports. At each pull-in point, they shall not be dragged over obstructions or rough floors without protection. Large cables shall preferably be pulled by hand directly from their reels using long radius guide fittings at the entrance of the associated tray.

Cables shall be laid neatly in trays. The Contractor shall take care to avoid unnecessary crosses and cable crowding at each tray edge. Where required, low voltage power cables may leave the tray vertically. These cables shall be supported to maintain their minimum bending radii (cables shall be supported at a minimum of every 3 feet).

Cables installed in trays shall be protected from mechanical and/or fire damage from the time of their installation. All cable trays shall be periodically inspected and cleaned throughout the facility’s construction to keep all dirt, refuse, scrap materials, and rubbish from accumulating in them.

7.8.5 Cable Terminations

General Requirements

All cables shall be terminated as soon as possible, if not, the cables shall be sealed in accordance with the manufacturer’s instructions. Indoor terminations shall be conducted in a clean environment free of excessive dirt or dust and protected from all potential contaminants.

Where required to provide a clean, dry and sheltered work area, the Contractor shall erect temporary weatherproof shelter for completing outdoor terminations.

Power Terminations

All termination work on medium voltage cable shall be performed by qualified and experienced workmen.

Connectors and terminal lugs for all power cable shall be of the compression type. Only dies and fittings of proper matching sizes shall be used. All terminal fittings shall be of the closed barrel type. Compression tools shall give positive indication of completion of compression and shall be hydraulically operated for size #6 AWG and larger. For size #8 AWG and smaller, compression tools may be manual positive ratchet type compression devices.

All connectors and lugs shall be ring type. Ring tongue type connectors shall not be cut to facilitate their installation on screw terminals. Pressure type connectors for 4/0 and larger shall be of the two-hole type.
Cable terminals having two or four bolt pads are preferred to single bolt pads. Bolt hole spacing shall meet NEMA standards and match the corresponding holes in the equipment terminal pads. Owner recognizes that single bolt lugs must be used in some applications.

Copper adapters shall be supplied by the Contractor at all low voltage terminations that do not provide sufficient space to accommodate the pad widths of the compression lugs utilized. If there is insufficient clearance between terminations, the portion of the cable terminal and adapter outside of the barriers shall be taped and painted with insulation varnish.

Joints between cable terminal pads and equipment terminal pads, buses, and other cable terminals shall utilize standard Unified National Course (UNC) bolting hardware.

Silicon-bronze hardware and lock washers shall be used for connecting all copper to copper surfaces.

Termination of power cables at or within switchgear and at other enclosures shall include clamping or sealing fittings to provide support to assure watertight assemblies at each conduit end. The Contractor shall supply the correct sizes and types of fittings for each associated cable. In addition, all cable openings shall match the actual diameters of cables. Sealing fittings shall be of the gland seal type and shall be installed in accordance with the manufacturer’s instructions.

Termination of 5KV-shielded cables shall utilize stress cones that meet the manufacturer’s recommendations.

After the completion of testing, all cable lugs shall be bolted to the equipment terminals and final insulation and taping completed. All power connections to medium voltage 5KV equipment shall be insulated for full voltage in accordance with manufacturer’s instructions. Bare copper contact surfaces shall be cleaned and wire brushed if heavily oxidized. Copper or aluminum contact surfaces which are tinned shall not be wire brushed or otherwise abraded.

Before motor terminations are made, a Phase Rotation Meter shall be used to verify phasing for correct rotation. Should the motor rotate in the wrong direction upon energization, the Contractor shall correct the condition by interchanging one set of phase leads.

### 7.9 Electrical Identification

#### 7.9.1 General Requirements

All nameplates and electrical identifications shall be supplied by the Contractor as part of the electrical system. In general, each nameplate shall identify the equipment or device designation. All electrical equipment, including, but not limited to, motor controls, disconnect switches, instrumentation, motors, transformers and panelboards shall be
furnished with an external nameplate for identification. Prior to nameplate mounting, the associated surface shall be cleaned to assure proper adhesion.

**Conduit**

Underground conduits shall be identified with non-ferrous tag at each turn-up or trench penetration.

**Cable and Wire**

Permanent identification tags delineating the complete cable number shall be installed at both ends of each cable. Cable identifiers shall be of either heat shrink or tie wrap type. Supplementary to the cable identification tags, the Contractor shall tag each individual conductor or instrument pair at each terminal with the wire designation as shown on the project schematics and/or the manufacturer’s as-built drawings. These identifiers shall be manufactured with white heat shrink tubing and shall be sized to slip neatly over each of their associated wires. The lettering shall be sized to facilitate the quick identification of each conductor and all spare wires shall be identified with an ID tag labeled “spare”.

7.9.2 **Grounding**

**General Requirements**

All equipment grounding shall comply with all NEC requirements. In addition, the following grounding rules shall apply:

- Bonding shall be performed to meet all Regulatory Requirements.
- Conduit shall not be used as a grounding conductor except for itself and lighting fixtures.
- All grounding conductors shall be 12 AWG or larger.
- All below grade connections between grounding conductors shall be made using exothermic weld type connections.
- Equipment grounding conductors shall be installed with all feeders and branch circuits. These ground conductors shall be terminated on each end on a suitable lug, bus or bushing.
- All underground grounding conductors shall be supplied with slack to allow for earth movement.
- Cable trays containing power and control cables shall be installed with a bare 2/0 continuous ground cable run the entire length of the tray.
• All grounding surfaces shall be thoroughly cleaned prior to the connection of any grounding conductor.

• Ground bushings shall be grounded with conductors sized in accordance with the National Electric Code, but not smaller than #8 AWG.

7.10 Instrumentation and Control

7.10.1 Instrumentation

Contractor shall furnish and install all instruments and instrumentation components associated with all project related equipment including the SCS. Contractor’s scope also includes installation of all instrumentation materials provided by Owner’s major equipment vendors.

Instruments shall be installed properly by the Contractor one time in accordance with the contract documents and more specifically according to Engineer’s and manufacturer’s recommendations. Initial factory or shop calibration of any instrument is the responsibility of whoever furnished that specific component. The Contractor shall perform any field calibration of plant components and a certificate of calibration shall be provided to the Owner. Owner supplied OEM instruments, if found to be out of calibration shall be corrected by Contractor.

7.10.2 Control Cable Terminations

Control cables consist of single or multiple conductor cables of sizes #8 to #14 AWG, inclusive. These conductors shall be terminated in panels or at equipment on screw or compression type terminal blocks. All control terminations to compression type terminal blocks shall utilize ferrules sized per the manufacturer’s requirements.

All control conductors landing on screw type terminals shall be provided with insulated, crimped, tinplated ring lugs.

No more then 2 conductors shall be terminated at each terminal connection.

Junction boxes containing more than two control wires shall use screw type terminal blocks and compression type lugs (also known as ferrules). All control wires shall be identified and splices shall not be permitted.

7.10.3 Instrument, Signal, and Communication Cable Terminations

Instrument, signal, and communication cables are defined as cables carrying low-level signals subject to electrical noise interference. They consist of twisted pairs, multipair communication cables, thermocouple pairs, multiple pair extension cables, sound powered communication cable and other special constructions. The conductors are generally copper (except for thermocouple extension cables) and conductor sizes are typically #14 AWG and smaller.
When the cable or equipment manufacturer does not provide termination or wiring instructions, terminal fittings and methods of termination similar to those outlined for control cables shall be utilized.

7.10.4 Instrumentation Installation

This section covers the general requirements for the installation of all instrumentation, control and sensing piping, as well as, the fabrication of the associated instrument racks. All installation shall be done in accordance with Instrument Society of America Standards.

Individual instruments shall be grouped on the instrument racks to minimize the length of the primary instrument tubing. However, primary instrument runs shall not be extended in order to allow large groups of instruments to be located on common racks.

After installation all piping, tubing, instrument racks and instruments shall be protected from damage caused by falling debris and weld slag. Any instrument, piping or tubing found to be damaged shall be replaced at the Contractor’s expense.

The air supply to all pneumatic operators shall terminate in an indicating pressure regulator with filter.

Head sensing devices are to be provided with instrument shutoff valves and instrument test valves.

Differential transmitters shall be provided with a three-valve manifold to isolate and calibrate the transmitter.

7.10.5 Instrument Rack Assemblies and Supports

The instrument racks and stands shall be constructed to retain structural integrity throughout the plant life. They shall remain intact and upright after a seismic loading test as described in previous sections of this standard.

Piping and tubing runs shall be solidly supported near the instrument to minimize instrument body stresses. All tubing supports shall be field removable without resorting to cutting or burning. The Contractor may use commercial 1-hole or 1-hole tube clips and 2-piece tube clamps to support instrument tubing. All tube hangers and hanger steel shall be zinc galvanized.

Instruments and instrument loop components shall be mounted in a manner that assures their protection against mechanical damage, wetting, extremes of heat, and harmful vibration. The instrument mounting shall provide easy access for the field repair and calibration of the instrument, as well as, access to the rear of the instruments for disconnecting, removing or replacing the devices. In addition:
Instrument racks, stands and mounts shall be located in a manner which shall conserve floor space and, shall not obstruct walkways or equipment handling areas.

Instrument supports shall not be mounted on or connected to handrails, stairways, machine bases, plant piping or to any equipment subject to severe vibration, sway or movement under load.

Indicating instruments shall be located and oriented for easy readability from the applicable operating station. Groups of indicating instruments shall be thoughtfully arranged with regard to their functional relationship to each other.

Local isolated instruments shall be mounted approximately 4 foot – 6 inches above the grade.

7.10.6 General Installation Details

Instrument and pneumatic pipe routing shall maintain adequate distances from all outside walls, doorways and areas of extreme heat to minimize ambient effects on control lines.

Field run piping shall be routed and shielded to protect it from any physical damage during construction and plant operation. The tubing shall not obstruct walkways or equipment maintenance, handling areas or space for equipment disassembly or removal. Where practical, clearances of 7 feet above floors and walkways and 10 feet above the ground floor shall be maintained.

Instrument lines subjected to severe sonic pulsation shall be of sufficient length, and of suitable configuration, to dissipate sonic wave energy before it reaches the instrument. The Contractor shall install pulsation dampers on all instruments requiring them.

Multiple tubing bundles may be used wherever they are feasible.

Spare pneumatic and hydraulic tubing lines shall be capped at both ends.

Instruments shall be freeze protected by utilizing soft, reusable type enclosures (reference Section 3.0 Mechanical Systems & Equipment, paragraph 3.18, Insulation and Cladding).

It shall be assumed that all instrument tubing is subject to thermal movement, including those used in cold water service and at ambient temperatures. The Contractor shall design all supports to accommodate this thermal drift.

Wherever practical, piping support structures shall be supported independently of instruments and/or instrument supports (cabinets, racks, stand, brackets, etc.). Where independent support is not possible, vibration-absorbing mounts shall be provided at all points of contact with the instrument.

Support structures for primary instrument piping shall not be supported from or connected to root valves or root nipples.
Tubing and piping which shall be hot while in service or that may be heated temporarily during a blowdown or as a result of a leakage, shall be routed and protected so that its heat shall not injure any personnel or damage any nearby equipment.

All tubing or piping located in personnel work areas or access ways shall be installed with a minimum 1” (one inch) clearance after the installation of insulation or metal barriers or both.

Hot tubing or piping shall be kept at a sufficient distance from other equipment to preclude heat damage or deterioration of the equipment by radiation or convection under all anticipated conditions of air movement, ambient temperature, etc.

Capillary tubing for filled system temperature and pressure measurement devices shall be protected by channel supports. All capillaries shall be attached to the channels with clips. Excess lengths of capillary tubing shall be neatly coiled and secured. The preferred location for excess capillary is at or near the instrument.

All copper, steel, stainless or alloy tube bending shall be performed cold. No tubing shall be heated to annealing or plasticizing temperature, except as required for the specified soldering, brazing, or welding work.

Where space permits, all tubing, except hard copper, shall utilize bending in lieu of elbows.

All male threaded pipe joints shall be doped with Crawford “High Purity Goop,” or equal. The use of Teflon tape is prohibited.

All instrument racks, enclosures and stands set on concrete floors shall allow a minimum of 1 inch clearance for grout. When mounted to decks covered with a grating or checker plate, these panels shall not be set on or fastened to the grating or plate. Instead, they shall be placed directly on the underlying steel beams or on additional beams provided and installed by the Contractor for added support purposes. Where necessary, all grating or plate shall be trimmed out eliminate interferences. Provisions shall be made to easily accommodate any removal sections of grading.

All transmitter racks shall be fully painted (one prime coat and two finish coats as specified above) before any equipment is mounted.

Touch-up painting shall be performed by the Contractor.

The Contractor shall subject all installed piping to tests and/or inspections to assure that there no leaks in piping or tubing.
7.10.7 Instrumentation and Instrument Racks

All instrumentation shall be identified by with an engraved external corrosion resistant nameplate. The nameplate shall identify the device tag number as shown in the plant Piping and Instrumentation diagrams.

All instrument tube ends shall be tagged at the bulkhead strip with a removable nameplate identifying the connected instrument and, in the case of pressure differential instrument, H or L to indicate the appropriate port connection.

All transmitter rack assemblies shall be identified with a permanent nameplate permanently attached to the steel rack in a highly visible location.

7.11 Commissioning/Turnover

Commissioning Support

Contractor shall provide qualified craft to commissioning team. The turnover and commissioning responsibilities shall be as defined in Section 8 of these Project Technical Requirements.

8 COMMISSIONING

8.1 Introduction

The requirements specified in this section pertain to the calibration, testing, preoperational checkout, commissioning, and testing of all equipment described at a summary level and do not fully specify all practices and procedures that the Contractor shall need to follow to meet his responsibility to furnish a safe, quality-built, timely, complete, functional facility while safeguarding the environment and adhering to all laws, ordinances, regulatory requirements, and standards. The Contractor shall have complete responsibility for performing all commissioning and acceptance testing planning, activities, documentation up to Commercial Operation, with exception of specific responsibilities assigned to the Owner herein.

This section’s requirements are supplemented by a sample Construction to Commissioning turnover package is for a typical MMC Chula Vista. All commissioning procedures, methods and forms shall be organized into a Commissioning Project Procedures Manual and submitted for Owner comment prior to use. The Contractor shall submit copies of all the commissioning records to the Owner to document the results of all the commissioning activities. Documentation shall be prepared and submitted in accordance with Scope Book Section 9: Documentation and Submittals.
8.2 General

8.2.1 Scope of Services

The following is intended to give a general definition of the scope of the work under this section, and shall not be construed to be an itemized listing of each element of work required.

The Contractor shall provide complete calibration, check out, testing, and commissioning of all systems. The Contractor shall perform manufacturer’s specific recommendations for commissioning, check out or testing in addition to those described in this section. All work shall be performed in accordance with the procedures and methods established by the Commissioning Project Procedures Manual.

The Contractor shall commission all equipment and systems associated with the plant except high voltage switchyard and the SDG&E fuel gas metering station. The Contractor shall work with the technical field advisors (TFA’s) to install and commission the CTG and SCR/CO exhaust systems.

As a minimum part of the commissioning process, the Contractor shall provide the following commissioning services as part of the required scope of services: Many of the items below are to be considered part of the construction process and shall be constructed prior to the turnover to S/U. Also many of the items listed below are part of the integrated testing for the facility. In any event all of the items below shall be part of a comprehensive construction and commissioning package.

- Scope Subsystem Turnover Packages P&ID’s
- Place System Boundary Tags in the field
- Prepare System Turnover Packages per “Sample Turnover Packages Table of Contents”
- Develop and maintain commissioning Schedule
- Provide Supervision of Craft Support for Commissioning
- Administer a Lockout Tagout Procedure, and transition LOTO to Owner
- Prepare and Maintain Master System Punch List
- Maintain Red Line As-Builts for Turnover Packages
- Prepare Required data Sheets and Test Records
- Provide Complete O&M Manuals for each Equipment Item Provided
- Provide Operator Training of Purchased Equipment
- Issue Commissioning As-built Drawings
- Prepare Plant Energization Procedures
- Prepare and Submit Performance, Noise, Stack Emissions, Reliability, and Functional Tests
- Perform Site Specific Training
Mechanical

- Perform equipment alignment (brake coupling)
- Design, supply, install and remove temporary piping gas blows
- Furnish, install and remove temporary piping and equipment for oil flushes
- Flush piping and equipment
- Clean tanks and equipment prior to commissioning
- First fill lubricants and chemicals
- Verify pump strainers and filters are installed
- Couple rotating equipment (final)
- Perform vibration checks
- Perform oil flushes
- Remove piping hanger stops and set in "cold" positions
- Furnish and install start up strainers, remove after commissioning
- Operate permanent plant equipment - coordinate with Owner
- Furnish start up spares
- Tag all equipment and valves

Electrical

- Provide temporary power for motor/equipment space heaters
- Continuity checks of all cables
- Megger all power cables 120 V and higher
- Hi-Pot medium voltage cables (2-15 KV)
- Dress out and fill transformers
- Test transformers
- Perform high voltage insulation tests
- Test transformers
- Provide Protective Relay Settings
- Backfeed plant (coordinate with RE and switchyard Contractor)
- Develop integrated Plant Protective Relay and Metering Coordination Study to develop relay settings
- Test high voltage breakers
- Test Current Transformers and Potential Transformers
- Megger motors 25 HP and larger per site quality control measures
- Check motor rotation
- Motor run-in and vibration checkout
- Final Relay Setting/Calibrate

Instrumentation

- Verify per instrument data sheet
- Provide calibration set points
- Final instrument calibration
8.3 Commissioning Safety

In addition to those safety processes and procedures implemented for construction, Contractor shall set up, execute, and maintain, a site-specific lock-out/tag-out process and procedure, which shall refer to, a safe means to secure all types of stored energy (electrical, mechanical, etc.) Contractor shall submit the same procedure to the Owner for review and comment prior to implementation. The LO/TO procedure shall be demonstrated through the site safety orientation. Any personnel dealing with any LO/TO implementation must first be trained to the specific procedure. The ECP Contractor shall maintain documentation of LO/TO procedure training for the duration of the project and records shall be available for audit by Owner at any time.

8.4 Commissioning Project Procedures Manuals

A Project specific Commissioning Procedures Manual shall be developed by the Contractor to cover all work to turn over a fully commissioned plant. This manual shall be submitted for review and comment to the Owner no later than 270 days after Notice to Proceed is issued by the Owner. The procedures shall be complete in all detail and shall be specifically designed for each component, equipment, and system.

Such manual shall include, but not be limited to, the items set forth below:

- An alphabetical listing of all plant systems, providing the names, general system description, and a brief description of mechanical and electrical boundaries.
- The sequence for commissioning each commissioning subsystem.
- A description of the Contractor’s inspection, testing, and preparational check out activities including sequential and step-by-step test procedures and write up.
- A general description of contractual performance, functional, and acceptance tests which are applicable to plant equipment and systems.
• A description of the environmental compliance tests which are required. These descriptions shall be grouped for each environmental consideration.
• Check lists, forms, test formats, and data sheets.
• A commissioning schedule providing task durations, forecasted turnover dates, and identification of critical path.
• Lock-out/tag-out procedures.
• Acceptance criteria for system cleanliness.

8.5 Personnel

The Owner reserves the right to approve the candidates for Commissioning Manager and Technical Supervisors.

The Contractor shall provide all labor including, but not limited to, supervision, administration, and management. The Contractor’s Commissioning Manager shall provide overall coordination of the Commissioning program from the completion of construction through system turnover to the Owner.

Personnel provided by the Contractor shall include, but not limited to, the following classifications.

Technical Supervisors

Each technical supervisor shall be experienced in the particular work he/she is assigned to administer. Technical supervisors shall be in the experience areas of electrical engineering and metering, instrumentation and control systems, and power plant mechanical and fluid process systems.

Electrical and Instrument Technicians

The Contractor’s technicians shall be experienced in the calibration and adjustment of electrical apparatus, protective relays, instrumentation, control equipment, and final drive devices. Technicians shall be experienced in working with electrical schematic and wiring diagrams, electrical one-line and three-line diagrams in accordance with calibration and checkout assignment.

Craft

Sufficient numbers of craft shall be provided by the Contractor to support completion of the work included under this specification. A group of craftsmen shall be assigned and dedicated for support of testing and checkout assignment.

Technical Field Advisors

Technical field advisors (TFA’s), and manufacturer’s service representatives (MSR), of various systems and equipment packages such as turbines, generator, switchgear, control system, general services pumps, air compressors, HVAC equipment, and others, shall be
present during erection and commissioning as required. Upon completion of construction, the TFA shall thoroughly inspect equipment and perform all adjustment with craft support furnished by the Contractor. The TFA for the SCS shall be onsite from the Energization of the control system through final tuning and runback tests.

Owner furnished equipment TFA’s will be provided by Owner. The Contractor, through the Owner, shall be responsible for coordination and scheduling of TFA’s to the site.

Note: The Contractor shall be cognizant of the limited total man-weeks of the TFA time included within the Owner furnished equipment.

**Owner Operational Personnel**

The Owner will make available Owner Operations personnel during commissioning and acceptance testing for purposes of operating plant equipment and systems during commissioning and testing up to Commercial Operation. Contractor shall provide direction of Owners Operations Personnel and in the job training during commissioning and acceptance testing.

### 8.6 Equipment

The Contractor shall supply all the test and calibration equipment, materials, and services necessary to perform the system calibration, checkout, flushing, acceptance and initial operation complete and in accordance with Contract.

The test equipment shall be periodically certified. Test equipment found out of tolerance during certification shall be replaced or repaired. Calibrations performed with the equipment found out of tolerance shall be recalibrated. Test equipment provided by Contractor shall include, but not limited to, the following categories:

- 5000 Volt Megger
- Dielectric Test Set, to test to any provided cable.
- Null Balance Earth Tester
- Resonant Reed Tachometer
- Strobe/Photo Tachometer
- Ultrasonic Corona Detector
- Protective Relay test Set
- Watt-hour Meter Test Set
- Low Voltage Breaker Test Set (for each amperage utilized)
- Motor Overload test set
- Molded Case Circuit Breaker Test Set
- Potential transformer test Set
- Current Transformer Test Set
- Harmonic Distortion Analyzer
- 2 and 3 Wire Outlet Tester
- Voltohm-milliammeter
8.6.1 Special Test Equipment

The Contractor shall be responsible for procurement of certain special test equipment. This equipment includes, but is not limited to, the following categories:

- Analyzer Calibration Equipment
- Special Circuit Card testers
- “DOBLE” Test Set (Transformer Tests)

The special test equipment maybe required to calibrate or adjust certain devices or systems, and may not be required for the full duration of the project schedule. The Contractor shall provide or arrange provisions for all required special test equipment in a timely manner to complete the work with accordance with the project schedule.

Any programmable logic controller (PLC) programming equipment for a PLC system shall be in a condition that is satisfactory to the Owner prior to its turnover to the Owner.

8.7 Notification

The Contractor’s Commissioning Manager shall notify the Owner in advance of all scheduled construction alignments and testing on any piece of equipment, subsystem, or system and shall provide access for the Owner’s personnel to witness the testing. The Commissioning Manager is also responsible for notifying and scheduling all TFA or other applicable representative witnesses for testing.

8.8 Coordination

The overall Commissioning sequence and logic shall be developed by the Contractor’s Commissioning Manager so that subsystem Turnover Packages are completed and presented to the Owner for review and comment in proper sequence to support an orderly Commissioning.
The Contractor shall maintain a system turnover checklist to track the status of the systems.

Commissioning activities shall be coordinated with the Owner’s staff and the Owner will have the right to witness any and all commissioning activities.

The Contractor shall energize and operate the equipment for the first time. The lineup of valving, and operation of required support elements for this commissioning activity shall be performed by the Contractor.

The Contractor’s Commissioning Manager shall coordinate the efforts of the Contractor and the applicable OEM representatives in commissioning of the equipment. The Contractor shall provide and connect the Commissioning instrumentation required to monitor initial operation and support control balancing for all BOP systems. The Contractor shall record data required to analyze the initial system performance.

The Contractor’s personnel shall perform calibration of permanent instrumentation at the direction of the Contractor’s Commissioning Manager. Errors found during or after system Commissioning shall be corrected. The subsystem Turnover Package exception items shall be completed and verified by the Contractor’s Commissioning Manager. The Contractor’s Commissioning Manager shall formally notify the Owner of exception item completion.

8.9 Commissioning Coordination Meetings

The Contractor’s Commissioning Manager shall conduct a weekly Commissioning Planning Meeting and a daily Commissioning Coordination Meeting. All Contractor personnel and subcontractors performing work shall attend, as well as the Contractor’s Construction Superintendent, appropriate TFA’s, and the Owner.

8.10 Mechanical

This section covers the testing, checkout, and calibration of the mechanical components of the equipment and systems furnished and installed under these specifications.

The Contractor shall render all services and do all the work required to place each item of equipment installed, including all auxiliaries, into operation in accordance with Commissioning Procedures manual, OEM instruction manuals, TFA written commissioning procedures, and the project specifications and drawings.

Preoperational checks and inspections shall be performed on all equipment as specified in the Commissioning Procedures manual and in accordance with the equipment manufacturer’s recommendations. A representative of the Owner shall be notified and have the right to be present during the equipment checks. It shall be the responsibility of the Contractor to have the TFA’s on site when required.
The Contractor shall furnish and apply all oils, greases, and other lubricants required to take permanent plant equipment in condition ready for operation. The Contractor shall provide all temporary instrumentation and gauging devices required during checkout and trial operation of the equipment and systems.

The Contractor’s construction and commissioning records shall document that all work and checkouts have been completed, and when the services of equipment TFA’s are required, the Contractor shall include verification by such representatives that the equipment is ready for trial operation.

8.10.1 Rotating Equipment

The Contractor shall perform, as a minimum, the following tasks and preoperational checks.

Before starting, all bearings, shafts, and other moving parts shall be checked for proper alignment. Alignments shall be in accordance with OEM specifications.

- Stuffing Boxes and Packing. All stuffing boxes shall be checked for correct take up on the packing.
- Equipment has been rough-set and preliminary alignment complete.
- Equipment has been grouted and checked for allowable pipe strain.
- Final alignment has been complete.
- Motors have been bumped for correct rotation.
- Piping is complete with correct gasketing.
- All oil tanks, reservoirs, gear cases, and constant level type oilers shall be checked for proper oil levels. All points requiring manual lubrication shall be greased or oiled as required.
- Cooling and Sealing Water. All cooling and sealing water supplies shall be flushed and checked for proper operation.
- Safety Equipment. All coupling guards, belt guards, and other personnel safety items shall be installed.
- All fire protection systems and equipment shall be installed and operative.
- Belts, Pulleys, and Sheaves. All belts, pulleys and sheaves shall be checked for correct alignment and belt tension.
• Pump Suction Strainers. All pump suction strainers shall be installed.

The Contractor shall perform equipment alignment in accordance with the manufacturer’s recommendations. The final alignment of major equipment shall be witnessed by the Commissioning Manager, Owner, and where applicable, by the TFA. The Contractor shall record the alignment on the Alignment Data Report, and include in the System Turnover Package. The Contractor shall be responsible for taking the base line data on equipment in the coupled and uncoupled state (until bearing temperature is stabilized), including but not limited to the following:

• Vibration readings
• Bearing temperatures
• Winding Temps (Driver)
• Hot alignments and rechecks if required by mfg.

The Contractor shall lubricate the equipment as required. The Contractor shall record the lubrication data on a Lubrication report, and submit in the System Turnover Package.

Drive motors shall be checked for correct rotation by bumping. The ECP Contractor shall confirm lubrication of the motor prior to the motor being bumped. Energization of the motors shall be under the direction of the Contractor’s Commissioning Manager and witnessed by the Owner and TFA. If required. The Contractor’s commissioning Manager shall note in the Turnover Package any special instructions such as no load vibration checks or marking for magnetic center for alignment purposes.

Contractor is responsible to dowel all rotating equipment per mfg. specifications. Some manufactures require doweling after run in and or hot alignment, on pump bases, motor bases, and bearing bases and bearing caps.

8.10.2 Fixed Equipment

Piping system flushes, chemical cleaning, and hydrostatic tests shall be performed prior to subsystem commissioning. The Contractor shall clean strainers, operate valves, change filters, install bearing jumpers, wrap pipe, heat and cool oil, etc.

The Contractor shall perform piping pressure testing to support the turnover package schedule and submit one copy of the Pressure Test Data in the System Turnover Package.

The Contractor shall furnish, install, and remove all temporary equipment required for flushing and testing of the piping and equipment.

The Contractor shall not allow pressurization of a system prior to the verification of setting, and testing of all safety valves.

The Contractor shall perform the following tasks and preoperational checks:
All applicable tasks listed in Section 7.14 Calibration and Test Forms have been completed and properly documented.

All insulation and other personnel safety items shall be installed.

All spring type pipe hangers shall be checked for correct for proper cold settings.

All safety valves shall be checked for correct settings.

All temporary shipping braces, blocks, or tie rods shall be removed from expansion joints.

Process piping shall be flushed, hydrostatically tested, and cleaned.

**Lube Oil Pipe Flushing**

The Contractor shall follow the following manufacturer’s procedures and specifications for flushing. Any deviation from plans and specifications requires prior Owner notification and acceptance.

The Contractor shall perform the following tasks and preoperational checks:

- Lubrication. Each lubricating system shall be flushed to the manufacturer’s standard of acceptance and the filters inspected. All temporary equipment required for lube oil flushes shall be provided by the Contractor.

  Contractor shall make ready all equipment that requires flushing including but not limited to;

  - Draining any existing oil from reservoirs and lube oil junction boxes.
  - Hand clean interior of reservoirs using lint free cloths/ or other approved cleaning methods.
  - Prior to first fill, ensure all required inspection/ are completed and signed off.
  - Ensure that all required inspection/ are completed and signed off.
  - Ensure that all temporary circuit jumpers are clean, lint free, and in good shape.
  - Ensure proper documentation including cleanliness reports, lab reports, MSDS reports and oil analysis.
  - Ensure that safety procedures are in place and followed to protect personnel and site environment.
– Ensure that all Lockout/Tagout procedures are in use, followed, and maintained.
– Ensure that all oil and hydraulic transfer valves are operating freely.

When an oil change is necessary, the Contractor shall remove and dispose of all the oil, filter and filters form previous oil. If the Contractor desires to combine two or more types of oil, an Oil compatibility check must be performed and this must be approved by the OEM and submitted to the Owner for acceptance.

8.11 Electrical

8.11.1 Motors/Drivers

Contractor shall be responsible for commissioning all rotating equipment drivers. Commissioning drivers shall include but not limited to;

• Ensuring that equipment was properly stored
• Winding were clean prior to initial run
• Motor shafts rotate freely
• Megger tests were completed and readings are acceptable
• Magnetic center market
• Proper lube used (lube survey)
• Proper lube level maintained
• Motor heater circuits have been installed and operating.

All of the above listed information should be properly documented in the System Turnover Package.

8.11.2 Backfeed

As a minimum the Contractor shall complete the following prior to backfeed;

Balance of Plant

• DC Batteries installed.
• Batteries, chargers and panels wired.
• Temporary power supplied to battery chargers
• Initial charge on batteries
• DC panels wired and associated circuits to the 5kV Switchgear, GSU transformers, Plant Protective Relay Panel, and station Service Transformers complete.

5kV and 13.8 kV Switchgear

• Switchgear and bus duct space heaters energized with temporary power.
• All cables and bus duct complete to transformers and switchgear ties.
• All cable complete to DC panels and switchgear.
GSU and Unit Auxiliary Transformer

- All control cabinet wiring complete to DC panels, station protective relaying panel, and switchyard marshalling panel.
- Dress out and field testing complete
- Temporary power supplied to cabinet space heaters
- Non-seg bus complete on transformer side of generator breakers

Station Protective Relay Panel

- Wiring complete to DC panels, GSU transformers, unit auxiliary transformers and switchyard marshalling.

Grounding

- Ground grid complete and tested at test wells
- Plant and switchyard grids bonded
- Protective relay coordination study
- 5kv cable testing
- Ground testing by Contractor
- GSU and unit auxiliary transformer field test results
- Non-seg bus energized and including the generator circuit breaker
- Control wiring complete to generator breaker
- Any vendor test done on generator breaker

Switchyard

- Temporary Power supplied to relay house

8.11.3 Electrical Testing Services

Electrical Testing Services provided by the Contractor shall include, but not be limited to the following:

- Performance or witnessing of field acceptance tests and verification of proper installation of electrical equipment such as a power transformers, circuit breakers, switchgear, secondary unit substations, motor control centers, motors, batteries, chargers, and inverters.
- Protective relay calibration, acceptance testing, and setting
- Calibration of metering and instrumentation
- Instrument transformer testing (current and voltage transformer)
- Testing of circuit breakers
• Motor starter overload relay and heater testing
• Testing of Motors
• Testing of transformer protective and alarm devices
• Testing of transformers
• Functional testing of emergency generator
• Testing of communication equipment
• Testing of inverters, including checking of harmonic content of inverter output
• Medium voltage high potential testing
• Functional testing of lighting system
• Testing of generator and generator peripheral systems
• Battery discharge test

All functional testing shall be performed at the direction of the Contractor’s Commissioning Manager. Electrical testing, including, but not limited to, control wiring verification, loop checks, grounding verification, metering, breaker testing, shall be performed and recorded.

Electrical equipment and systems shall be tested, checked out, and calibrated as follows.

All terminal connections on primary rate 5kv and higher voltage systems shall be retightened as required if the integrity of the system has been compromised.

Mechanical adjustment and testing of all circuit breakers, contactors, control switches, indicating lights, annunciators, and all other electrical devices, apparatus, and equipment shall be performed to assure proper mechanical functioning and operation.

Measurement of resistance to ground of all motors, switchgear, secondary unit substation bus, and isolated phase bus, motor control center bus, and panelboard resistance shall be performed immediately prior to placing in service. Measurement of resistance shall be with a line operated megger as manufactured by Biddle or equal acceptable to the Owner. Each resistance value shall be approximately infinite after 21 minute of applied test voltage.

Voltage of testing device shall be in general accordance with the following table:
Each high voltage bus (above 600 volts) or cable, circuit breaker, or important items of equipment shall be meggered just before it is energized if Owner or Contractor believes that the integrity of the system has been compromised to verify the removal of grounds. A megger shall be made between each phase of the grounded conductor, between all phases. Transformer neutrals shall be disconnected and reconnected from the ground as required to isolate the system grounds during the megger tests. Test showing lower values than usual shall be thoroughly investigated to determine and correct the cause before equipment is energized.

For all breakers rated 480 volts and above, the breaker alignment, mechanical operation, lug tightness, contact resistance insulation resistance, and fuse installation shall be verified. All instantaneous trip points shall be set and recorded.

All current transducers shall be calibrated to within 5 percent of the stated accuracy using the primary current injection method.

The external circuit for each current transformer shall be completely tested before the shorting devices are removed from the current transformer secondary terminals. Test shall include the following as a minimum:

1. Continuity check of the circuit external to the current transformer by application of current.

2. Operational check to verify that all devices in the current transformer circuit shall be actuated by current flowing in the circuit, that effect of the current on each device is correct for the quantity of current flowing, and that the circuit remains complete for all the value of current through the maximum current output capability of the current transformer whose external circuit is being tested.

3. Phase check to verify correct phase relationship at each device connected in the current transformer circuit.

4. Phase check of switchgear buses, including bus ties, using a Detex hot stick voltmeter as manufactured by Biddle or equal. Verification of proper installation of electrical equipment.

5. All testing and reconnection necessary to obtain proper equipment rotation. Functioning, and operation; correct phasing and polarity of all power conductors; and correct location and termination of all power, control, and instrument conductors.
6. All mechanical adjustment necessary or recommended by the manufacturer of the equipment being connected or installed.

7. Complete check of all the field wiring after installation and connection to verify that field wiring is as indicated on the Engineer’s drawings and schematic wiring diagrams.

8. Shielded cable ground check using a Simpson Model 260 or equal volt-ohmmeter acceptable to the Owner after termination is complete to determine that each is grounded only at the points indicated on the Contractor’s drawings.

9. All metering shall be injection tested.

   All transfer switches shall be manually exercised to determine proper alignment and contact surface mating. All transfer switches shall then be functionally checked by simulating a loss of the primary power source and the return of the primary power source. The Contractor shall calibrate the transfer switches as required to meet the manufacturers’ specifications for transfer minimum voltage, transfer time, and transfer maximum voltage. The Contractor shall verify that the transfer switches shall not become oscillatory at any voltage between minimum transfer and maximum retransfer voltages.

   Automatic synchronizers shall be calibrated for the closing time of the generator breakers. The automatic synchronizers operation within the manufacturers’ specifications shall be verified. These operation verifications shall be accomplished with the breaker in auto closed disabled. All safety precautions (breaker maintenance switches open) shall be employed during these tests. The Contractor shall re-verify the operation of the automatic synchronizer with the synconizer fully enabled.

   All convenience outlets and receptacles shall be verified for the standard polarity, neutral and ground.

   The capability of all protective devices to trip all low and all medium voltage breakers shall be verified. The maximum battery supply voltages for these verifications shall be 200 volts ± 2 volts. The verification shall be done with the breakers in the test position. After the completion of the verification, the tie between the unit batteries shall be reinstalled.

   All motor control center and separately mounted starter overloads and molded case circuit breakers shall be tested with current under simulated operating conditions. Overloads shall be acceptable if, when set midrange with heater installed, the unit operates at current levels of 110 percent of the median trip current rating of the assembly or higher, but does not operate at current levels below 90 percent of the median trip current rating; the ampere rating of the thermal overloads shall be recorded. Breakers shall be acceptable if, when set at midrange, the breaker trips and all the poles open at the current levels of 110 percent of the normal trip rating of the breaker, but does not trip at current levels below 90 percent of the normal trip rating.
Overload breakers found not accessible shall be corrected. Replacement overloads and breakers shall be obtained and tested. Test results shall be recorded and reported to the Owner. The reports shall also include any discrepancies, such as defective contactors, auxiliary relays, or thermal blocks that are discovered in the course of testing.

The Contractor shall verify that no grounds exist on either polarity of the unit or inverter batteries, or on or on the inverted ac panels. Should a ground be detected, the Contractor shall locate the ground source.

All auxiliary electric protective relays and medium voltage and low voltage switchgear protective relays shall be calibrated and tested in accordance with the Owner’s procedure and with the appropriate relay instruction manuals form the manufacturers.

The Contractor shall measure resistance at all field assembled bus connections in the electrical equipment to insure proper connection.

8.11.4 Relays, Meters, and Controls

All relays, meters, controls, and miscellaneous devices shall me tested, calibrated, and set in accordance with the following paragraphs and other applicable parts of this section.

Meters and Transducers

Meters, transducers, and other electrical panel instrumentation shall be tested, set, and calibrated as described below.

All meters shall be visibly inspected for damage, and wiring connections shall be verified.

Unless specified otherwise, all meters shall be tested and calibrated with equipment of no more than 50 percent of the manufacturer’s stated accuracy instrument being tested:

- Ammeters – All ac and dc ammeters and dc milliammeters shall be zero set and verified at three quarters of full scale.

- Voltmeters – All wattmeters and watt transducers shall be zero set and verifies at three quarters of full scale.

- Wattmeters – All wattmeters and watt transducers shall be tested and calibrated to within ½ percent accuracy for at least two different power factors above 0.5 percent.

- Varmeters – All varmeters and watt transducers shall be tested and calibrated to within 1 percent accuracy for at least two different power factors below 0.5 percent. Varmeters having external phase shifting transformers shall be tested without removal of these transformers.
• Watt-hour meters – All watt-hour meters shall be tested and calibrated to within ½ percent accuracy. Watt-hour meters with pulse initiators shall be verified for the watt-hour per pulse listed with each device.

• Power factor meters – all power factor meters shall be tested and calibrated for 80% and 90% (leading and lagging) and unity power factors.

• Synchroscopes – all synchroscopes shall be tested (if required) to ensure the needle is no more than one third its width for the zero marker at zero phase difference and that the needle shifts at least 30 degrees when de-energized. The proper incoming and running potentials shall be verified in conjunction with the proper rotation. A phase angle meter shall be used for all tests. The standard receptacle test is not acceptable.

• Every instrument utilizing a plastic lens or window shall be given a static effect check. The static check shall consist of wiping the lens or window vigorously with a dry cloth of type recommended by the manufacturer which shall not harm the surface. If the needle or pointer holds up-scale or below zero set for more than 15 seconds, the surface of the lens or window shall be treated with a clear antistatic compound recommended by the manufacturer.

8.11.5 Indicating Lights, Switches, and Annunciators

Indicating lights, switches, and annunciators light boxes shall be checked and adjusted as part of the work associated with verification of the internal panel wiring and verification of the circuit logic.

8.11.6 Communication Systems

The entire communication system shall be functionally checked. This check shall include, but not limited to, the following:

• Verification of all party lines for clarity and elimination of cross talk to the page and other party lines.

• Verification of all controls.

• Verification of all internal and external volume controls.

• The final setting of all internal and external volume controls as directed by the Owner.

8.11.7 Low and Medium Voltage Switchgear

All switchgear breakers shall be functionally checked. This check shall include proving the capability of all protective devices to trip all low and medium voltage breakers. Additional tests shall include, but not limited to, the following:
• Prior to hi-potential test, megger test using 2.5 kV dc for a minimum of 1 minute. Low voltage switchgear shall have 2.5 kV dc megger test for bus and breakers only.

• Hi-potential test each breaker (ANSI C37.20)

• Hi-potential test of bus work (breakers may be inserted into their positions to save time).

• Low and medium breaker trip units shall be set and verified the proper values.

• Bus protective relaying calibration.

• Calibration and testing of switchgear instruments (transducers and meters).

• Verification of space heater functionality.

• Verification of proper phase rotation.

• Check contact resistances to be acceptable.

• Check and measure the resistance of ground bus and equipment enclosure; notify the Owner if any ground connection resistance is more than 0.01 ohm.

• Check current transformers for correct tap settings and leave them shorted and grounded until just before the switchgear is placed in operation. At that time, remove all shorts and grounds from current transformers being used.

• Physically check polarity mark orientation on all CTs and VTs against the manufacturer’s shop drawings. Check insulation and CT and VT ratio to be correct.

• Verify circuit breakers and other drawout devices (such as VT and fuse trays) are level and can be easily withdrawn from the switchgear cubicle.

• Verify that all mechanical (Kirk key) type interlocks are properly installed and keys placed as directed by the Owner.

• Verify that all high voltage connections are properly insulated.

• Check that blockings, supports, and other temporary ties have been removed from the breakers, instruments, relays, etc.

• Check that all secondary wiring has been reconnected at shipping splits.

• Check for correct operation of all switchgear and bus duct space heaters and record the current through each space heater branch circuit protective device.
• Check adjustments and operation of safety shutters, interlocks, and auxiliary and limit switches.

• Verify all fuses are of the correct sizes and not “blown”.

• Check all relays, contactors, switches, and other devices for correct mechanical operation.

• Check alignment of movable and stationary contacts and adjust as necessary, in accordance with the manufacturer’s recommendations.

• Record the reading of each circuit breaker operation counter at completion of testing.

• Test operate each circuit breaker from its local control switch and protective relays. Check that a momentary contact closure shall remotely operate the breaker.

• Check the tightness of all terminals, connections, and attachments.

• Check for the presence of all covers, supports, hardware, and field mounted accessories.

• Check for proper operation of alarm and status contacts.

• Repair all areas where paint surfaces have been damaged.

• Perform other checks, adjustments, and tests as may be required by the manufacturer’s service representative to clarify the equipment ready for energization.

8.11.8 Ground Verification

The Contractor shall verify that direct grounds do not exist on any dc, essential ac, or 4160 volt powered systems. Should a ground be detected, the Contractor shall locate the ground source and correct as required.

The Contractor shall verify the grounding system by the following test:

• After connecting of all individual grid systems to the thermal plant site grid, the Contractor shall take grid readings by three terminal “megger” type method. The readings shall be 1 ohm or less. If the readings greater than the above values are obtained, the Contractor shall notify the Owner. Corrective action shall be acceptable to the Owner. The retest shall be witnessed by the Owner.

After the grid has been tested and accepted with a reading less than or equal to 1 ohm, the following test shall be performed:
• Equipment buses in electrical equipment, such as switchgear, motor control centers, distribution panels, etc., shall be tested to assure low resistance bolted connection between bus and equipment enclosure.

• Ohmmeter readings using a “Kelvin Bridge” shall be taken between the equipment ground bus and the equipment enclosure. The maximum acceptable resistance shall be .01 ohm.

• A test shall be made at each 4160 volt MCC, 4160 volt secondary unit substation and 4160 volt panel board to determine the adequacy of the equipment ground conductor.

• A “Kelvin bridge” shall be connected between the equipment ground bus (to which the equipment ground conductor is connected) and the nearest building ground bus or ground strap connected directly to the building ground grid.

• The readings taken shall indicate the resistance between the equipment ground bus and the building ground grid. The maximum permissible resistance shall be 0.1 ohm.

8.11.9 Protective Relay Calibration, Testing, and Setting

All protective relaying systems shall be calibrated, tested, and set using “in case” and “out of case” characteristic test in accordance with the manufacturer’s relay instruction book. The Contractor shall verify all functions of protective relays and control circuitry, by actual trip of relays using simulated trip currents.

8.11.10 Motors

All motors shall be checked for proper insulation of power cables and space heaters wiring (as applicable). Each motor shall be verified as to proper rotation direction prior to being coupled to the driven equipment. All medium voltage motors shall undergo a Polarization Index (PI) test preformed by the Contractor. Additional tests may be required by the Owner:

• Check equipment ground to assure continuity of connections.

• Before applying voltage, measure and record the 1 minute insulation resistance of the stator winding.

• For all motors above 4160 volts, the polarization index of the stator winding shall be measured.

• Insulation resistance tests shall be performed in accordance with IEEE std 62, Guide for making Dielectric Measurements in the field.

• Check lubrication, starter, and control circuits. Check the motor is free of dirt and dust and rotate by hand to determine that rotor tunes freely.
• Motors 74kW and above shall have a 1 hour (minimum) “run-in” while uncoupled. The motor shall be operated uncoupled until the bearing and winding temperatures stabilize. Winding and bearing temperatures shall be monitored noting any high temperature levels or rapid variation.

• On large motors with an insulated bearing, measure the shaft-to-bearing and bearing-to-ground voltages with a high resistance (5,000 ohms per volt or more) 0 to 5 volt scale ac voltmeter while the motor is running under load to check the integrity of the bearing insulation.

• Verification of all nameplate data.

• Mastermind of alignment of the coupling between the motor and the driven equipment.

• Uncoupled directional check.

• Vibration measurement.

• Functional test of the drive and the auxiliaries.

• Functional checks of the protective devices.

For motors greater than 480 volt, the following additional tests shall be performed.

• Measurement of stator winding insulation resistance and checking of winding temperature by RTDs.

• Verification of cooling water has been checked to be in working order.

• DC hi-potential test in accordance with manufacturer’s recommendation.

8.11.11 Generator and Exciter Terminal Equipment

• Check all equipment and neutral grounds to assure continuity of connection.

• Check neutral grounding transformer.

• Field high potential test the generator isolated phase bus duct and voltage transformer (VT) and surge unit in accordance with ANSI C37.20, Section 8.2.4.2, “dielectric test” for 1 minute, before connection to generator or transformer terminals.

• Measure resistance of neutral grounding resistor.
• Electrical test of correct wiring and cabling of all control, alarm, and auxiliary power circuits for proper connection and insulation resistance to ground.

• Testing and setting of all relays, protection equipment, and transmitters including calibration of the electrical control equipment.

• Check of all excitation system wiring of power and control connections for correct connection and insulation resistance to ground.

• Energizing of excitation equipment from experimental excitation (overcurrent, overvoltage, short-circuit protection).

• Check of all excitation control functions from the exciter panel and the control room computer (SCS).

• Check automatic start and stop sequences.

• Repeat the armature winding high voltage test with dc at .85 x 1.7 x factor ac test voltage.

• Functional test of the shaft seal oil system and check of the proper operation of all functions.

• Functional test of the generator cooling and of the lube oil supply from the turbine.

8.11.12 Commissioning Tests

• Trial run of the turbine generator unit at no-load, unexcited, with measurement of vibrations of bearings (with the range “good” of VDI 2056) and of bearing and oil exit temperature and behavior of the shaft seals.

• Performance of the following measurements with the turbine generator unit at rated speed:
  b. Automatic control voltage build-up and input/output static characteristic test.
  c. Check and transfer of voltage control from “automatic” to “manual” and visa versa.
  d. Static characteristic test and preliminary setting of all excitation system limiter functions, alarm and protective devices (field current limiter, armature current limiter, underexcitation/stability or load angle limiter, loss of excitation, loss of sensing voltage), alarm and tripping circuits function test.
e. Check of generator and auxiliary control system and of excitation system failure indicator panel.

f. Measurement of the no-load and of the short-circuit characteristics of the generator.

g. Verification of the symmetry of the voltages and currents in the three phases.

h. Oscillographic determination of the voltage waveform and measurement of the telephone harmonic factor by wave analyzer.

- Final setting of the line drop compensation, dampening, reactive current dependant droop and of excitation limiters as required for satisfactory operation.

- Trial run of the turbine generator unit on load up to full load and check of satisfactory operation and check all parameters, such as vibrations, pressure, temperature, and temperature rise of winding being within permissible limits.

**Transformers**

All transformers, including small power and distribution transformers, shall be tested by the Contractor in accordance with manufacturer’s direction. Additional transformer tests required include, but are not limited to, the following:

- Ration verification.

- Ground resistor resistance (as applicable).

- Insulation/Dielectric Test.

- Check and measure resistance of ground connections; notify the Owner if any ground connection resistance is more than 0.01 ohm.

- Check current transformers for correct tap settings and leave them shorted and grounded until just before the transformer is placed in operation. At that time, remove all shorts and grounds from current transformers being used.

- Megger each winding of the transformer for grounds as recommended by the manufacturer with a 2500 volt dc megger to 10 minutes (high to low, high to ground, and low to ground).

- Check all control and metering circuits on the transformer, including on-load tap changer if applicable.

- Clean the exterior of all bushing porcelain surfaces.
• Check the tightness of all terminals, connections and attachments.

• Check for the presence of all covers, supports, hardware, and field mounted accessories.

• Measure winding resistance (turns ratio test). Set taps if applicable.

• Repair all areas where paint surfaces have been damaged.

• Check for proper operation of all alarms and status contacts.

• Test oil for dielectric, moisture, and impurities.

• Perform other checks, adjustments, and tests as may be required by the manufacturer’s service representative to certify the equipment ready for energization.

After the transformer is energized (before load is added) the additional tests required include, but are not limited to, the following:

• Measurement of the no-load current at low voltage side of each phase.
• Ratio, polarity, and phase rotation tests.
• No-load test.
• Measurement of impedance voltage.
• Tap changer, and control checks.
• Check operation of forced air fans.

Motor Control Centers

Motor control centers shall be tested in accordance with this article. Additional tests shall include, but not limited to, the following:

• Verification of proper phase rotation
• Megger test of bus work.
• Functional Test

Battery Chargers

• Functional testing.
• Insulation testing.
• Meter and transducer calibration testing.
• Voltage ripple testing.
• Test equipment is accordance with manufacturer’s instructions.
• Check input voltage at charger when connected, and reconnect input on proper input taps as required.
• Set output dc float and equalize per manufacturer’s instructions.
• Set battery charger alarms to appropriate values as directed by Owner.
• Check for proper operation of alarm and status contacts.

Batteries

• Before battery is put on charge, the following readings are to be made:
  – Volts per cell.
  – Specific gravity per cell.

• Before energizing batteries, check the operation of the emergency eye wash facility. Verify that the emergency eyewash facility is “recharged” to proper operating pressure after testing.

• After the battery is put on charge, record voltage and specific gravity per cell at the following times or as specified by the manufacturer:
  – After 25 percent of the manufacturer’s recommended charging time.
  – After 50 percent of the manufacturer’s recommended charging time.
  – After 75 percent of the manufacturer’s recommended charging time.
  – After 90 percent of the manufacturer’s recommended charging time.
  – After 25 percent of the manufacturer’s recommended charging time has been completed, make continuous readings or as required to ascertain that all cells are fully charged.

• Check that all cell containers are numbered.

• Check the liquid level in each container.

The battery shall be discharged into a dummy load, and then charged to full capacity (using the battery chargers) to verify the operational compliance of the system.

Inverters

• Inverter testing.
• Bypass switch testing.
• Distortion testing.
• Automatic transfer switch testing (verify the specified speeds).
• Current limit testing
• A function check shall be performed on the inverters and associated instrumentation shall be calibrated.
Raceway

- Verify that cable tray, ducts, conduits, trenches, and wireway are identified in accordance with the requirements of the specifications and as noted on the raceway drawings.

Panelboards

- Check phase rotation on 3-phase panelboards immediately after energization.
- Check modeled case breakers in accordance with the following article.
- Check frame and neutral grounds.
- Megger each phase bus for grounds.
- Check that the ac and dc panelboard circuits are grouped in accordance with the drawings and the directory is in place correct.

Molded Case Circuit Breakers (600 Volt or Below)

- Check circuit ground connection.
- Visually inspect each breaker and operate manually.
- Megger each pole for freedom from grounds.
- Check all connections for tightness.
- Check for proper current and voltage rating for circuit to which is connected.
- Set adjustable magnetic trips to proper values.
- Molded case breakers shall be tested by passing a specified overcurrent through the heater or overload coil and observing the time required to trip in accordance with ANSI C37.50, test procedures for Low voltage AC Power circuit Breakers used in enclosures. The actual tripping time shall be compared for thermal, magnetic, and thermal magnetic operation with the manufacturer’s current time characteristic.

Non-segregated Phase Bus Duct

- Hi-potential test.
- Pressure test.
- Check welding dye penetrant method.
- Megger test using 2.5 kV dc for 10 minutes.
- Check all mechanical joints of the bus and the bus system.
- Nonseg bus duct shall be tested the same as isolated phase duct except no pressure test or dye penetrant is required.

Lighting Tests

- Test all systems for proper operation and correct phasing.
- Test all emergency lighting facilities.
- Adjust area lights at night to provide best light distribution of the facility area and equipment.
8.11.13 Wire Checks

Complete point-to-point check of all field wiring shall be made after installation and connection to verify that field wiring is indicated on drawings and schematics wiring diagrams.

Shielded cable ground check should be made after termination is complete using a Simpson Model 260 or acceptable equal volt-ohmmeter to determine that each is grounded only at the points indicated on the drawings.

The Contractor shall perform a complete de-energized check of all field wiring to verify conformance with shop prints and schematic wiring diagrams; to assure proper phasing and polarity of all power conductors; and to conform that cable shields are grounded at the proper points. These checks include, but are not limited to, the following:

- Performance of continuity tests to verify that each conductor installed under these specifications originates and terminates at the locations designated.
- Conformance of circuit terminations and connection diagrams shall be visually checked.
- Meggering or high potential testing of all power and control conductors
- Shielded cable ground check using an acceptable volt-ohmmeter after termination is complete to determine that each shield is grounded only at the proper points. Check shall be made between the cable shields.

8.11.14 Control Scheme

All electrical controls shall be tested by trail operation of control equipment after all wiring is completed to see that each interlock and control function operates according to the connection diagrams, as well as in accordance with the manufacturer’s schematics and operating instructions.

8.11.15 Electrical Equipment Systems

The Contractor shall be calibrate and check out electrical equipment systems as described in the following articles.

8.11.16 Molded Case Circuit Breaker and Starter Overload Tests

All motor control center and separately mounted starter overloads and molded case circuit breakers shall be tested with current under simulated operating conditions. Overloads shall be acceptable if, when set a midrange with heater installed, the unit operates at current levels of 110 percent of the median trip current rating of the assembly or higher, but does not operate at current levels below 90 percent of the median trip current rating. Breakers shall be acceptable if, when set a midrange the breaker trips all
the poles open at current levels of 110 percent of the nominal trip rating of the breaker, but does not trip at current levels below 90 percent of the nominal trip rating. Overloads and breakers not found acceptable shall be replaced by Contractor. Replacement overloads and breakers shall be tested as a part of the work under these specifications until all motor control center and separately mounted starter overloads and breakers are acceptable. Test results shall be reported to the Owner. The reports shall also include any discrepancies, such as defective contactor, auxiliary relays, terminal blocks, that are discovered in the course of testing. Motor control center overloads and circuit breakers shall be initially set at midrange (if adjustable).

8.11.17 Control System

The Contractor shall verify that each system operates in the correct direction, and that the final control element position resulting from control air supply or control signal failure is specified in the relevant data sheet.

8.12 Instrument and Controls

8.12.1 Mechanical Calibration Services

The Contractor shall perform all mechanical calibration services including, but not limited to, performing and providing setting and calibration documentation for the following:

- Adjustment of mechanical position and limit switches of motor operated valves, control valves, damper drives, and control drives.

- Adjustment and calibration of control valves including all accessories such as positioners, solenoid valves, volume boosters, and similar devices.

- Setting of air supply regulators for pneumatic devices.

- Adjustment of damper drive and control drive positioners, solenoid valves, and other drive accessories.

8.12.2 Instrument Device Calibration

The Contractor shall perform all instrument device calibration services including, but not limited to, the following:

- Loop checking and verification of pneumatic and electronic control loops such as pressure, temperature, level, and flow control.

- Loop checking and verification of motor control circuits including relay logic, programmable logic, process permissive, control panel hardware, output devices, and annunciation.
• Loop checking and verification of plant interlocks circuits including relay logic, programmable logic, control panel hardware, process permissives, output devices, and annunciation.

• Loop checking and verification of plant analog signals not necessarily process related, such as current, and voltage, etc.

• Functional checkout and service limitation of the plant SCS, including verification of individual device inputs by system.

The Contractor’s Commissioning Manager shall maintain the instrument calibration set points and ranges listing and issue to the Owner and the Operations Manager revised set points and ranges to meet field conditions.

Control loop checking shall be performed in conjunction with the functional testing and as directed by the Contractor’s Commissioning Manager. Pneumatic operated control valves shall be stroke and adjusted with support form the manufacturer's service representative or Contractor’s personnel.

**Instrument Equipment and Systems.**

All control and instrument equipment shall be calibrated at the site after installation.

All instrument primary piping shall be hydrostatically tested.

All instrument air headers and instrument supply takeoffs shall be blown out with clean dry air using a full receiver pressure.

All control and instrument tubing shall be pressure checked.

All logic systems shall be functionally checked out. All control systems shall have the inputs and outputs verified. All logic systems shall be checked out and verified. All timers shall be set and verified. Each final device shall be directly operated by its own logic system in all cases where it is practical. All interlock and alarm functions shall be verified.

All communication systems between systems shall be verified.

Instrument piping not hydrostatically tested shall be air tested for leaks.

Control valves shall be disassembled as required for inspection or cleaning.

Contractor shall calibrate and adjust all pneumatic devices which consist generally of sensors; controllers; control accessories such as bleed-volume chambers, speed control valves, and solenoid valves; local and/or remote indicators; control valves, with associated signal converters and accessories; regulators of air supply and air purge; and the interconnecting pneumatic tubing. The Contractor shall verify the system operates in
correct direction, and that the final control element position resulting from control air
supply or control signal failure is specified. The Contractor shall put preliminary settings
on controllers set point, gain, and integral rate. The Contractor shall modify the
preliminary settings to provide accurate and stable operation at such time as the systems
can be observed in operation. The Contractor shall verify all system output can be as
status contacts, and analog information.

8.13 Turnover Packages

A subsystem Turnover Package is a group of one or more components which function
together and which shall be started up together as a functional group. All components in
a system or subsystem Turnover package shall be part of the same plant system; however,
in some situation, components form different plant systems shall be included in the same
subsystem Turnover Package. In general, only one major piece of equipment is in the
same subsystem turnover package. In general, only one major piece of equipment is
included in a particular subsystem Turnover Package.

8.13.1 Preparation of Subsystem Turnover Packages

The Contractor’s Commissioning Manager shall prepare system Turnover Packages. The
commissioning sequence shall commence with scheduling and issuing package
definitions for information and shall continue with completion of construction and testing
work for each package, electrical testing and calibration, initial operation, and subsequent
debugging of any operational problems by the Contractor. Each Turnover Package shall
be reviewed and accepted by the Owner.

Each system/subsystem Turnover Package shall contain the following:

- Package Index
- Commissioning Release Form
- System Open Item List (Punchlist)
- System Boundary with scoped P&ID’s and Electrical One-lines
- Red Lined Drawings
- System descriptions with valve line-ups, alarm and Trip settings, Start-up/Shut-down
  Procedures
- System Test index
- I&C Instrumentation Index and Calibration Reports
- Instrument Loop Check Reports
- Initial Motor Rotation/Run-in Reports
- Initial Pump Operation Reports
- Initial Fan Operation Reports
- System Flush Reports
- System Hydro Test Reports
- Final Tank/Vessel Inspection Reports
- Final Hot Alignment Reports
- Electrical Test Reports
WorleyParsons

- Megger Test Reports / Hi-pot Test Reports
- Cable Pull Tickets
- Continuity Test Reports
- Temporary Condition / Modification Reports
- D/C System Reports
- RFI’s/ECN’s
- Other

Mechanical Completion Contractor Turnover acceptance Form Sign-Off

- Contractor Part of Commissioning Release Form
- Manufacturer’s Service Representative Release Form
- Contractor’s Commissioning Manager part of Commissioning Release Form
- Owner Part of Commissioning Release Form

Lists of included Equipment

- Major Equipment See System Description Above
- Power Sources Part of System Description Above
- Instrumentation/Electrical Devices See I&C Instrumentation Index and Calibrations Above
- Motor Operated Valves, Control Valves, Control Drives, See System Description Above
- List of Alarms See System Description Above

Applicable Drawings

- Piping and Instrument Diagrams Part of each system Turnover Book
- Schematics
- Logic diagrams Hi-lited Control Logic Diagrams shall be a part of a separate T/O Book
- Manufacturer’s drawings as required for functional checkout.
- Others as required

Remarks

- Exceptions See Open items List above
- Special Conditions
- Temporary Connections (jumpers, bypasses, etc.) A Jumper Log Book shall be maintained by the Commissioning Manager
Supporting Documentation

All supporting documentation shall be supported by either the construction or commissioning group and shall be inserted into its’ appropriate section of the system turnover book.

- Hydrotest Forms
- Test Forms
- Calibration Sheets
- Manufacturer’s Service Reports
- Alignment data Sheets
- Lubrication Data
- Others as required

The subsequent Turnover Package definition shall include the piping and instrument diagrams, one-lines diagrams, loop diagrams, and electrical schematic diagrams marked to define the limits of the subsystem. Applicable data and test forms and manufacturer’s service reports shall be prepared by the Contractor’s Commissioning Manager and included in the package. Manufacturer’s drawings shall be included as required to support the testing and functional checkout of the subsystem.

The Contractor’s Commissioning Manager shall note instructions regarding additional construction activities after Commissioning such as piping flushes utilizing the permanent plant equipment and additional loop checks required during Commissioning.

Sign-off’s shall be provided by the Contractor and the Contractor’s testing elements. Incomplete, non-critical elements shall be noted described and expected completion date indicated.

8.13.2 Issue of Subsystem Turnover Packages

The introduction, list of included equipment, engineering drawings showing subsystem boundaries and content, and list of applicable drawings for each subsystem Turnover Package shall be issued for information and scheduling purposes as soon as they are prepared, but no less than 30 days prior to commencing Commissioning activities.

The final subsystem Turnover Packages shall be submitted to the Owner only when it includes the completed and signed sign-off sheet, and the completed test sheets, exception sheets, manufacturer’s service reports, pressure test forms, alignment data, and other applicable information.
8.14 Turnover Package Documentation

8.14.1 Calibration and Test Forms

The Contractor shall complete calibration and test forms for each device calibrated or tested. The format of the forms shall be acceptable to the Owner. The forms shall include, but not limited to, the following information:

- Equipment Tag Number
- Equipment name.
- Equipment description and location
- Description of test or check including date, time, and person performing test.
- Nameplate data
- Readings taken
- Test results – description as required
- Description of test equipment including serial numbers
- Observable data for future reference – notes.
- Test procedure used.
- Reference drawing numbers.

In addition to the above, protective relay forms shall include an accurate curve of relay operation, so drawn that it may be read at various points in the relay operating range.

The calibration and testing forms developed by the ECP Contractor shall include, but not limited to, the following categories:

- Cable Test data
- Relay Test data
- Metering Test data
- Current Transformer Test Report
- Transformer Test Report
- Breaker Test Report
- Transformer Thermal Device Setting
- Ground Resistance Test Report
- Power Cable, Motor and Control Test Report
- Motor Test Data
- Ground Rod Resistance Test Report
- Pressure Test Data Report
- Pressure Test Data Report (Steel Pipe)
- Pressure Test Data Report (Non-Metallic)
- Lubrication Data Report
- Coupling and Alignment Check Report
- Control Test Data
- Calibration and Adjustment Report
All reports, calibration sheets, corrected drawings, and other data shall be maintained by the Contractor, with updates to current status at least weekly. The documents shall be maintained at the Contractor’s filed office until the specified turnover to the Owner. The documents shall be made available for inspection and review.

The manufacturer’s service representatives shall submit a service report to the Contractor’s Commissioning Manager stating whether or not the equipment is ready for operation. Electrical and control testing required by the manufacturer shall be coordinated between the Commissioning Manager and the Manufacturer’s service representative and the results shall be attached to the service report. The Service Report shall be placed in the turnover packager prior to final submittal to the Owner.

8.14.2 Corrected Drawings

The Contractor shall keep one set of the following drawings, marked up with all field corrections performed throughout the construction, testing, and Commissioning phases. The marked up copy shall be retained onsite until the drafted “as constructed” drawings become available:

- Site Arrangements
- Plant Arrangements
- Detailed Piping Drawings
- Pneumatic Interconnect Diagrams.
- Logic Diagrams
- Electrical Schematic and Wiring Diagrams
- Electrical One-line and Three-line Diagrams
- Switchboard and control Panel arrangement Drawings
- Switchboard and Control Panel Wiring Drawings
- Equipment Interconnection Wiring Drawings
- Power Wiring Drawings
- Raceway Drawings
- Circuit and Raceway Lists
- Input/Output Lists
- Ladder Diagrams
- Programming Documents
- Lighting Drawings
- Communication Drawings
- Piping and Instrument Diagrams
- Duct Work and Instrument Diagrams
- Equipment Lists
- Pipeline Lists
- Valve Lists
- Mechanical Device Lists
- Instrument Lists
The Contractor shall supply the Owner with lubrication list indicating the equipment name, manufacturer’s recommended lubricant, lubrication points, and quantity of lubricant required for each piece of equipment or system requiring lubricant. The Contractor shall provide fill quantity, replacement frequency and/or analysis criteria for replacement, lubrication specification, and recommended lubricant manufacturer.

As part of the system Turnover Package (STP) the Contractor shall provide documentation stating the following tasks were completed per the OEM’s Operation Manual.

- Proper lube was installed (lube survey)
- All lube reservoirs were cleaned prior to the first fill
- Proper lube levels have been maintained
- Flushing was performed when required

8.14.3 Exceptions

The Contractor’s Commissioning Manager shall maintain a working file of all subsystem Turnover Package definition exception sheets. Each exception shall be monitored until complete. The Contractor’s Commissioning Manager shall pursue correction and completion if all exceptions in an expeditious manner.

Exceptions shall consist only of minor item, which do not affect safe and reliable operation.

8.15 General Commissioning Procedures

Procedural requirements shall include, but are not limited to, the following:

8.15.1 Inspection

The Contractor shall inspect the installed systems and equipment prior to the starting calibration and checkout, and shall correct all deficiencies that could prevent proper checkout of such equipment and systems as noted herein.

8.15.2 Manufacturer’s Procedures

Drawings and Installation and operating instructions from manufacturers of instrumentation and other equipment appropriate to the work describe in this specification shall be submitted to the Owner for review. The Contractor shall follow the manufacturer’s instructions in the performance of his work.

8.15.3 Discrepancy Procedure

The Contractor shall endeavor to promptly discover major discrepancies in the equipment, materials, and installation and notify the Owner of such discrepancy, and initiate corrective procedures, without delay. When the Contractor discovers equipment and materials with incorrect rating, damaged equipment, or equipment which is not
specified or is otherwise unsatisfactory, arrangements shall be made for replacement of
the equipment and materials.

8.15.4 Calibration In-Place

Devices and equipment shall be adjusted and calibrated with the equipment normally
installed in-place. Exceptions to this procedure may be permitted with the concurrence of
the Owner for the specific device categories for which in-place calibration is not
practical.

8.15.5 Calibration Range

Analog devices shall be calibrated to be accurate within the manufacturer’s specified
tolerance. Digital or switch contact devices shall be set to accurate or change state at the
required process condition and shall be checked for accuracy and hysteresis (dead band)
at this condition. Both accuracy and hysteresis for both analog and digital devices shall
be certified to within the manufacturer’s stated tolerances.

8.15.6 Loop Checks

For pressure and differential pressure instruments, the Contractor shall perform final loop
checks by applying pressure to the instrument and performing a five point check though
the control system. For thermocouples, the Contractor shall utilize a portable sand bath
calibration in the field. The thermocouple shall be removed and a five point check
though the control system be performed. For RTD’s, wiring shall be disconnected at the
RTD and a temperature compensated signal shall be introduced to perform a five point
check through the control system. Other devices, such as positive displacement meters
and vortex shedding or target meters, shall be operationally checked and verified by
conventional test instruments measuring differential.

8.15.7 Calibration Sticker

The Contractor shall furnish and affix a self-adhesive label to each device calibrated or
adjusted. The label shall indicate the date and the name of the person performing the
calibration or adjustment, and shall include the set point or range which the device is
calibrated.

8.15.8 Test Instrument Certification

The Contractor shall provide and maintain an onsite facility to perform periodic
calibration and certification of test instruments and equipment.

Certification methods shall follow recommendations of the test instrument manufacturers.

The Contractor’s personnel performing certification shall be specially trained in the
methods required.
8.15.9 Operation Control

The Contractor shall establish a control system to protect personnel while working around energized systems and equipment. This system shall be used as the permanent plant equipment and systems are completes and capable of energization.

The system shall consist of placing appropriate tags on all equipment and system components to indicate its status and requiring mandatory clearances from designated personnel to operate, energize, or remove from service the equipment or systems. The controls established shall encompass the following phases:

- Equipment of systems completed to the point where they may be energized, pressurized, or operated but not yet checked out, shall be tagged; and the sources of power or pressure shall be turned off and tagged. The affected components shall not be operated without clearance.

- Following initial operation of the equipment or system, tagging shall be performed as in the above paragraph and the affected components shall be operated only by the personnel designated by the Contractor.

- Equipment and system released for service shall be so tagged. Only personnel so designated by the Contractor shall operate or remove from service such system or equipment. When a request to move from service is made, all controls and sources of power or pressure shall be tagged out and shall not be operated under any circumstances. Only the personnel originally tagged the system shall clear the system for service. Contractor’s personnel shall be required to become thoroughly familiar with the procedures.

8.16 Device Commissioning Procedure

The Contractor shall include in his commissioning manual written calibration and adjustment procedures to be utilized for performing work on the various device categories. The procedures describe in the following paragraphs are intended to define general scope and are included for the Contractor’s reference. The following paragraphs shall not be construed to include all procedures included in the Contractor’s scope of work. The Contractor shall submit his written calibration and adjustment procedures to the Owner 30 days prior to starting device calibration work.

8.16.1 Temperature Instrumentation

Thermocouples and extension lead wirers shall be checked for proper ISA type, proper polarity, proper grounding. Thermocouple reasonability shall be checked with a “Mini-mite” or equivalent thermocouple potentiometer. Resistance temperature detectors shall be checked for proper connection of lead wire resistance compensation and proper grounding. Resistance temperature detector element type and integrity shall be verified with an ohmmeter or portable readout device.
Temperature switches shall be checked by immersion of the active element in a temperature regulated over or bath. The actuating point shall be set using a laboratory thermometer. Set and reset temperatures indicative of the switch dead band shall be noted on the Calibration and Adjustment Report form. Other filled systems devices shall also be calibrated using a regulated temperature oven or bath.

8.16.2 Pressure Instrumentation

Low-pressure instruments shall be calibrated dry using a pneumatic test kit and manometer. High-pressure instruments shall be calibrated using a dead weight tester. Test gauges shall be used where necessary to verify calibration of a device which is in service. Calibration shall include appropriate liquid static head suppression, which shall be measured and noted on the Calibration and Adjustment Report forms by the Contractor’s personnel. All pressure instruments shall be calibrated to read the pressure at the process root valve. No liquid shall be introduced to any instrument which normally operates dry. All pressure instrument Calibration and adjustment Report forms shall include up-down (hysteresis) and switch set-reset pressure (deadband) readings. Vacuum and absolute pressure instruments shall be calibrated using a vacuum source and using a reference to known barometric pressure as a compensation for absolute pressure calibration.

8.16.3 Position (Limit) Instrumentation

All limit switches shall be set by actually positioning the device for proper operation. Limit switches shall be set for reliability or operation in a normal plant environment. All limit switch positioning shall account for dimensional changes which may occur when the equipment is placed in service. Vibration sensors and switches shall not be calibrated, but shall be adjusted.

8.16.4 Level Instrumentation

Level instruments of the displacer or float type shall be calibrated by actually filling the float chamber with water and observing the operating level of the device through a temporary gauge glass. Electronic type or nuclear type (if applicable) level devices shall be calibrated in accordance with manufacturer’s procedures. Strain gauge, ultrasonic, and load cell type instrumentation shall be calibrated by manufacturer’s procedures and verified when in operation. Tilt switch devices shall be manually actuated and shall be observed to swing freely as required for reliable operation. Differential pressure type level devices shall be calibrated dry using precision manometers and a low-pressure source, such as a pneumatic test kit.

8.16.5 Flow Instrumentation

Differential pressure type flow devices shall be calibrated dry using precision manometers and low-pressure source such as a pneumatic test kit. Target meters shall be calibrated out of the line, using weights in accordance with manufacturers’ procedures. Various in-line meters of the positive displacement type shall be inspected, but not
calibrated. Flow switches of the paddle type shall be tested by manual actuation and verified by inspection while in operation.

8.16.6 Driving Instrumentation

Control valve stroke shall be verified by pneumatic loading of the positioner. Each valve shall be operated by using a simulated signal equivalent to the normal control signal output for the associated control system, e.g. electronic (milliampere) signal form an electronic control system or pneumatic signal converter, if applicable. All motor operated valves shall be stroked using the associated logic or control system. All valve limit switches shall be set whether integral or attached. Accessories such as position transmitters and solenoid valves shall be adjusted with the valve. Control valve action or air or signal failure shall be verified.

Control drives shall be stroked using a simulated signal equivalent to the normal control signal output for the associated control system. All control drive limit switches shall be set. Each drive shall be checked with its input signal converter, if applicable. Accessories such as position transmitters and solenoid shall be adjusted with the drive.

8.16.7 Miscellaneous Instrumentation

Process constituent analyzers, smoke detectors, temperature rise detectors, and other similar proprietary devices shall be calibrated and adjusted by methods and procedures as recommended by the respective manufacturers.

8.16.8 Panel Instrumentation

Indicating lights, switches, relays, subpanels, and panel stations shall be adjusted and checked out as part of the checkout work on associated logic systems, as described in these specifications. Electric metering for volts, watts amperes, and other electrical quantity functions shall be checked out as described in this article and the following article.

Panel indicators for process quantities shall be calibrated by simulating the electronic signals normally received by the indicator. The final calibration shall be performed using the actual transmitter, signal converter, or system output to be connected to an indicator. The transmitter-receiver combination shall be calibrated to read out accuracy tolerance no greater than twice the average tolerance of the individual devices throughout the range form 10 percent to 90 percent of total scale. In certain instances for specific equipment, the Owner will specify a range of interest. In these cases, the Contractor shall calibrate transmitter-receiver combination to read exactly correct with the calibration standard being utilized, within the range of interest.

Panel recorders shall be calibrated as described for indicators in this article. In addition, the Contractor shall install the correct recorder charts and shall verify that the chart drive inking systems are performing correctly.
8.16.9 Special Instrumentation

Special devices including annunciator light boxes, cathode ray tubes, gong horns, buzzers, and the like shall be checked out as part of the checkout of special instrumentation systems with which they are associated.

8.17 System Calibration and Checkout

8.17.1 Scope

The Contractor shall perform all calibration, adjustment, and check out operations on all systems, which are required to ready the systems for service.

8.17.2 Recalibration After Initial Calibration

In the event Owner/Contractor believe the integrity of the system has been compromised, the Contractor shall recalibrate or readjust systems when necessary or as directed by the Owner. The Owner will initiate such requests when systems are damaged or are suspected of being out of adjustment after the Contractor has completed initial work on the systems. The Owner will prepare forms to advise the Contractor of the need to recalibrate or readjustment. The Contractor shall complete the forms and submit them to the Owner after the recalibration or readjustment is performed. The Contractor shall prepare and submit revised Calibration and Adjustment Report forms for devices, which have been recalibrated. The Owner will indicate on recalibration or readjustment request reason for the request. The recalibration or readjustment shall be performed by the Contractor at his own expense.

8.17.3 Procedures

The Contractor shall provide written calibration and adjustment procedures to be utilized for performing the work on the various systems categories, including but not limited to, the following, which are intended to define general scope and are included for the Contractor’s reference. The Contractor shall submit his written calibration and adjustment procedures to the Owner 30 days prior to starting system calibration work.

8.17.4 Plant Auxiliary Equipment Logic Systems

The systems covered by this article are generally electromechanical consisting of local sensors and switch devices; local motor starters and breakers; panel mounted lights, manual switches, and meters; alarm outputs; cabinet mounted relays and timers; and the cables interconnecting the various items. The Contractor shall check out and verify operation of each logic system, using logic diagrams and electrical schematic diagrams prepared by the Contractor or his sub Contractor/equipment suppliers. All inputs and outputs shall be verified for proper functions. All timers shall be set and verified. Each final drive device shall be directly operated by its own logic system in all cases where it is particle. All indicating lights and alarms shall be verified in operation. All interlock and alarm modes shall be verified.
8.17.5 Special Instrumentation Systems

The systems covered by this article include, but are not limited to, those systems listed below:

- Supervisory Control System
- Vibration Monitoring System
- Plant Load Control (SCADA) System

In general, each system consists of local sensors and switch devices; local drive controllers, drives, valves, and signal converters; panel mounted display and control subpanels; cabinet mounted logic modules; and the cables interconnecting the various items. The Contractor shall perform the calibration and checkout operations, and shall be responsible for direct supervision of his personnel engaged in the work.

The Contractor shall verify correct function of all system inputs. Each final drive device shall be verified to operate correctly and shall be directly operated by its own logic system in all cases where practical. All system outputs to recorders, indicators, indicating lights, and similar display devices shall be verified to operate correctly.

System logic equipment shall be calibrated and verified as appropriate for the specific system and as directed by the respective manufacturer’s representatives.

System peripheral devices such as cathode ray tubes, printers, control subpanels, and key board shall be adjusted and checked out as appropriate for the specific system and as directed by the representative manufacturer’s representative.

All interfaces between systems shall be verified. Interfaces shall include but not necessarily be limited to status contacts, commands contacts, and exchange of information via dedicated wiring and by data link.

8.17.6 Equipment “Package” Control Systems

This category of systems shall be defined as complete self-contained instrumentation and control systems provided with the plant equipment, and requiring little to no interface with other systems for correct operation. The Contractor shall calibrate, adjust, and check out these “package” systems in accordance with the manufacturer’s recommendation. The “package” systems include, but are not necessarily limited to, those listed below:

- Air dryers
- Air Compressors
- Gas Compressors

8.17.7 Instrumentation and Control Devices and Systems Provided with Major Equipment

This category shall be defined as instrumentation and control equipment provided with plant equipment, but which is not self-contained and which requires extensive interface with other systems for correct operation. The Contractor shall calibrate, adjust, and
The Contractor shall provide the services of one or more manufacturer’s representatives to give direction concerning the work. In addition, the Contractor shall verify correct operation of the interfaces with other systems. The interfaces may be contact status, contact command, or analog inputs or outputs. The interfaces shall be defined by manufacturers’ and/or Contractor’s Logic Diagrams, Electrical Schematic Diagrams, or other documents. The systems provided with major equipment include, but are not necessarily limited to, those listed below:

- Stand-alone control systems, PLC’s, etc.
- Annunciator System.
- Vibration Monitoring System

8.18 Trial Operation Of Equipment

Trial Operation of equipment and subloop systems shall extend over a period of time as required to reveal any equipment weaknesses in bearings, cooling systems, heat exchangers, and other components, or any performance deficiencies which may later handicap the operation of main systems and the complete plant.

All rotating equipment shall be checked by the Contractor for overheating, noise, vibration, and any other condition which would tend to shorten the life of the machinery. All equipment shall operate such that a level of vibration displacement, in microns peak-to-peak, is not more than shown under “GOOD” on International Research and Development corporation Curve 305D, “General machinery vibration sensitivity Chart,” or as required by the equipment manufacturer for reliability and longevity, whichever is more stringent.

Cooling water systems shall be adjusted by the Contractor to provide proper flow of coolant to each item of equipment.

The Contractor shall adjust control system set points, gains, and reset rates, field device set points, timing relays, and all other devices and systems necessary to provide correct operation.

All motor driven equipment shall have amperage readings taken during trail operation.

8.19 Post-Commissioning Checkout

8.19.1 Main System Checkout

Main systems shall be checked, operated, and tested by the Contractor in the presence of the Owner after each individual piece of equipment and its accessories have been operated and declared ready for on-line operation. The Contractor’s Test and Commissioning Manager shall be present during the main systems checkout.
All functional and operational testing of protective interlocking, automatic controls, instrumentation, alarm systems, and all other field testing of the main systems shall be completed before the systems are started.

8.19.2 On-Line Operational Checks

During on-line operation of the integrated systems, all equipment shall be checked by the Contractor for overheating, noise, vibration, and any other checks recommended or required by the manufacturer of the specific piece of equipment. Representatives of the Contractor shall be present during the on-line operational checks.

Contractor shall be responsible for the following:

- All piping systems shall be visually checked for leaks, plugged pressure gauges, interference, excessive vibration, and other abnormal conditions.

- Pump suction strainers shall be checked periodically for clogging. These strainers shall be kept in service during initial operation and shall be cleaned as required to minimize pressure drop due to clogging. Whenever equipment is shut down due to strainer clogging, the strainer shall be cleaned immediately, regardless of time delay, to assure availability of the equipment. New gaskets furnished by the Contractor shall be installed after each cleaning operation. After initial operation, when strainer loading no longer occurs, temporary strainers shall be removed from the piping. Spacers shall be furnished and installed where temporary cone type strainers are removed.

- Any realignment, recalibration, and adjustments necessary to make system acceptable for on-line operation.

Conducting plant thermal imaging to identify any locations where insulation is not properly installed or equipment is running hotter than normal.

Conduct testing of the Power system Stabilizers (PSS), Automatic Voltage Regulators (AVR’s) and Western Energy Coordinating Council (WECC) interface equipment to ensure that all applicable requirements are met.

8.20 Acceptance and Guarantee Testing

Acceptance and Guarantee Testing shall be as defined in Exhibit I of the Contract

9 TERMINAL POINTS AND LOCATIONS

This section defines the terminal points and interface points for various equipment and systems for the project. Physical locations are described below, and are generally shown on the site arrangement drawing provided as Figure 2.1-1. The Terminal point Locations indicated on the drawings should be considered suggested or approximate location.
9.1 Mechanical

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Location</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP-M1</td>
<td>Natural Gas</td>
<td>Near east side of site at outlet of SDG&amp;E Metering Station.</td>
<td>Engineer to coordinate connection size &amp; details with SDG&amp;E.</td>
</tr>
<tr>
<td>TP-M2</td>
<td>Service Water - City Water Supply</td>
<td>Near east side of site near main access road.</td>
<td>Engineer to coordinate connection size &amp; details with water provider.</td>
</tr>
<tr>
<td>TP-M3</td>
<td>Sewer Discharge - Permanent</td>
<td>Near southeast corner of site.</td>
<td>Engineer to coordinate connection size &amp; details with sewer provider.</td>
</tr>
<tr>
<td>TP-M4</td>
<td>Aqueous Ammonia Off Loading</td>
<td>At existing NH3 tank; south side of GSUT</td>
<td></td>
</tr>
<tr>
<td>TP-M5</td>
<td>Fire Water- City Water Supply</td>
<td>Near east side of site near main access road.</td>
<td>Engineer to coordinate connection size &amp; details with water provider.</td>
</tr>
</tbody>
</table>

9.2 Electrical

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Location</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP-E1</td>
<td>Electrical Transmission</td>
<td>East side of site near site entrance</td>
<td>Engineer to coordinate with SDG&amp;E.</td>
</tr>
<tr>
<td>TP-E2</td>
<td>12kV alternate electrical connection</td>
<td>East side of site near site entrance</td>
<td></td>
</tr>
<tr>
<td>TP-E3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TP-E4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TP-E5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10 DOCUMENTATION AND SUBMITTALS

This section identifies typical documents to be submitted by the Contractor to the Owner and Owner’s Engineer and further delineates which documents require Owner’s approval; review and comment; or which are to be provided for information only.

From time to time additional submittals shall be required by the work. It shall be the responsibility of the Contractor to make all required submittals in a timely fashion so as not to adversely impact the engineering, design, construction or start-up of the Project.

10.1 Requirements

Owner and Owner’s Engineer will establish a management, engineering, operations, financial and construction core of personnel to develop and maintain the appropriate interfaces with the Contractor during the course of the project. The Contractor shall establish a corresponding project organization. Communications and the interchange of information between the three organizations will be encouraged through various channels.
within each organization. Owner’s decision-making actions will flow through appropriate management representatives.

10.2 Document Control

The following minimum number of documents shall be submitted to Owner for distribution as per the schedule of Submittal Requirements found in Article 9.5.

<table>
<thead>
<tr>
<th>Document</th>
<th>Number of Copies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reports</td>
<td>Electronic*</td>
</tr>
<tr>
<td>System Descriptions</td>
<td>Electronic*</td>
</tr>
<tr>
<td>Engineering/Construction Drawings-Preliminary</td>
<td>2 sets and Electronic*</td>
</tr>
<tr>
<td>Engineering/Construction Drawings- IFC Issue</td>
<td>2 sets and Electronic*</td>
</tr>
<tr>
<td>As-Built Drawings</td>
<td>1 set</td>
</tr>
<tr>
<td>As-Built CAD CD ROM</td>
<td>2 sets</td>
</tr>
<tr>
<td>O&amp;M Manuals*</td>
<td>4 sets and Electronic*</td>
</tr>
<tr>
<td>Vendor Drawing and Data Submittals</td>
<td>2 sets</td>
</tr>
</tbody>
</table>

* If electronic files are not available, then 5 hard copies.

10.3 Drawing and Submittal Review

The Owner’s Engineer will provide to the Contractor copies of Design Basis Drawings, (e.g., site arrangement and equipment arrangement drawings, one line drawings, process flow diagrams). These drawings will be for implementation into the Engineer’s overall detailed design. The Project Technical Requirement Documents are included in Appendices A, B, F, and G.

All design drawings, piping and instrument diagrams, specifications, monthly progress reports, cost monitoring reports, progress meeting minutes and documents specified in Attachment A shall be submitted to Owner and Owner’s Engineer for review. Comments will be returned to the Contractor no later than 20 working days of document receipt.

The Contractor shall submit plant equipment drawings and technical data to Owner and Owner’s Engineer in accordance with Attachment A at the end of this section. Documents submitted for review will be reviewed and comments will be returned to the Contractor no later than 20 working days of document receipt.

10.4 Drawings

Each drawing and reproducible shall be clearly marked with the Owner’s Name (MMC Energy, Inc.), project title, a project drawing number, plant name, unit number, A/E name, manufacturer name, the associated bill of material reference number and the A/E’s Registered Engineer’s Certification. All drawings shall conform to the laws of the State of California.
CAD Drawings

All drawings shall be CAD generated using a Bentley Micro-Station System.

Permit Drawings

Drawings required to support the permit process shall be of the size required by the permitting authority and shall be signed and sealed by a Professional Engineer registered in the State of California as required by the permitting authority.

10.5 Document Submittal Schedule

The Document Submittal Schedule is found in Attachment A at the end of this Section 9.

10.6 As-Built Drawings

Contractor shall maintain as-built drawings throughout the construction period in the form of a red-lined set of the drawings. Red-lined copies shall be furnished to Owner in the System Turnover Package. As-built information shall be incorporated by the Engineer into the final drawing issue. The following drawings and information shall be submitted As Built:

a. P&IDs
b. One-Lines
c. Three-Lines
d. Site & General Arrangements
e. Foundation Drawings
f. Structural Steel Design Drawings (including pipe racks)
g. Underground Utilities Drawings
h. Detailed Piping and Piping Isometric Drawings
i. Wiring Diagrams
j. Electrical Schematics
k. Instrumentation Loop Diagrams
l. Instrumentation Location
m. Mechanical Equipment List (including mechanical accessories)
n. Electrical Equipment List
o. Pipe Line List
p. Pipe Support List
q. Manual Valve List
r. Control Valve List
s. Cable & Raceway Schedules
t. Instrumentation List
u. DCS I/O List. Including cable identification and terminal points
v. Drawing List
w. Electrical Load List
x. Instrumentation Installation Details
y. Instrumentation Data Sheets
z. Raceway drawings
aa. Relay Settings
bb. Grading and Paving Drawings
cc. Architectural Drawings
dd. Steel Drawings

As-built drawings shall also be provided for all equipment furnished by Contractor for all equipment manufacturers’ drawings where engineering or field changes have occurred.

10.7 Site Specific Operation & Maintenance Manuals

The Contractor shall provide O&M manuals for all equipment supplied by the Contractor in the Scope of Work. The manuals shall be submitted for review and comment thirty (30) days prior to shipment of the equipment.

O&M manual binders shall conform to the table below.

1. Manufacturer: ViaTech Publishing Solutions
2. Binder Type: Swing Hinge Overlay
3. Color: White
4. Imprinting: In accordance with drawing bound at end of this section
5. Capabilities available: 2 and 3 inch

Binder capacities shall not exceed 3 inches, nor shall material included exceed the designed binder capacity. If material to be bound exceeds capacity rating, multiple volumes shall be furnished.

The Title sheet of each binder shall contain project title and location, MMC’s name, Contractor’s name, address and telephone number and, as applicable to terms, names, addresses and phone numbers of sub-Contractors, nearest material, equipment and parts suppliers, and service organizations.

10.7.1 Site Specific O&M Manual Format

O&M Manuals shall include all literature, data sheets, etc. required for operation and maintenance of the equipment. Nomenclature used to reference each item shall be consistent throughout Manuals.
Data shall be complete for all equipment and systems.

Data shall include drawings, diagrams (including wiring diagrams), pictures or actual photographs when they add to the understanding and clarity of the text.

Precautions and warnings relative to the safety of life and equipment shall be included where applicable.

Commercial-type handbooks for many items of equipment shall be utilized under the following conditions:

- If the publication of the sub-assembly or component part manufacturer does not contain a complete care, operation, maintenance and parts breakdown meeting the intent of these requirements, such information shall be included in the O&M Manual by arranging with the sub-assembly manufacturer to provide a publication that shall meet these requirements.

- The sub-assembly or component part item is of such a nature that local repair normally is not employed, and the item is usually returned to the factory as a unit for overhaul, reference shall be made to such fact in the O&M Manuals, and the specific information concerning its repair and parts breakdown may be omitted.

- The pages shall be punched and fitted to a loose-leaf binder. The use of foldout pages shall be kept to a minimum.

If handbooks of sub-assembly equipment or other components are included as part of the O&M Manuals as permitted herein, these associated handbooks shall be noted under the “Manufacturer’s Catalog” heading of the index.

O&M Manuals shall be divided into the following sections:

- Title
- Index
- Installation Instructions
- Operation Instructions
- Maintenance Instructions
- Parts Catalog
- Associated Publications

Installation Instructions shall include the following:

- Handling and rigging procedures.

- Equipment installation procedures including assembly methods, special precautions, sequence of work and adjustment requirements.
• Set point for all relays instruments meters and other devices requiring calibration.

• Allowable temperature, pressure, flow, vibration levels, etc., to test and verify operation of mechanical equipment.

• Complete set of the instrument installation details.

• Complete startup instructions include a step-by-step startup checklist.

• Complete set of the instrument loop diagrams.

Operation instructions shall include the following:

• Starting instructions, detailed and specific, for all equipment furnished, noting the step-by-step procedures to be followed. Precautions and critical points to be observed shall be noted and emphasized as required.

• Operating instructions, detailed and specific, for all equipment furnished. Included shall be precautions and critical points to be observed. There shall be a tabulation of possible operating difficulties with the probable cause listed and remedial action recommended to be taken.

• Complete set of logic diagrams furnished with technical description.

• Shutdown instructions, detailed and specific, for all equipment furnished, noting the step-by-step procedure to be followed for shutting down the equipment.

Maintenance instructions shall include the following:

• Lock-out and tag-out procedures.

• Disassembly instructions complete, detailed and specific for major assemblies of all equipment furnished, noting the step-by-step procedure to be followed. Precautions and critical points to be observed shall be noted and emphasized as required.

• Maintenance instructions complete, detailed and specific for major equipment furnished, including preventive maintenance instructions and lubrication information. Schedules covering test and inspections to be performed after various periods of operation shall be included. A summary description and identification of special tools required and furnished for maintenance shall also be included.

• Settings, clearance and adjustment data tabulated for major equipment, covering instrument settings for operation, alarm and shutdown, and operating clearances and adjustments required for proper operation. Also, a tabulation of recommended operation conditions for all equipment and systems. Whenever instrumentation is
provided with the manufacturer’s equipment, calibration procedures and instrument data sheets for this instrumentation shall be provided.

Parts Catalog shall include the following:

- Detailed replacement parts drawings and lists, including applicable specific replacement part drawings and lists. These drawings and documents shall include all information required for ordering replacement parts, such as part name, part number, equipment serial number, technical specifications, and quality assurance requirements.

- Special storage or handling procedures required by any particular parts shall be noted including shelf life limits.

10.7.2 Associated Publications

The Associated Publications section of the O&M Manuals shall be utilized when it is feasible to include existing publications on sub-assembly or associated equipment components in the O&M Manuals. Such publications shall be located in this section unless they can be subdivided, and integrated as previously described.

10.8 Construction Turnover Package Requirements

A Construction Turnover Package Procedure shall be developed by the Contractor and submitted to Owner for review and approval 120 days prior to the start of the pre-operational testing phase. Content of each Construction Turnover Package shall be in accordance with Section 7.0 of these Design Guidelines.

10.9 Project Procurement Specifications

The Contractor shall purchase balance of plant equipment and materials in Contractor’s scope of supply using equipment technical specifications prepared by the Engineer. The specifications shall include provisions for the following items if applicable:

- Proposed Manufacturers

  Contractor shall purchase equipment from vendors listed in the Recommended Vendors List.

- Recommended Spare Parts

  Contractor shall obtain from supplier a list of recommended spare parts with firm unit pricing. Duration of firm unit pricing from Purchase Order issue date shall be provided for Owner review.

- Warranty Preservation
Contractor shall include provisions for service Engineer(s) including wages, travel, per diem, auto expense or other costs associated with inspections, tests or other activities necessary to preserve equipment warranties.

- **Start-up Spares**
  Contractor shall obtain from supplier a list of start-up spares and accessories with firm unit pricing. Duration of firm unit pricing from P.O. Issue date shall be provided for Owner Review.

- **Start-Up Support/Training**
  Contractor shall include provisions for vendor supplied start-up support services and training on a firm price basis including wages, travel, per diem, auto expenses and specialty test equipment for the fire system. Cost basis shall be eight (8) hours per day S/T-forty (40) hours per week. Travel time shall be in addition to the on-site work days specified.

- **Operations and Maintenance Manuals**
  Contractor shall include provisions of vendor furnished O & M Manuals on CD ROM compatible with Windows 2000 or higher.

10.10 **Quality Assurance Manual**

The QA/QC program shall be documented in a quality assurance manual. The form and format of the quality assurance manuals are at the discretion of the Contractor. The content of the quality assurance manual may be in the form of written descriptions of QA/QC policies, procedures, methods, instructions, exhibits, or other quality assurance method descriptions.

The Contractor’s quality assurance manual shall describe the authority and responsibility of the persons in charge of the quality assurance program and inspection of activities. The manual shall also include, as a minimum, control procedures or methods to assure the following:

- Design documents, drawings, specifications, quality assurance procedures, test records, inspection procedures, inspection reports and purchase documents are maintained current, accurate, and under control.

- Purchased materials, equipment and services conform to the requirements of these documents and the Contract.

- Receipt inspection, in-progress inspection, examination and testing of the equipment and material installed by the Contractor.

- Complete inspection and documentation of subcontracted work.
• Quality of special processes such as welding, heat-treating and nondestructive testing.

• Proper methods are employed for the qualification of personnel who are performing welding and nondestructive examinations.

• Shop inspections are performed and documented at an adequate frequency rate.

• All deviations and non-conformances shall be communicated to Owner in writing.
## ATTACHMENT A  List of Document Submittals

<table>
<thead>
<tr>
<th>Description of Submittal</th>
<th>Purpose of Submittal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 3 Project Schedule (Engineering/Construction)</td>
<td>R</td>
</tr>
<tr>
<td>Monthly Progress Reports</td>
<td>I</td>
</tr>
<tr>
<td>Applications for Permits Assigned to Contractor</td>
<td>-</td>
</tr>
<tr>
<td>QA Manual</td>
<td>R</td>
</tr>
<tr>
<td>Detailed Design Drawings, Lists, Etc.</td>
<td>R</td>
</tr>
<tr>
<td>Construction Commodity Lists</td>
<td>I</td>
</tr>
<tr>
<td>• As Designed</td>
<td>I</td>
</tr>
<tr>
<td>• As Built</td>
<td></td>
</tr>
<tr>
<td>Design Changes – RFI’s and ECN’s – Hold Notices</td>
<td>R</td>
</tr>
<tr>
<td>Process System Descriptions</td>
<td>R</td>
</tr>
<tr>
<td>Construction Documents</td>
<td></td>
</tr>
<tr>
<td>• Contractor’s Safety Program (Site Specific)</td>
<td>A</td>
</tr>
<tr>
<td>• Daily Construction Reports</td>
<td>I</td>
</tr>
<tr>
<td>• Detailed Construction Schedule</td>
<td>R</td>
</tr>
<tr>
<td>• Construction Procedures</td>
<td>R</td>
</tr>
<tr>
<td>• QC Program Manual</td>
<td>R</td>
</tr>
<tr>
<td>• Construction Inspection and Test Requirements</td>
<td>R</td>
</tr>
<tr>
<td>• Welding and Brazing Procedures, and Personnel Qualifications Procedures</td>
<td>R</td>
</tr>
<tr>
<td>• NDT Procedures</td>
<td>R</td>
</tr>
<tr>
<td>System Turnover Procedures</td>
<td>A</td>
</tr>
<tr>
<td>Safety Tagging Procedures (Construction)</td>
<td>I</td>
</tr>
<tr>
<td>Vendor Production and Shipping Schedule (Contractor procured equipment)</td>
<td>R</td>
</tr>
<tr>
<td>Performance Curves for Each Pump (Contractor procured pumps)</td>
<td>I</td>
</tr>
<tr>
<td>Motor Performance Curves for Motors (Contractor procured motors)</td>
<td>I</td>
</tr>
<tr>
<td>Vendor Installation, Maintenance, and Operating Instructions</td>
<td>R</td>
</tr>
<tr>
<td>Records Turnover</td>
<td></td>
</tr>
<tr>
<td>• Final As-Built Drawings and Design Documents</td>
<td></td>
</tr>
<tr>
<td>• Manufacturer’s Inspection and Test Records (Contractor Procured Equipment)</td>
<td>I</td>
</tr>
<tr>
<td>• Construction Inspection and Test Records</td>
<td>I</td>
</tr>
</tbody>
</table>