

Solicitation No.
VA-101-12-RP-0140
Project No. 640-424



**Department of
Veterans Affairs**

Specifications

Vol. 2 and 3 Addendum No. 02

For: Loop Road and Site Utilities

Radiology Consolidation

Parking Structure 2

At: VA Medical Center – Palo Alto

3801 Miranda Avenue

Palo Alto, California 94304

Issue:

Open Bids:

Property of Department of Veterans Affairs

Amendment	
No.	Date

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(Add#01)	18 SEP 2013, Addendum No. 01
(Add#02)	07 OCT 2013, Addendum No. 02

SECTION 23 10 00

FACILITY FUEL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. Diesel fuel oil tanks, pumps, piping, and accessories located outside, underground or aboveground as shown on contract drawings. Refer to contract drawings for type of fuel, for tank capacities, pump schedules, tank configuration and tank appurtenances including tank access platform, hand rails and access platform ladder.
- B. Tank fluid level monitoring and alarm systems.
- C. Leak detection system for tanks and ~~underground~~ piping. ^(Add#02)
- D. Fuel oil quality maintenance system (water and particulate removal).

1.2 RELATED WORK:

- A. ~~Deleted Excavation and backfill for underground piping: Section 31 20 00, EARTH MOVING and Section 31 20 11, EARTH MOVING (SHORT FORM).~~ ^(Add#02)
- B. Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT: Procedures and requirements for managing and disposing construction and demolition waste.
- C. Section 01 81 11.01, SUSTAINABLE DESIGN REQUIREMENTS: Sustainable design requirements including submittal requirements.
- D. Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS: Requirements for commissioning, systems readiness checklists, and training.
- E. Concrete ballast foundations and concrete pads: Section 03 30 00, CAST-IN-PLACE CONCRETE.
- F. Platforms, stairs, ladders and railings for aboveground tanks: Section 05 50 00, METAL FABRICATIONS.
- G. Sealing of pipe penetrations: Section 07 92 00, JOINT SEALANTS.
- H. Primer and finish painting: Section 09 91 00, PAINTING.
- I. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
- J. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- K. Fuel oil pumps for engine generators and day tanks: Section 26 32 13, ENGINE GENERATORS.

- L. Underground conduit systems for tank fluid level monitors and tank and piping leak detectors: Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION.

1.3 SEISMIC PERFORMANCE REQUIREMENTS

- A. Mechanical equipment and components are to be seismically qualified/certified per ASCE 7-05, Chapter 13, and as clarified in the Office of Statewide Health Planning and Development (OSHDP) Code Application Notice (CAN) No. 2-1708A.5.
- B. Seismic Performance: Active equipment shall be special seismic certified utilizing shake table testing in accordance with ASCE 7-05, Section 13.2.5, using criteria applicable to IBC Seismic Design Category F. The unit supplied for installation in this Project shall not have been subjected to shake table testing. Testing shall be conducted at nationally recognized test laboratory acceptable to the VA. No alternate method of proving compliance will be accepted for this Project. Components with hazardous components shall be certified by supplier as maintaining containment following the design earthquake analysis or by shake table testing as described above.
- C. See Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS for additional seismic performance criteria.

1.4 QUALITY ASSURANCE:

- A. Approval by Contracting Officer is required of products or services of proposed manufacturers, suppliers and installers, and will be based on Contractor's certification that:
 - 1. Manufacturers regularly and currently manufacture tanks, tank and piping accessories, tank fluid level monitoring and leak detection systems, fuel quality management systems.
 - 2. Manufacturers of steel tanks participate in the Quality Assurance Program of the Steel Tank Institute (STI).
 - 3. The design and size of each item of equipment provided for this project is of current production and has been in satisfactory operation on at least three installations for approximately three years. Current models of fluid level and leak detection systems with less than three years service experience are acceptable if similar previous models from the same manufacturer have at least three years service experience.
- B. Apply and install materials, equipment and specialties in accordance with manufacturer's written instructions. Conflicts between the manufacturer's instructions and the contract drawings and specifications shall be referred to the Resident Engineer (RE)/Contracting Officers Technical Representative (COTR) for resolution. Provide copies of installation instructions to the RE/COTR two weeks prior to commencing installation of any item.

- C. All equipment shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components or overall assembly.
- D. Tanks, Secondary Containment Systems for Piping, Plastic Piping and Containment Systems, Tank Level Monitoring Systems, Leak Detection Systems, Fuel Quality Management Systems, ~~Cathodic Protection Systems~~: Authorized manufacturers representatives shall provide on-site training of installers and supervision of the installation and testing of the equipment and systems to assure conformance to written instructions of manufacturers. ^(Add#02)
- E. Tank and piping installation contractor shall be certified as acceptable by local and state pollution control authorities.
- F. Entire installation shall conform to requirements of local and state pollution control authorities.
- G. Pipe Welding: Conform to requirements of ASME B31.1. Welders shall show evidence of qualification. Welders shall utilize a stamp to identify their work. Unqualified personnel will be rejected.
- H. Assembly of Glass Fiber Reinforced Plastic Piping: Installation personnel shall have been trained, tested and certified under a procedure approved by the manufacturer of the piping. Proof of certification, in writing, shall be provided to the RE/COTR.
- I. Where specified codes or standards conflict, consult the RE/COTR.
- J. Label of Conformance (definition): Labels of accredited testing laboratories showing conformance to the standards specified.
- K. Equipment and materials installed shall be compatible in all respects with other items being furnished and with existing items so that the result will be a safe, complete and fully operational system which conforms to contract requirements and in which no item is subject to conditions beyond its design capabilities.
- L. Tank accessories shall include access platform, access ladder, and hand rails. These accessories shall fully comply with California OSHA requirements.

1.5 SUBMITTALS:

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. LEED Submittals: Submit in accordance with Section 01 81 11.01.
 - 1. LEED submittals are in addition to other submittals. If submitted item is identical to that submitted to comply with other requirements, submit duplicate copies as a separate submittal to verify compliance with indicated LEED requirements.

2. LEED Product Data Submittal Form: Submit completed product data form provided by the Contracting Officer's Representative; certified by vendor, installer, subcontractor, and/or manufacturer as appropriate.
- C. Aboveground Steel Tanks, Including Vault-type Tanks:
1. Drawings of tanks, supports, ladders, platforms, tank manholes, emergency relief vents and all accessories. Include overall dimensions and dimensional locations and sizes of pipe connections, and access openings.
 2. Recommended tank support locations.
 3. Weight of entire tank assembly, empty and flooded.
 4. Design and construction of primary tanks, insulation, secondary containment, supports, pipe connections, platforms.
 5. Application and performance data on coatings from manufacturer of coatings.
 6. Data certifying tanks are designed for surcharge loads of platforms shown.
 7. Certification of compliance with specified standards.
 8. Certification that steel tank manufacturer participates in Steel Tank Institute (STI) Quality Assurance Program.
 9. Design, construction, performance, dimensions of emergency relief vents.
 10. Seismic Data: Refer to Section 130541, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
- D. Fuel Piping and Pumps:
1. ASTM and UL compliance.
 2. Grade, class or type, schedule number.
 3. Manufacturer.
- E. Pipe Fittings, Unions, Flanges:
1. ASTM and UL compliance.
 2. ASTM standards number.
 3. Catalog cuts.
 4. Pressure and temperature rating.
- F. Foot Valves, Check Valves, Overfill Prevention Valves:
1. Catalog cuts showing design and construction.
 2. Pressure and temperature ratings.
 3. Pressure loss and flow rate data.
 4. Materials of construction.
 5. Accessories.

G. Secondary Containment System for Fuel Piping:

1. Sizes, materials, construction of containment system including end seals, sumps, coatings and pipe supports.
2. Layout of system.
3. Installation instructions.
4. ~~Deleted Design of cathodic protection system (steel casing).~~ (Add#02)

H. Leak Detection System:

1. Drawings, description and performance data on sensors, control units.
2. Description of operation.
3. Layout of system.
4. Installation and operating instructions.
5. Data on interconnecting wiring systems to be furnished.

I. Tank Fluid Level Monitoring Instrumentation System:

1. Drawings showing instruments and in-tank sensing units, with dimensions.
2. Design and construction of all elements of system.
3. Installation instructions.

J. Tank and Piping Accessories: Design, construction, and dimensions of vent caps, fill boxes, fill caps, spill containers, hand rails, access platform, access ladder, and other accessories.

K. Fuel Quality Maintenance System:

1. Drawings and description of all components and arrangement of system.
2. Design and performance of pumps, filters.
3. Catalog data and operation of control system.
4. Installation instructions.

L. Seismic Qualification: Submit proof of equipment qualification to requirements for Special Seismic Certification. See Seismic Performance Requirements article.

1. Proof of qualification shall consist of certificate issued by testing laboratory, signed by both laboratory representative and equipment manufacturer.
2. Alternate proof of qualification: OSHPD pre-approved equipment with OSHPD OPA number.

1.6 DELIVERY, STORAGE AND HANDLING:

A. Protection of Equipment:

1. Equipment and material placed on the job site shall remain in the custody of the Contractor until phased acceptance, whether or not the

Government has reimbursed the Contractor for the equipment and material. The Contractor is solely responsible for the protection of such equipment and material against any damage.

2. Place damaged equipment in first class, new operating condition; or, replace same as determined and directed by the RE/COTR. Such repair or replacement shall be at no additional cost to the Government.
3. Protect new equipment and piping systems against entry of foreign matter on the inside. Clean both inside and outside before painting or placing equipment in operation.

B. Cleanliness of Equipment and Piping:

1. Exercise care in storage and handling of equipment and piping material to be incorporated in the work. Remove debris arising from cutting, threading and welding of piping.
2. Piping systems shall be flushed, blown or pigged as necessary to provide clean systems.
3. Clean interior of all tanks prior to delivery for beneficial use by the Government.
4. Contractor shall be fully responsible for all costs, damages and delay arising from failure to provide clean systems and equipment.

1.7 APPLICABLE PUBLICATIONS:

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.

B. Federal Specifications (Fed. Spec.):

1. A-A-60005 Frames, Covers, Grating, Steps, Sump and Catch Basin, Manhole

C. ASTM International (ASTM):

1. A36/A36M-05 Carbon Structural Steel
2. A53/A53M-10 Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
3. A105/A105M-12 Carbon Steel Forgings for Piping Applications
4. A106/A106M-10 Seamless Carbon Steel Pipe for High Temperature Service
5. A126-04 (R2009) Gray Iron Castings for Valves, Flanges and Pipe Fittings
6. A234/A234M-10 Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
7. B62-09 Composition Bronze or Ounce Metal Castings
8. D2996-01 (2007) Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting-Resin) Pipe

- D. American Society of Civil Engineers (ASCE):
 - 1. ASCE 7-05 Minimum Design Loads for Buildings and Other Structures.
- E. American Society of Mechanical Engineers (ASME):
 - 1. B16.5-09 Pipe Flanges and Flanged Fittings (NPS 1/2-24).
 - 2. B16.9-07 Factory-Made Wrought Buttwelding Fittings
 - 3. B16.11-09 Forged Fittings, Socket-Welding and Threaded
 - 4. B31.1-10 Code for Pressure Piping, Power Piping with Current Amendments
- F. National Electrical Manufacturers Association (NEMA):
 - 1. 250-08 Enclosures for Electrical Equipment (1000 Volts Maximum)
- G. National Fire Protection Association (NFPA):
 - 1. 30-08 Flammable and Combustible Liquids Code
 - 2. 31-06 Installation of Oil Burning Equipment
 - 3. 70-08 National Electrical Code
- H. Underwriters Laboratories Inc. (UL):
 - 1. 142-10 Steel Aboveground Tanks for Flammable and Combustible Liquids
 - 2. 971-06 Non-Metallic Underground Piping for Flammable Liquids
 - 3. 2085-10 Protected Above-ground Tanks for Flammable and Combustible Liquids
- I. NACE International (Corrosion Engineers) (NACE): (Add#02)
 - 1. ~~Deleted SP0169-07 Control of External Corrosion on Underground or Submerged Metallic Piping Systems~~): (Add#02)
 - 2. NACE 3/SSPC-SP6-07 Commercial Blast Cleaning
 - 3. NACE 4/SSPC-SP7-07 Brush-off Blast Cleaning
- J. ~~Deleted American Petroleum Institute (API):~~ (Add#02)
 - 1. ~~1631-01 Interior Lining and Periodic Inspection of Underground Storage Tanks~~ (Add#02)

1.8 PERMITS:

- A. Contractor shall obtain and complete all tank permit and registration forms required by governmental authorities.

PART 2 - PRODUCTS

2.1 DELETED (Add#01)

2.2 ABOVEGROUND CONCRETE-INSULATED STEEL VAULT TANKS:

- A. Type: All-welded steel tank, horizontal cylindrical or rectangular configuration, atmospheric pressure, concrete insulation, double-containment, ballistics and impact tested for aboveground installation as shown. Entire unit factory-fabricated, including steel tank and concrete insulation. Provide tank supports that can be anchored to a concrete foundation.
- B. Construction:
1. Comply with UL-2085 for protected tanks, vehicle impact resistant and projectile resistant with secondary containment. Provide label of conformance.
 2. Inner tank ASTM A36 steel constructed in conformance with UL-142. Provide label of conformance. Steel tanks shall be supported as recommended by steel tank manufacturer. Top of secondary tank shall be sloped to shed rainwater. Test tanks for leaks with test pressure of 20 - 34 kPa (3 - 5 psi) gage. Furnish certificate that inner and outer tanks have been tested and are leak-free and pressure-tight.
 - a. Interstitial space between tank walls shall provide minimum containment of 110 percent of primary tank contents. (Add#01)
 3. Concrete Insulation:
 - a. Shall consist of 25 mPa (3000 psi) minimum concrete.
 - b. Shall be structurally designed to support the filled tank and a top live load of 4.8 kPa (100 lb./sq. ft.).
 - c. Monolithic pour with no cold joints, heat sinks. As an alternate, there may be one continuous shiplap joint located at horizontal center of vault sealed with fire and fuel resistant gaskets.
 - d. Construct in accordance with ACI and AASHTO standards including concrete placement, vibration, and quality assurance.
 4. Conform to NFPA 30 or 31 fire safety standards as applicable. Design for two-hour fire exposure. Provide fittings for grounding per NFPA 70.
 5. The tank assembly shall have capability of physical monitoring for leaks between primary and secondary containment.
 6. Provide overfill containment (spill container) with internal drain and positive seal.
- C. Factory Cleaning: Clean interior and exterior. Remove mill scale, dirt, rust, oil, welding debris, loose coatings and coatings incompatible with fuel stored or protective coating.
- D. Factory Coatings: Provide coating of rust resistant red oxide primer on non-fuel side of steel tanks. For tanks with interior access, coat interior of primary tank from bottom to 1 m (3 feet) above bottom in conformance

with API RP 1631. Provide two coats of fuel resistant epoxy coating on exposed surfaces of the external concrete tank.

- E. Platforms, Ladders, Stairs, and Handrails: Provide as shown. Shall be welded steel assemblies conforming to OSHA requirements. Paint in accordance with Section 09 91 00, PAINTING. Galvanizing is an acceptable alternative.
- F. Pipe Connections to Tanks:
 - 1. Pipe shall terminate 75 mm (3 inches) minimum from top of unit.
 - 2. Conform to UL 142.
 - 3. Pipe sizes 50 mm (2 inches) and smaller, threaded. Pipe sizes 65 mm (2 1/2 inches) and larger, 1025 kPa (150 pound) ASME flanged.
 - 4. Welded joints required on steel piping located inside tanks.
 - 5. Provide and coordinate tank connection quantities, sizes and types with requirements of tank level gage unit; leak detector sensor; sounding rod; vent, fill, supply and return pipes; and other pipes as shown.
 - 6. Provide valved drain on interstitial space.
- G. Tank Manholes: Provide quantity and size shown. Bolted cover type, gasketed.
- H. Emergency Relief Vents for Fire Exposure: Venting capacity shall conform to NFPA 30 or 31 as applicable. Provide separate vents for primary and secondary tanks. Standard product of a manufacturer, designed to automatically open at tank pressure of 17 kPa (2.5 psi). Spring-loaded lid, aluminum or cast iron construction, with Teflon-coated seating surface.
- I. Internal Ladder: Provide as shown with 50 mm x 6 mm (2 inch x 0.25 inch) sides and 20 mm (0.75 inch) diameter rungs at 300 mm (12 inches) on center. Provide slide supports to allow for tank movement.
- J. Wear (Striker) Plates: Provide 300 mm (12 inch) square, 6 mm (0.25 inch) thick steel plates welded to tank bottom directly under the sounding opening, the fuel return discharge, and the fill discharge.
- K. Lifting Lugs: Provide for rigging tanks.
- L. Seismic Design: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

2.3 TANK AND PIPING ACCESSORIES:

- A. Vent Caps: Galvanized cast iron or cast aluminum with brass or bronze screens, arranged to permit full venting and to prevent entry of foreign material into the vent line. Same pipe size as vent pipe.
- B. Fill Boxes:
 - 1. Fill cap shall be lockable, tight-fill design with provision for padlock on the top of the cap. Fill cap shall screw onto threaded

adapter that can be removed without removing fill box. Entire assembly shall seal tight with no leakage during filling and when cap is in place.

2. Provide special tools necessary for opening fill boxes and fill caps.
- C. Fill caps located above grade without fill boxes shall be lockable, tight-fill design, operated by special wrench that shall be furnished. Entire assembly shall seal tight with no leakage during fill and when cap is in place.
- D. Refer to Section 05 50 00, METAL FABRICATIONS, for access platforms shown for aboveground tanks.
- E. Support horizontal portion of pipes located inside tank every 2100 mm (7 feet) maximum.
- F. Furnish gauging chart, liters versus mm and gallons versus inches depth.
- G. Furnish sounding rod for each tank size. Mark rods in increments representing five percent of tank capacity. Provide length of rod suitable for tank burial depth (if applicable). Rods shall be graduated in gallons.
- H. Fill Point Identification:
 1. Fill Caps above Grade: Aluminum, brass or bronze plate, clamped to fill pipe, with stamped or engraved letters 18 mm (0.75 inch) high.
 2. Legend: "DIESEL FUEL FILL" as appropriate.
- I. Containment Sumps: *(Add#01)*
 1. Provide containment sumps for connection of supply and return piping within secondary containment conduit, of material to match tank, with sump base, add-on extension pieces as required, sump top, lid, and gasket-seal joints.

2.4 PIPING, VALVES, FITTINGS:

- A. Fuel supply and return, tank fill, vents, sounding, pump out, steam and condensate. Contractor may choose pipe and fitting materials from those listed below. *(Add#01)*
- B. Steel Pipe and Fittings:
 1. Piping: Steel, seamless or electric resistance welded (ERW), ASTM A53 Grade B or ASTM A106 Grade B, Schedule 40. Aboveground piping shall be painted. Refer to Section 09 91 00, PAINTING.
 2. Joints: Socket or butt-welded. Threaded joints not permitted except at valves, unions and tank connections.
 3. Fittings:
 - a. Butt-welded joints: Steel, ASTM A234, Grade B, ASME B16.9, same schedule as adjoining pipe.
 - b. Socket-welded joints: Forged steel, ASME B16.11, 13 700 kPa (2000 psi) class.

4. Unions: Malleable iron, 2050 kPa (300 psi) class.
 5. Companion flanges: Flanges and bolting, ASME B16.5.
 6. Welding flanges: Weld neck, ASME B16.5, forged steel ASTM A105, 1025 kPa (150 psi).
- C. Glass Fiber Reinforced Plastic (FRP) Pipe and Fittings:
1. Conform to UL 971 and ASTM D2996 using a filament-winding process and epoxy or vinyl ester resins.
 2. Design pipe, fittings and joining system for required fuel service, 66 °C (150 °F), 1030 kPa (150 psi) pressure, 68 kPa (20 inches HG) vacuum.
 3. Provide an integral resin-rich liner, 0.5 mm (0.020 inches) minimum thickness to enhance the corrosion resistance. Outer layer shall include ultra-violet inhibitors. Joining adhesive shall be designed for the pipe furnished and shall be supplied by the pipe manufacturer.
 4. Plastic pipe and fittings are not permitted on steam or condensate service. ^(Add#01)
 5. Plastic pipe utilized for this Project shall be approved for use above-ground. ^(Add#01)
- D. Check Valves - Fuel Pump Suction.
1. Pipe Sizes 50 mm (2 inches) and under: Rated for 1375 kPa (200 psi) water-oil-gas, swing-type, threaded ends, ASTM B62 bronze body. Provide union adjacent to valve.
 2. Pipe Sizes 65 mm (2 1/2 inches) and above: Rated for 1375 kPa (200 psi) water-oil-gas, swing-type, 850 kPa (125 pounds) ASME flanged ends, ASTM A126 class B cast iron body.
- E. Foot Valves - Fuel Pump Suction: Double poppet, lapped-in metal-to-metal seats, double-guided stems, 20 mesh inlet screen, same size as fuel suction piping. Foot valve shall be removable to above grade through the tank manhole enclosure or through extractor fitting.
- F. Extractor Fittings: Arranged to permit removal of foot valves, overfill prevention valves, and other devices that are located below grade. Access point shall be through a cast iron fill box-type manhole located at grade. Provide extractor wrench.
- G. Overfill Prevention Valve: Aluminum automatic valve designed for aboveground tanks. Locate valve near the top of the tank in the fill pipe. On aboveground tanks, or tanks pressure-filled, provide single stage valve, rated for fill flow and pressure, which stops flow completely at 95 percent of tank capacity. Valve shall include method for draining oil trapped above the valve into the tank.
- H. Flexible Connections: Annular corrugated stainless steel close-pitch hose with stainless steel over braid, designed and listed for use in handling diesel fuel oil.

2.5 SECONDARY CONTAINMENT FOR FUEL PIPING SYSTEMS: (Add#01)

- A. Enclose the fuel supply, return and fill pipes in factory-engineered and fabricated secondary containment conduit systems. The systems shall be complete with end seals, with 25 mm (1.0 inches) minimum continuous annular space, 37 mm (1.5 inches) between carrier pipes, which shall contain all leakage and which has provisions for leak detection system as specified. Contractor may choose containment conduit materials from those listed below.
- B. Steel Conduit with Fusion-Bonded Epoxy Coating and Cathodic Protection:
 - 1. Galvanized carbon steel pipe, ASTM A53, Grade B, Schedule 40 for diameters through 125 mm (5 inches), 3.4 mm (0.134 inch) thick for diameters greater than 125 mm (5 inches) up through 650 mm (26 inches). All welded construction.
 - 2. Sand blast exterior per NACE 3.
 - 3. Coat exterior with 0.5 mm (20 mils) thick fusion-bonded epoxy.
 - 4. ~~Deleted Provide cathodic protection designed by corrosion specialist and consisting of galvanic anodes, test stations, interconnecting wiring in conformance with UL 1746 and NACE SP-0169. Electrical isolation required between all connecting systems in manholes and buildings.~~ (Add#02)
- C. Steel Conduit with Fiberglass Reinforced Plastic (FRP) Coating:
 - 1. Carbon steel pipe, ASTM A53, Grade B, Schedule 40 for diameters through 125 mm (5 inches), 3.4 mm (0.134 inch) thick for diameters greater than 125 mm (5 inches) up thru 650 mm (26 inches). All welded construction.
 - 2. Blast clean exterior per NACE 4.
 - 3. Apply fiberglass reinforced polyester (FRP) external cladding at least 2.5 mm (0.10 inches) thick with ultra-violet inhibitor. Cladding on field joints shall be equivalent to factory-applied cladding applied on remainder of system.
 - 4. Test entire system for holidays using a 35,000 volt holiday detector.
 - 5. This system not permitted when carrier pipe or tracing system contains steam or condensate.
- D. Glass Fiber Reinforced Plastic (FRP) Conduit:
 - 1. Conform to UL 971 and ASTM D2996 using a filament-winding process and epoxy or vinyl ester resins.
 - 2. Design pipe, fittings and joining system for carrier pipe fuel service, 66 deg C 150 deg F) 1030 kPa (150 psi) pressure, 68 kPa (20 inches Hg) vacuum.
 - 3. Provide an integral resin-rich liner, minimum thickness 0.25 mm (0.010 inch). Outer layer shall include ultra-violet inhibitors.
 - 4. Minimum total wall thickness 1.8 mm (0.07 inch) for diameters below 200 mm (8 inches), 2.8 mm (0.11 inch) for diameters 200 mm (8 inches) and 250 mm (10 inches), 5 mm (0.20 inch) for diameters 250 mm (10

inches) through 500 mm (20 inches), and 6 mm (0.25 inch) for diameters above 500 mm (20 inches).

5. This conduit system is not permitted when carrier pipe or tracing system contains steam or condensate.
- E. Pipe Supports: Provide supports within conduit for fuel carrier pipes spaced 2100 mm (7 feet) apart except 3000 mm (10 feet) apart for carrier pipe size 50 mm (2 inches) through 100 mm (4 inches). Support design shall permit differential movement of pipes, allow drainage of leakage to sumps, and maintain alignment of carrier pipes.
- F. Conduit End Seals: Same material and coating as conduit; leak tight.
- G. Leak Detector Sensor Locations: On each piping system, provide sumps at the low points with water-tight openings above grade for access to leak detector sensors. Design sumps to intercept all potential leakage. Maximum spacing between sumps, 3000 mm (100 feet).

2.6 LEAK DETECTION SYSTEMS:

- A. Automatic digital continuous monitoring systems responsive to the presence of water and hydrocarbons in the interstitial space of the double-wall tanks, in the tank manhole access enclosures, and in the secondary containment of fuel piping systems. System shall distinguish between hydrocarbon and water and identify location of leak as to individual tank and piping system. System may be combined with tank fluid level monitor and alarm system specified in Article, TANK FLUID LEVEL MONITOR AND ALARM SYSTEM.
- B. Functions and Arrangement:
 1. Single control station to monitor all sensing probes.
 2. Visual indicator to monitor and identify leaks as water or hydrocarbon and location.
 3. Indicators showing system status including faults and alarms.
 4. On board printer that provides complete reports of all system functions upon command.
 5. Panel circuit test button.
 6. 95 dB audible alarm with silencing control to sound when leak is detected.
 7. Eight hour memory backup system with battery.
 8. NEMA 250 Type 4 cabinet.
 9. UL or other accredited testing laboratory listing.
 10. RS232 Modbus communications with engineering control system to indicate system in service and alarm conditions.
- C. Sensors:
 1. Designed for required locations including: Insertion between walls of double-wall tanks, in sumps in double-wall piping systems, and in

tank manhole enclosures. Sensing points shall be at lowest point of each tank, ~~or sump, or piping run.~~ Intrinsically safe design. (Add#02)

2. Sensing units shall detect presence of water and a minimum 3 mm (0.125 inch) thick layer of hydrocarbon on surface of water and minimum 50 mm (2 inch) thickness of hydrocarbon in area that has no water present.
3. Sensors shall be arranged to allow replacement of individual sensors without disturbing other portions of leak detection system or fuel storage and piping system. ~~Underground sensors shall be accessed through caps as grade.~~ (Add#02)
4. Materials of construction shall be non-corroding.
5. Transmit status signal to control unit.

D. Components:

1. ~~Deleted Provide manholes at grade for each sensor cap similar in construction to fill boxes. Manholes shall be cast iron, quick opening cover, watertight, minimum size necessary to accommodate sensor caps. Provide identification plates, similar to those specified for fill points, labeled "MONITORING/OBSERVATION WELL DO NOT FILL". Provide special tools if necessary for opening covers.~~ (Add#02)
2. Sensor housings from tank and piping to grade shall be Schedule 40 PVC, or stainless steel.
3. ~~Deleted Underground wiring between probes and control unit: Place in water tight corrosion resistant conduit system conforming to Section 26-05 41, UNDERGROUND ELECTRICAL CONSTRUCTION.~~ (Add#02)

2.7 TANK FLUID LEVEL MONITOR AND ALARM SYSTEMS:

- A. Digital systems for central monitoring of fuel and water levels in all fuel oil storage tanks in the project. High and low level visual and audible alarms. Volumetric tank-tightness testing. Complete with all transducing, transmitting, and receiving devices. On board printer to provide complete report of all system functions upon command. System may be combined with leak detection system specified in Article, LEAK DETECTION SYSTEMS.
- B. Fluid Level Monitor:
1. Digital continuous readout, showing tank oil and water levels in gallons, smallest reading one gallon. Provide identification of product measured, measuring units, and the tank number.
 2. Tank and fuel characteristics contained in preprogrammed non-volatile field-replaceable databases. Protected power supply.
- C. High and Low Fluid Level Alarm System:
1. Automatic continuous on-line monitoring of all tanks.
 2. Visual and audible indicators combined with fluid level monitor. Identify the tank that is in alarm condition.
 3. Manual alarm test and silencing controls.
 4. Low level alarm actuation adjustable 0-25 percent of tank capacity. High level alarm actuation adjustable 75-100 percent of tank capacity.

- D. Locate all indicators, selector switches, alarms on face of wall-mounted NEMA 250, Type 4 panel.
- E. Remote Alarm Annunciator:
 - 1. Visual and audible high level alarms adjacent to tank fill box locations. Locate in NEMA 250 Type 4X weatherproof exterior wall or pole-mounted panels.
 - 2. Alarm shall include flashing red light with 180 degree visibility for each tank and 95 dB horn or 100 mm (4 inch) diameter bell. Provide alarm silence control.
 - 3. Provide identification sign: "WHEN ALARM SOUNDS - FUEL TANK FILLED TO CAPACITY - DO NOT OVERFILL".
- F. Modbus communication to engineering control system to indicate tank fluid level and alarm conditions. Telephone modem communication capability.
- G. System Performance: Accuracy plus or minus 2.5 mm (0.01 inch) of fluid height in inventory mode and 0.25 mm (0.001 inch) in leak detection mode. Automatic compensation for fluid temperature changes. Volumetric tank tightness sensitivity of 0.4 lph (0.1 gph).
- H. Sensors:
 - 1. Provide sensor types such as magnetostrictive, capacitance, float, hydrostatic and other types as necessary for the applications.
 - 2. Apply in accordance with manufacturer's instructions with provisions for easy future replacement without need for excavation.
 - 3. Provide for each hydrostatic sensor a constant flow differential pressure regulator and pneumatic transmitter protected from fuel contamination. Air supply shall include filter and over-pressure protection. Provide desiccant-type dryer on air supply designed for removal of water vapor. Dryer rating, minimum 280 cubic liters per minute (10 scfm). Provide moisture indicator. Dryer may be deleted if air supply source has a refrigerated dryer.
 - 4. Float-type units shall be designed for installation and removal through a 100 mm (4 inch) diameter vertical pipe mounted in the top of the tank.
- I. ~~Deleted Underground Wiring and Piping: Enclose in water-tight corrosion-resistant conduit system sized and arranged as recommended by system manufacturer and conforming to Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION. (Add#02)~~
- J. Code Conformance: NFPA-70.

2.8 FUEL OIL QUALITY MAINTENANCE SYSTEMS:

- A. Complete factory-assembled automatic particulate filtration and dewatering system to maintain the purity of No. 2 fuel oil in storage. The system shall circulate the oil from the storage tank, through the system, and back to the storage tank. Provide quantity and capacity of systems to serve tanks as shown. Drawings may show multiple tanks served

by one system. Smaller systems without large water storage tanks and without fuel additive injection shall be wall-mounted. Units with water storage tanks and/or additive injection shall be floor-mounted on steel skids on concrete foundations. Digital controls.

- B. Performance: Design for nearly 100 percent water removal. Provide 2 micron particulate filtration. Each system shall have capacity to turnover the largest connected full tank one time within 22 hours maximum. System shall be designed to allow continuous operation with brief interruptions to manually change filters and clean strainers.

C. Components:

1. Strainer: 100 mesh perforated stainless steel basket. Clamped covers. 860 kPa (125 psi) design pressure.
2. Water Separation Unit: Two stage, designed to reduce water content of fuel to less than 10 ppm. Centrifugal separator for removal of large droplets and renewable resin-impregnated cellulose water coalescing elements. Water removed shall flow to water holding sump in the unit. Water sensing probe to alert the operator when water level in bowl has reached capacity.
3. Filter: 2 micron filtration with 96% removal efficiency, valved manual drain. Replaceable elements.
4. Filtration Pump: Positive displacement base-mounted pump with cast iron or bronze housing, for circulating the oil from the storage tank, through the water separation and filter units and back to the storage tank. Pump shall have carbon bushings, stainless steel shaft and Teflon mechanical seal, ODP motor.
5. Controls:
 - a. Digital PLC electronic controls for all system control and alarm functions. Relay logic not acceptable.
 - b. Control panel with selector for modes of operation, indicators to show system status, and visual and audible alarms to signal the need for operator intervention. Operator interface shall be 2 x 20 LCD and keypad.
 - c. Controls shall include:
 - 1) Control power "on-off".
 - 2) "Cycle Start".
 - 3) "Cycle Cancel".
 - 4) "Hand-off-Auto" for filtration pump.
 - 5) Pump cycle timer set function.
 - 6) Cycle duration selector.
 - d. Indications shall include:
 - 1) "Control Power On".
 - 2) "Pump Run".
 - 3) "Pump Failure".
 - 4) "Excess Water In Fuel".
 - 5) "Filter Water Level High".
 - 6) "Rupture Basin Leak" alarm.

- 7) "High Pressure Drop in Strainer" alarm.
 - 8) "High Pressure Drop in Filters" alarm.
 - 9) "High Pressure" alarm and automatic shut down.
 - 10) "High Water Level" in water storage tank.
 - e. Filter and strainer differential pressure gages, differential pressure switches and control. Provide indication when filters should be changed.
 - f. Over pressure switch and control to shut down pump if filter inlet pressure exceeds limits.
 - g. All primary wiring exiting the enclosure shall be encased in conduit.
 - h. Magnetic motor starters with overload protection.
 - i. Circuit breakers.
 - j. Control enclosure shall be NEMA 12, fully gasketed doors with 3 point lockable latching. Interior shall have white gloss finish; exterior shall be chemical-resistant gray enamel. All controls and indicating devices shall be mounted on front of enclosure and labeled with black phenolic labels with white lettering.
 - k. Modbus communication to engineering control system for alarms and system status.
- D. Enclosure - Wall Mounted Units: 14 gauge steel, NEMA 12/13 standards, continuously welded, framed cabinet. Provide doors for complete access to all equipment. Doors shall have a turned edge, piano hinges, three-point locking mechanisms. Corrosion-resistant prime and finish coatings on all interior and exterior surfaces.
- E. Water Drainage System: Sealed bowl (bottle) with high level alarm system. Water collected in filters shall drain to a sealed bowl that can be easily removed and emptied.

2.9 FUEL TRANSFER PUMPS:

- A. Provide submersible fuel oil transfer pumps from main storage tanks to day tanks and from above ground day tanks (other than belly tanks below generators). Pumps shall be UL listed and designed for Class I, Group D hazardous atmospheres. Pump shall be compatible with diesel. Equip for mounting on exterior storage tank. Provide with line pressure port, vent port and siphon ports. Shall be adjustable to suit tank depth.
- B. Provide base mounted, light oil pump and motor assemblies for returning fuel from day tank to main storage tank unless shown with submersible type. Pump assembly shall be direct drive unit suitable for No. 2, No. 4 and diesel oil. Pump and motor shall be mounted on a structural steel channel base. Shafts shall be directly connected with a flexible coupling with all rotating parts protected by an OSHA guard. Pumps shall be bi-rotational, positive displacement, internal gear types with cast iron housings and BUNA-N self adjusting mechanical seals. Provide with over pressure relief valve.

2.10 CONCRETE FOUNDATIONS:

- A. Concrete pads for aboveground tanks are specified under Section 03 30 00, CAST-IN-PLACE CONCRETE. Credit for overburden is allowed.

2.11 ~~BURIED UTILITY WARNING TAPE:~~

- A. ~~Tape shall be 0.1 mm (0.004 inch) thick, 150 mm (6 inches) wide, yellow polyethylene with a ferrous metallic core, acid and alkali-resistant and shall have a minimum strength of 12,000 kPa (1750 psi) lengthwise and 10 300 kPa (1500 psi) crosswise with an elongation factor of 350 percent. Provide bold black letters on the tape identifying the type of system. Tape color and lettering shall be unaffected by moisture and other substances contained in the backfill material.~~ (Add#02)

PART 3 - EXECUTION

3.1 INSTALLATION AND TESTING, ABOVEGROUND TANKS:

- A. Conform to NFPA 30 or 31 as applicable.
- B. Support tanks on steel saddles welded to the tanks. Anchor to concrete foundations. Provide molded neoprene isolation pads between the steel supports and the concrete foundation.
- C. After tanks are installed, test steel tanks with air pressure of 20 kPa to 35 kPa (3 - 5 psi), using soapsuds to locate leaks. Repair leaks by chipping to bare metal and rewelding. Retest until all leaks are repaired. Repair all damaged areas of prime coat on tanks and steel dikes (if furnished). Test interstitial area between steel tank walls with air at pressure recommended by tank manufacturer. Tests shall be witnessed by the RE/COTR.
- D. Surface finish coating for tanks and steel dikes (if furnished) is specified under Section 09 91 00, PAINTING.
- E. Provide electrical grounding in accordance with NFPA 70.

3.2 ~~INSTALLATION AND TESTING, UNDERGROUND-PIPING SYSTEMS:~~ (Add#02)

- A. Leak Detection System: Arrange fuel and tracing media (if required for heated oil) carrier piping, enclosed in secondary containment piping, to accommodate leak detection system. Slope piping down toward tanks and leak detectors at 25 mm in 10 m (1 inch in 40 feet).
 - 1. Provide new leak detection system where required.
 - 2. Extend existing leak detection system where required.
- B. Steel Fuel and Tracing Media Carrier Piping: All joints butt or socket welding. Threaded piping is not permitted. Piping ends shall be accurately cut, true, and beveled for welding.

- C. Glass Fiber Reinforced Plastic (FRP) Fuel Carrier Piping and Secondary Containment Piping: Install in accordance with printed instructions of pipe manufacturer. Installation personnel trained in accordance with Article, QUALITY ASSURANCE. Plastic piping not permitted in same secondary containment system with steam or condensate piping.
- D. Secondary Containment Piping:
1. ~~Deleted Provide sand bedding and backfill material for steel piping and pea gravel for FRP piping.~~ (Add#02)
 2. ~~Deleted Top of system 450 mm (18 inches) minimum below grade.~~ (Add#02)
 3. ~~Design and locate~~ Locate leak detector ~~sumps~~ sensors to ~~intercept~~ detect all potential leakage. Maximum spacing along each system, 3000 mm (100 feet). (Add#02)
 4. Seal all building ~~and manhole~~ and containment sump wall penetrations with watertight flexible link seal system. (Add#02)
 5. After placing system, ~~prior to backfill~~, repair all damage, including coatings, as recommended in printed instructions of system manufacturer. Perform 10,000 volt holiday test on coated steel systems. (Add#02)
 6. ~~Deleted On steel systems that do not have FRP cladding, install cathodic protection system.~~ (Add#02)
- E. Leak Test: Test carrier pipes with air pressure at 690 kPa (100 psi), and test the containment piping with air pressure at 55 kPa (8 psi). Systems shall hold the pressure for 30 minutes. Repair all leaks and retest.
- F. Coatings for Steel Piping not in Secondary Containment System: Provide urethane coating ~~and cathodic protection.~~ (Add#02)
- G. ~~Deleted Buried Utility Warning Tape: Install tape 300 mm (12 inches) below grade above the piping system.~~ (Add#02)

3.3 DELETED (Add#01)

3.4 INSTALLATION AND TESTING, LEAK DETECTOR SYSTEMS FOR TANKS AND PIPING:

- A. Wiring shall conform to NFPA-70.
- B. Locate control monitor panels 1500 mm (5 feet) above the floor on inside wall of boiler room, generator room or garage, depending on type of fuel tank served, unless shown otherwise.
- C. Test operation of each probe, and monitoring system with fuel and water. If type of probe utilized is damaged by exposure to fuel, provide temporary probe for testing monitoring system.

3.5 INSTALLATION, TANK FLUID LEVEL INDICATOR AND ALARM SYSTEM:

- A. Wiring shall conform to NFPA-70.

- B. Locate level indicator and alarm panel 1500 mm (5 feet) above the floor on inside wall of boiler room, generator room or garage, depending on type of fuel tank served, unless shown otherwise.
- C. Locate remote high level alarm on exterior wall or pole in view of tank fill point, 2400 mm (8 feet) above grade.

3.6 INSTALLATION, FUEL OIL QUALITY MAINTENANCE SYSTEMS:

- A. Locate systems within easy reach of persons standing on floor, with sufficient elevation to allow gravity flow of water from system to water storage tank sitting on the floor.
- B. Connect to tank suction and return piping systems with isolation valves. Provide compound pressure gages at suction and discharge piping connections.

3.7 ~~Deleted~~ ~~INSTALLATION, CATHODIC PROTECTION TEST STATIONS:~~ (Add#02)

- ~~A. Provide separate station for each tank and each piping system, anchor firmly, locate so that terminal board is 600 mm (2 feet) minimum above grade. Connect wiring from all anodes and protected structures to the test stations.~~

3.8 ~~Deleted~~ ~~TESTING, CATHODIC PROTECTION:~~ (Add#02)

- ~~A. Testing performed by NACE-certified corrosion specialist; witnessed by RE/COTR.~~
- ~~B. Test Instruments:~~
 - ~~1. Volt Ammeter.~~
 - ~~2. Saturated copper-copper sulfate reference electrode.~~
 - ~~3. Other instruments as required.~~
- ~~C. Procedures: Conform to NACE SP-0169. (Add#01)~~
- ~~D. Test Results Required for Acceptance:~~
 - ~~1. Potential of minus 0.85 volt between protected structure and reference electrode.~~
 - ~~2. Minimum shift of minus 300 millivolts upon application of protective current. Voltage measured between protected structure and reference electrode.~~
 - ~~3. Minimum shift of minus 100 millivolts upon interruption of protective current. Voltage measured between protected structure and reference electrode.~~
- ~~E. Test Report: Provide complete report to RE/COTR showing all test measurements, calculations, list of instruments used.~~

3.9 CONSTRUCTION WASTE MANAGEMENT

- A. General: Comply with Contractor's Waste Management Plan and Section 01 741 9, CONSTRUCTION WASTE MANAGEMENT.
- B. To the greatest extent possible, separate reusable and recyclable products from contaminated waste and debris in accordance with the Contractor's Waste Management Plan. Place recyclable and reusable products in designated containers and protect from moisture and contamination.

3.10 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specifications will be tested as part of a larger system. Refer to Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS and related sections for contractor responsibilities for system commissioning.

3.11 INSTALLATION AND TESTING, ABOVE GROUND PIPING SYSTEMS: (Add#01)

- A. Leak Detection System: Arrange fuel and tracing media (if required for heated oil) carrier piping, enclosed in secondary containment piping, to accommodate leak detection system. Slope piping down toward tanks and leak detectors at 25 mm in 10 m (1 inch in 40 feet).
 - 1. Provide new leak detection system where required.
 - 2. Extend existing leak detection system where required.
- B. Steel Fuel and Tracing Media Carrier Piping: All joints butt or socket welding. Threaded piping is not permitted. Piping ends shall be accurately cut, true, and beveled for welding.
- C. Glass Fiber Reinforced Plastic (FRP) Fuel Carrier Piping and Secondary Containment Piping: Install in accordance with printed instructions of pipe manufacturer. Installation personnel trained in accordance with Article, QUALITY ASSURANCE. Plastic piping not permitted in same secondary containment system with steam or condensate piping.
- D. Secondary Containment Piping:
 - 1. Seal all building wall penetrations with watertight flexible link seal system.
 - 2. Mount aboveground piping per Drawings details.
- E. Leak Test: Test carrier pipes with air pressure at 690 kPa (100 psi), and test the containment piping with air pressure at 55 kPa (8 psi). Systems shall hold the pressure for 30 minutes. Repair all leaks and retest.

3.12 IDENTIFICATION SIGNS

- A. Tanks containing hazardous materials shall be labeled with contents and placarded per UFC Standard 79-3. ^(Add#01)

- - - E N D - - -

^(Add#01) 18 SEP 2013, Addendum No. 01

^(Add#02) 07 OCT 2013, Addendum No. 02

SECTION 23 12 34

FUEL GAS COMPRESSOR

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section describes the requirements for natural gas compressor system used in conjunction with the gas turbine generator system, including compressors, electric motors and starters, receiver, all necessary piping, fittings, valves, gages, switches and all necessary accessories, connections and equipment.
- B. The natural gas compression system specified herein is part of an integrated 'co-generation' (co-gen) or combined heat and power (CHP) system consisting of the CTG, the Heat Recovery steam generator (HRSG), the PLC control system, the natural gas compression system, and the continuous emissions monitoring system. It is the intent of these specifications that the CHP system be furnished complete as a system with a single source of responsibility to coordinate the procurement of the associated components to insure compatibility and performance. Refer to Section 26 32 14, Combustion Turbine Generator, for language regarding 'packaging' and single source responsibility and Section 25 60 00, CHP PLANT CONTROL SYSTEM, for language regarding 'system integrator' for controls.
- C. The manufacturer shall design, fabricate, assemble, factory test, deliver, and provide startup and commissioning supervision and training for one (1) natural gas compressor system, complete with all components and features as specified. The natural gas compressor system shall each be of a single skid mounted construction, with all components mounted on skid. Skid shall be complete and ready for hooking up interconnecting piping, power, and interconnecting control wiring and the external connections to make the system operative.

1.2 RELATED WORK

- A. Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT: Procedures and requirements for managing and disposing construction and demolition waste.
- B. Section 01 81 11.01, SUSTAINABLE DESIGN REQUIREMENTS: Sustainable design requirements including submittal requirements.
- C. Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS: Requirements for commissioning, systems readiness checklists, and training.
- D. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- E. Section 23 11 23, FACILITY NATURAL GAS PIPING.
- F. Section 23 21 11, COGENERATION PLANT PIPING SYSTEMS: High pressure natural gas piping.

- G. Section 25 60 00, CHP PLANT CONTROL SYSTEM.
- H. Section 26 29 11, MOTOR STARTERS.
- I. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT.
- J. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- K. Section 26 32 14, COMBUSTION TURBINE GENERATOR.

1.3 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's Literature and Data shall be submitted for the following products:
 - 1. Supporting elements.
 - 2. Pressure Gages.
 - 3. Pressure Reducing and Regulating Valves.
 - 4. Automatic drain valves.
 - 5. Filter capacity and operating characteristics.
 - 6. Vibration Isolation.
 - 7. Control Panel and Alarm System.
 - 8. Compressor System:
 - a. Characteristic performance curves.
 - b. Sound ratings measured in dBA.
 - c. Efficiency.
 - d. Compressor; manufacturer and model.
 - e. Compressor operating speed.
 - f. Capacity; (CFH at discharge pressure).
 - g. Stroke, piston speed.
 - h. Type of lubrication.
 - i. Capacity of cooling fan and motor size.
 - j. Unloader; manufacturer, type, and model.
 - k. Type and adjustment of drive.
 - l. Electrical motor; manufacturer, frame and model.
 - m. Speed of motor.
 - n. Current characteristics and HP of motor.
 - o. Oil cooler; manufacturer, type, and model.
 - p. After cooler; manufacturer, type, and model.
 - 9. Compressor Acoustic Enclosure: Product data including sound rating for enclosure measured in dBA.

C. Drawing Requirements (not all inclusive):

1. Final equipment layouts shall include arrangement drawings in plan and elevation, with all major components identified. Product and service tie-ins shall be identified by size, type and dimensions for locating tie-ins. Access clearances for service of equipment and removal of components shall also be shown. Mechanical interfaces to other systems or utilities shall be clearly identified and dimensioned, including size and type of connection. Detailed location and characteristics of all terminal points, electric connection requirements, etc. shall be provided.
2. Elevations and sections shall be provided as necessary to show full details of tie-ins, service access and control components.
3. P&ID diagrams.
4. Control Seismic Diagrams - including control logic. Include page and/or rung comment, or Logic Diagram in sufficient detail to allow for the future maintenance of the system.
5. Field Electrical Wiring Diagrams.
6. Overall dimensions and detailed floor loading shall be shown.

D. Brazing and welding certificates shall be submitted.

E. For Seismic Restraint design the following shall be submitted:

1. Dimensioned drawings of equipment identifying center of gravity and location and description of seismic mounting and anchorage systems.

F. LEED Submittals: Submit in accordance with Section 01 81 11.01.

1. LEED submittals are in addition to other submittals. If submitted item is identical to that submitted to comply with other requirements, submit duplicate copies as a separate submittal to verify compliance with indicated LEED requirements.
2. LEED Product Data Submittal Form: Submit completed product data form provided by the Contracting Officer's Representative; certified by vendor, installer, subcontractor, and/or manufacturer as appropriate.

1.4 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American National Standards Institute (ANSI)/American society of Mechanical Engineers (ASME):
 1. A13.1- 07 Scheme for the Identification of Piping Systems
- C. American Petroleum Institute (API)
 1. 11P-89 Specification for Packaged High Speed Separable Engine Driven Reciprocating Gas Compressors

2. 618-95 Reciprocating Compressors for General Refinery Services

D. National Fire Protection Association (NFPA):

1. 99-2005 Health Care Facilities

1.5 AS-BUILT DOCUMENTATION

- A. The electronic documentation and copies of the Operations and Maintenance Manual, approved submittals, shop drawings, and other closeout documentation shall be prepared by a computer software program complying with Section 508 of the Rehabilitation Act of 1973, as amended (29 U.S.C 794d). The manufacturer or vendor of the software used to prepare the electronic documentation shall have a Voluntary Product Accessibility Template made available for review and included as part of the Operations and Maintenance Manual or closeout documentation. All available accessibility functions listed in the Voluntary Accessibility Template shall be enabled in the prepared electronic files. As Adobe Acrobat is a common industry format for such documentation, following the document, "Creating Accessible Adobe PDF files, A Guide for Document Authors" that is maintained and made available by Adobe free of charge is recommended."
- B. Four sets of manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- C. Four sets of operation and maintenance data updated to include submittal review comments shall be inserted into a three ring binder. All aspects of system operation and maintenance procedures, including piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices such as damper and door closure interlocks shall be included. A list of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

1.6 INSTALLATION, COMMISSIONING AND STARTUP SERVICES

- A. The Manufacturer shall provide the necessary services to assist in the installation and assembly of the work provided, field commissioning and startup services to fully commission the equipment to achieve performance guarantees. This service shall include, but not be limited to, verification of proper installation, performance of all tests and procedures as stated in the startup and installation manuals, verification of the proper operation of the control panels to perform as designed, performance of all necessary adjustments and calibrations of all unit sensors and meters and necessary technical assistance to assure that the Manufacturer's equipment meets the performance guarantees. The Manufacturer shall make all reasonable efforts to insure that the same service technician is utilized for startup, training and commissioning.

- B. Additional hands on training shall be provided on an informal basis, as time permits, by the Manufacturer's representative during plant startup and commissioning.

1.7 TRAINING

- A. The Manufacturer shall provide on-site training for up to 5 operating and maintenance personnel. This service shall include operating instructions and training for Owner's personnel. Instructions shall include, but not be limited to, training materials, hands-on and classroom instruction and complete review of all manuals. Classroom training shall be performed for two groups of personnel in a maximum of 2-8 hour daily sessions. The hands-on instructions shall include startup, operation (normal and expected transients), shutdown and maintenance.

1.8 SPARE PARTS

- A. Manufacturer shall identify all spare parts, including source, cost and identification of the manufacturer and associated model number, critical to initial startup that are recommended for the Owner to have on-hand to minimize unplanned construction delays or equipment downtime, as well as a standard priced spare parts list for replacement of components as needed. The Manufacturer shall recommend spare parts expected for replacement during two (2) years of operation.

1.9 SPECIAL TOOLS

- A. The Manufacturer shall furnish one (1) set of new special tools normally provided for the system proposed.

1.10 PERMITS (Add#01)

- A. Obtain any required permits to construct from Bay Area Air Quality Management District (BAAQMD), and hazardous materials permits from the City of Palo Alto and County of Santa Clara as required.

1.11 WARRANTY (Add#01)

- A. Work subject to the terms of the Article "Warranty of Construction", FAR clause 52.246-21. Provide manufacturer's and installer's specialty warranty as follows:
 - 1. Special warranty includes labor and parts for the ~~CHP Control~~ Fuel Gas Compressor System free from defects for the specified warranty period.
(Add#02)
 - 2. The warranty shall include, but not be limited to, the following: Labor, travel, living expenses, parts replacement, system maintenance and testing, and software/hardware updates and revisions.
 - 3. Work shall have a single warranty date, even if the Government receives beneficial use due to early startup.
 - 4. Provide updates to project-specific software and firmware that resolve installer or Government identified software deficiencies at no additional charge during the warranty period.

5. In the event that the installer service call work causes damage to additional equipment, the installer shall be liable for labor and material to restore the system to full operation.
- B. During the warranty period, the installer shall update the software free of charge as manufacturer's software is improved.
- C. Warranty Period: Four years from the date the system is completely installed, fully operational, and accepted by the Government. The Resident Engineer representing the Government shall verify in writing that the CHP Control System has been tested and accepted in accordance with this specification. The date of acceptance shall begin the warranty period.

PART 2 - PRODUCTS

2.1 REFER ALSO TO SECTION 23 21 11, COGENERATION PLANT PIPING SYSTEMS

2.2 GAS COMPRESSOR

- A. Fuel gas boost compressor shall be of the horizontal opposed reciprocating piston design and including crosshead guides. The compressor shall be a balanced-opposed design and have fully machined crankshaft to provide optimum balance and vibration free operation. Units shall be designed in accordance with API Standards 11P and 618.

1. Compressor Materials:

<u>Components</u>	<u>Material</u>
Crankcase	Grey iron
Crosshead guides	Grey iron
Crankshaft	Ductile iron
Connecting rods	Ductile iron 60-40-18
Connecting rod bearings	Steel backed babbit
Main bearings	Double row spherical roller
Connecting rod bushings	Phosphor bronze
Crossheads	Ductile iron 60-40-18 babbitt faced
Crosshead pin	Alloy steel 8620
Crosshead pin bushings	660 bronze
Piston rod	Alloy steel 4140
Rod packing rings	Non metallic full floating

<u>Components</u>	<u>Material</u>
All stress bolts	High tensile alloy
Pistons	Steel, grey iron, or alum
Standard piston rings	Non metallic
Standard rider rings	Non metallic
Valve cover O rings	Viton
Valve seats	Carbon steel
Valve guards	Carbon steel

- B. The frame shall be pressure lubricated including crosshead guide, wrist pin bushings, connecting rod bearings and (spray) main bearing.
- C. The compressor shall be equipped with double acting or tandem, single acting cylinders as needed to meet the configuration requirements of the application. The maximum allowable working pressure shall be at least 10% over the maximum operating pressure of the application. Cylinder shall be hydro tested at two times the maximum allowable working pressure. Design temperature of the cylinder shall be 350 Deg F with maximum operating temperature being less than 300 Deg F.
- D. Compressor package shall include air cooled intercooler and aftercooler sections. Cooler assembly shall be forced draft type designed for gas approach temperature of 20 Deg F to site design temperature (93 Deg F). Fan shall be driven by electric motor.
- E. Provide the following features:
1. Piston/rider and packing rings material to be compatible with the specified gas and service.
 2. Non-cooled double acting cylinders.
 3. Non-interchangeable compressor valves of the plate design.
 4. Variable head end clearance pockets on each cylinder.
 5. Lubricated cylinders and packing.
 6. Motor driven cylinder lubricator.
 7. Motor driven oil pump to accommodate variable speed drive.
 8. Minimum four hour run test of compressor to insure proper fit up.
 9. Special tools kit containing tools required for compressor maintenance and repair that would not be considered normal mechanics tools.
 10. Compressor to be mounted on a rigid structural steel skid.
 11. Direct motor driven - coupling, flywheel and non sparking guards

- required, 250 HP TEFC 460/3/60 motor with thermostats for hazardous area.
12. Inlet connection shall be at skid edge, piped to 1st stage suction vessel and shall include removable startup screen.
 13. Coalescing filter with 1 micron retention rating at discharge.
 14. Separator at suction of both stages. Separators shall be designed for adequate pulsation suppression at suction.
 15. Liquid level drain control for separators and filter.
 16. Pulsation vessels shall be provided at outlet of each cylinder.
 17. Interstage piping with relief valves at each stage.
 18. Air cooled intercooler, aftercooler, and oil cooler.
 19. Control panel suitable for the service in a NEMA 4 enclosure. Controls shall be intrinsically safe, suitable for the hazardous area. Controls will be based on standard fuel gas boost system.
 20. Pressure and temperature indication shall be on display screen.
 21. Discharge to inlet block and bypass loop for capacity control.
 22. Variable frequency control to vary motor speed from 50 percent to 100 percent capacity. Controller to be installed in non-hazardous area by others.
- F. Acoustic enclosure designed to reduce noise levels. The enclosure shall be rated for noise level not to exceed 65 dBA at a distance of three feet. Enclosure will include electric lights suitable for hazardous area. Provide gas detection system to shutdown equipment in case of leakage.

2.3 STRUCTURAL SKID

- A. Supply a structural steel skid, designed in accordance with AISC Manual of Steel Construction. For reciprocating compressors, the skid shall be concrete filled under the compressor/motor pedestal.
- B. Components shall be mounted with anchor bolts to structural members.
- C. Access area skid surfaces shall be 1/4 inch checkered plate.
- D. A total flooded and dry skid weight estimate, including all components, is to be included on the Approval Drawings.
- E. Skid stiffness shall be of such magnitude to prevent any local resonances.
- F. A 2" drip lip or suitable containment barrier shall be provided around the compressor. Drain connection shall terminate at skid edge.
- G. Lifting lugs shall be provided by the Supplier, and designed for a single lift of the compressor skid. Supplier shall furnish spreader bars, slings and shackles, if required.

2.4 INSTRUMENTATION

- A. Provide a fuel gas compressor system control panel complete with all associated process instruments, annunciators, power supplies, pushbuttons, lights, and accessories. The panel shall be furnished in a NEMA 4x enclosure, completely wired, programmed, and functional.
- B. Unless indicated otherwise, the panel shall be skid-mounted and suitable for the area classification of location installed. The panel shall utilize a PLC. The panel logic shall be designed for valve sequencing and alarm/shutdown functions for fully automated compressor package. HMI screen shall be 10 inches or larger.
- C. Provide a Modbus or Ethernet connection for monitoring and alarming through the FMCS.
- D. Shutdowns, with panel annunciation, shall include, but not be limited to:
 - 1. Compressor low oil pressure
 - 2. Compressor lubricator no-flow
 - 3. Compressor vibration
 - 4. Compressor low oil level
 - 5. Cylinder high discharge temperature, for each cylinder
 - 6. Vessel high liquid level, for each scrubber or filter-coalescer
 - 7. Low suction pressure, skid and interstage
 - 8. High suction pressure
 - 9. High interstage pressure, if applicable
 - 10. Low discharge pressure
 - 11. High discharge pressure
 - 12. Remote stop
 - 13. Cooler vibration
 - 14. Low discharge Delta temperature (less than 50 deg F superheat).
 - 15. High discharge temperature alarm (195 deg F) and shutdown (200 deg F)
 - 16. Motor vibration
- E. The skid wiring method shall be suitable for Class I, Division 2, Group D areas.
- F. All tubing and fittings shall be 316 stainless steel. Tubing fittings shall be Swagelock. Other threaded connections shall be sealed with a suitable sealant.
- G. All instrument items contacting process gas shall be stainless steel.

2.5 ELECTRICAL

- A. All electrical components shall be suitable for Class I, Division 2, Group D area classification, or as noted on the system Specification sheets. Wiring system shall be armored cables.
- B. The required power feeders for the main drive motor and other motors shall be installed by others. Power connections will be made directly to the motors. Control connections will be made at the skid mounted panel or skid mounted junction box (if panel is to be located off-skid). Cable wireways to be provided for customer-provided motor load and control cabling.
- C. The complete electrical installation of skid shall comply with the requirements of the National Electrical Code and applicable industry standards as referenced in article, Applicable Publications.

2.6 SIGNAGE AND LABELING (Add#01)

- A. Provide pipe labeling and signage as required by the City of Palo Alto fire department and Santa Clara County, per ANSI A13.1, NFPA 704, and UFC Standard 79-3.

PART 3 - EXECUTION

3.1 COMPRESSOR SKID

- A. Secure skid to substrate with anchors as detailed on plans or otherwise specified.

3.2 TESTS

- A. Make tests under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of compressors shall be performed simultaneously with the compressed fuel and cogeneration system of which each compressor is an integral part.

3.3 CONSTRUCTION WASTE MANAGEMENT

- A. General: Comply with Contractor's Waste Management Plan and Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.
- B. To the greatest extent possible, separate reusable and recyclable products from contaminated waste and debris in accordance with the Contractor's Waste Management Plan. Place recyclable and reusable products in designated containers and protect from moisture and contamination.

3.4 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

- B. Components provided under this section of the specifications will be tested as part of a larger system. Refer to Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS and related sections for contractor responsibilities for system commissioning.

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(Add#01) 18 SEP 2013, Addendum No. 01

(Add#02) 07 OCT 2013, Addendum No. 2

SECTION 23 50 11

COGENERATION PLANT MECHANICAL EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Condensate and HRSG feed pumps, condensate receiver/pump unit, receiver, compressed air systems, blow down separator and after cooler flash tank economizer, chemical treatment systems, steam vent silencer, and other equipment that supports the operation of the HRSG.

1.2 RELATED WORK

- A. Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT: Procedures and requirements for managing and disposing construction and demolition waste.
- B. Section 01 81 11.01, SUSTAINABLE DESIGN REQUIREMENTS: Sustainable design requirements including submittal requirements.
- C. Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS: Requirements for commissioning, systems readiness checklists, and training.
- D. Section 09 91 00, PAINTING.
- E. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- F. Section 23 05 51, NOISE and VIBRATION CONTROL FOR COGENERATION PLANT.
- G. Section 23 07 11, HVAC and COGENERATION PLANT INSULATION.
- H. Section 23 21 11, COGENERATION PLANT PIPING SYSTEMS.
- I. Section 23 22 23, STEAM CONDENSATE PUMPS.
- J. Section 22 31 11, WATER SOFTENERS.
- K. Section 25 60 00, CHP PLANT CONTROL SYSTEM.

1.3 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Flash Tank Economizer Accessories:
 - 1. Drawings showing arrangement and overall dimensions of pumps, receiver and supports. Show locations and sizes of all pipe connections and access openings.
 - 2. Weight of entire assembly empty and flooded.

3. Design and construction (including pressure and temperature limitations) of receiver, continuous blowdown heat exchanger (if provided), control valves, water level control system, level alarm switches and all accessories.
 4. Performance data on control valves and continuous blowdown heat exchanger (if provided). Refer to drawings (Schedules) for requirements.
 5. Interior Coating: Material specification, service limitations, instructions for application, experience record under the required service conditions.
 6. Continuous blowoff heat exchanger tube bundles: Dimensions, design, construction, heating surface, performance data.
- C. Blow Down Separator and After Cooler:
1. Drawing showing outline dimensions, arrangement and weight of tank and accessories. Locations and sizes of all pipe connections and access openings.
 2. Design and construction of tank, supports and accessories.
 3. Design and performance of blowoff tank temperature control valve.
- D. Boiler Feed Pumps:
1. Drawings with dimensions of assemblies of pumps and drivers.
 2. Catalog data and specification sheets on design and construction of pumps, drivers and couplings (flexible-coupled units).
 3. Motor efficiency and power factor at full load.
 4. Performance curves showing discharge head, required flow plus recirculation, NPSH required, efficiency, driver power, impeller diameter to be furnished. Refer to drawings for requirements.
 5. Pressure and temperature limitations of pump unit and accessories.
 6. Size and capacity of recirculation orifice.
 7. Data on variable frequency drive units and pressure controllers (if VFD specified).
- E. Compressed Air System:
1. Drawing with dimensions and arrangement of air compressor, motor, air dryer, receiver and all accessories.
 2. Catalog data and specification sheets on the design and construction of air receiver, compressor, after-cooler, motor, air dryer, all accessories, condensate traps. Solenoid valves and filters.
 3. Performance data on compressors, after coolers, air dryer, relief valves.
- F. Steam Vent Silencer (Muffler):
1. Drawings with silencer dimensions and weights, and sizes and types of pipe connections.

2. Catalog data and specification sheets on the design and construction.
 3. Sound attenuation data at required flow rates.
- G. Automatic Continuous Blowdown Control System:
1. Drawings with arrangement and dimensions of entire unit. Include locations and sizes of all pipe connections.
 2. Catalog data and specification sheets on design and construction of conductivity sensor, control valves, controller.
 3. Performance data on control valves.
 4. Pressure and temperature limitations of valves and conductivity sensor.
- H. Test Data - Acceptance Tests, On-Site: Four copies all specified tests.
- I. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion in accordance with the requirements of Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS.
- J. Seismic Restraint Data: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
- K. LEED Submittals: Submit in accordance with Section 01 81 11.01.
1. LEED submittals are in addition to other submittals. If submitted item is identical to that submitted to comply with other requirements, submit duplicate copies as a separate submittal to verify compliance with indicated LEED requirements.
 2. LEED Product Data Submittal Form: Submit completed product data form provided by the Contracting Officer's Representative; certified by vendor, installer, subcontractor, and/or manufacturer as appropriate.

1.4 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society for Testing and Materials (ASTM):
1. A53/A53M-07 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
 2. A106/A106M-08 Standard Specification for Seamless Carbon Steel Pipe for High Temperature Service
 3. A234/A234M-10 Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
 4. A285/A285M-03(2007) Standard Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate - Tensile Strength

5. A414/A414M-10 Standard Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy for Pressure Vessels
 6. A515/A515M-03(2007) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-temperature Service
 7. A516/A516M-06 Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate-and Lower-Temperature Service
- C. American Society of Mechanical Engineers (ASME):
1. Boiler and Pressure Vessel Code: 2007 Edition with Amendments.
 2. Section VIII Pressure Vessels, Division I and II. Performance Test Code:
 3. PTC 12.3-1997 Performance Test Code for Deaerators
 4. B16.9-2007 Factory-Made Wrought Butt Welding Fittings
 5. B16.34-2009 Valves, Flanged, Threaded and Welding End
- D. National Board of Boiler and Pressure Vessel Inspectors:
1. NB-23-2007 Inspection Code
- E. American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE):
1. ASHRAE Handbook 2008 HVAC Systems and Equipment

1.5 **WARRANTY** (Add#01)

- A. Work subject to the terms of the Article "Warranty of Construction", FAR clause 52.246-21. Provide manufacturer's and installer's specialty warranty as follows:
1. Special warranty includes labor and parts for the ~~CHP Control System~~ Cogeneration Plant Mechanical Equipment, specified in this Section, free from defects for the specified warranty period. (Add#02)
 2. The warranty shall include, but not be limited to, the following: Labor, travel, living expenses, parts replacement, system maintenance and testing, and software/hardware updates and revisions.
 3. Work shall have a single warranty date, even if the Government receives beneficial use due to early startup.
 4. Provide updates to project-specific software and firmware that resolve installer or Government identified software deficiencies at no additional charge during the warranty period.
 5. In the event that the installer service call work causes damage to additional equipment, the installer shall be liable for labor and material to restore the system to full operation.
- B. During the warranty period, the installer shall update the software free of charge as manufacturer's software is improved.

- C. Warranty Period: Four years from the date the system is completely installed, fully operational, and accepted by the Government. The Resident Engineer representing the Government shall verify in writing that the CHP Control System has been tested and accepted in accordance with this specification. The date of acceptance shall begin the warranty period.

PART 2 - PRODUCTS

2.1 FLASH TANK ECONOMIZER

A. General:

1. Furnish packaged flash tank coil type heat exchanger system, designed to handle a maximum blow down rate of 20 gpm and a maximum makeup rate of 100 gpm.
2. The system shall be designed for HRSG of the capacity and operating limits as scheduled, minimum. The unit shall be designed to cool the blow down to within 30 deg F of the makeup water temperature. The unit shall have a 150 psig rating at 365 deg F.
3. The system's flash tank shall have an ASME code design pressure of 150 psig and an internal flash pressure of 5-15 psig. The flash tank shall be complete with a tangential blow down inlet, stainless steel wear plate, steam outlet, ball type float trap with all working parts constructed of stainless steel, tank stand, brass-bodied site glass, and a safety relief valve set at 150 psig. The flash tank shall have a flanged bottom section for quick access to the sludge area and to the coil.
4. The system shall also have a vertical coil-type heat exchanger. The exchanger shall be constructed of stainless steel and shall be integral with the flash tank. The coil shall be complete with threaded connections for the makeup water inlet and outlet.
5. A gauge panel shall be furnished and shall include dial thermometers for indicating makeup inlet temperature, makeup outlet temperature and blow down outlet temperature. The gauge panel shall be pre-piped and mounted on the unit.
6. The entire system shall be supported by steel legs with 3/4 inch diameter holes for customer-supplied 1/2 inch diameter bolts. The system will be painted with rust proof coating.

B. Provide with the following additional features and components:

1. Drain Valve and Level Control
2. Sample Coolers and Assembly
3. Flow Control Valve and Assembly
4. Safety Valve
5. Gauge Glass
6. Pressure Gage
7. Gauge Panel

8. Level Alarm
9. Level Alarm Control Panel - Provide signals to PLC control system
10. Thermometers for exchanger operation

- C. Insulation: Field apply insulation as specified in Section 23 07 11, HVAC and COGENERATION PLANT INSULATION.

2.2 BLOW DOWN SEPARATOR

- A. Type: Centrifugal type constructed of cylindrical stamped or welded steel tank mounted vertically. Tank shall include accessory equipment and shall be suitable for rigging into the available space. Overall dimensions and arrangement of the tank and accessories shall conform to the drawings if noted. Tank sizes shall be as indicated and vent sized for a maximum of 5 psig in separator and after cooler.
- B. Service: Suitable for venting, cooling and discharging into the drain the effluent from the boilers resulting from the intermittent operation of the boiler bottom blowoffs, boiler accessory drains, and the use of continuous blowdowns.
- C. Construction:
1. Construct tank and appurtenances in accordance with ASME Boiler and Pressure Vessel Code, Section VIII. Tank shall have cylindrical shell and dished heads.
 2. Material of construction shall be carbon steel ASTM A285, A414, A515 or A516.
 3. Design tank for 275 kPa (40 psi) working pressure; the minimum material thickness shall be 10 mm (3/8-inch). Thickness of head material at any point shall not vary more than 10 percent from the nominal thickness.
 4. All tank joints shall be double-welded butt joints or single-welded butt joints with backing strips.
 5. Provide 10 mm (3/8-inch) thick stainless steel wear plate welded to interior of tank adjacent to tangential blowoff inlet as shown.
 6. Provide nozzles for piping connections and provide tangential blowoff inlet located above the normal water level. Tangential pipe for blowoff inlet shall be Schedule 80, ASTM A53 or A106, seamless steel pipe with beveled end for field-welding of blowoff from boilers. All other nozzles shall have threaded pipe connections for pipe sizes 50 mm (2 inches) and under, 1025 kPa (150 psi) ASME flanged connections for pipe sizes over 50 mm (2 inches). Nozzle sizes listed below are based on "National Board" recommendations.
 7. The inlet connection on the separator must match the HRSG blow-off valve size.

Boiler Blowoff	Water Outlet	Vent
25(1)	25(1)	63(2.5)

Boiler Blowoff	Water Outlet	Vent
32 (1.25)	32 (1.25)	80 (3)
38 (1.5)	38 (1.5)	100 (4)
50 (2)	50 (2)	130 (5)
64 (2.5)	64 (2.5)	64 (6)

8. Furnish completed ASME Form U-1 or U-1A MANUFACTURERS' DATA REPORT FOR PRESSURE VESSELS. Hydrostatically test tank at 1.3 times the design pressure.
 9. Tank nameplate shall be affixed to bracket which projects beyond the tank insulation that will be applied in the field. Apply ASME data stamp to nameplate to show compliance with design, construction and inspection requirements of the Code.
 10. Support tank by steel legs welded to shell of tank. Design saddles or legs to support tank (full of water), accessories, and portions of connecting piping to first hanger.
- D. Cleaning and Painting: Remove all dirt, heavy rust, mill scale, oil, welding debris from interior and exterior of tank. Prime exterior of tank with rust-resisting paint (See Section 09 91 00, PAINTING).
- E. Insulation: Field apply insulation as specified in Section 23 07 11, HVAC AND COGENERATION PLANT INSULATION.
- F. Accessories:
1. Install red line type gage glasses with protecting rods. Provide off set type gage valves with ball-check feature to automatically prevent flow when glass is broken. Provide drain cock on lower gage valve. Glass shall be at least 300 mm (12 inches) long and centered at the overflow level.
 2. Provide thermometer and pressure gage. Conform to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR COGENERATION PLANT.
 3. Water Outlet Temperature Control Valve:
 - a. Type: Self-contained, reverse-acting thermal bulb-operated water flow control valve.
 - b. Performance: Control valve shall operate automatically to control blowoff tank water outlet temperature to 60 °C (140 °F) maximum by regulating the flow of cold water which mixes with the blowoff water and reduces the temperature of the blow-off water. Provide valve designed for modulating and tight shut-off service. Valve flow rates and pressure drops shall be as shown. Temperature control range shall be adjustable, 38 to 77 °C (100 to 170 °F) minimum.
 - c. Service: Provide valve designed to control the flow of city water with temperature 4 to 27 °C (40 to 80 °F), and pressure up to 690 kPa (100 psi). Thermal bulb will be inserted in blowoff tank outlet pipe and will be subjected to water temperatures up to 100 °C (212 °F).

- d. Construction: Cast iron or bronze valve body designed for 850 kPa (125 psi) minimum WOG. Design of valve shall permit access to internal valve parts. Thermal bulb shall be separable socket type with well.
4. Provide blowoff water outlet pipe inside tank as shown to provide a water seal. Locate a 20 mm (3/4-inch) hole in top of this pipe inside tank to act as siphon breaker.

2.3 CENTRIFUGAL MULTI-STAGE BOILER FEEDWATER PUMPS

- A. Type: Two or more stages, centrifugal diffuser type, direct-coupled, vertical shaft, in-line, base-mounted, motor-driven, arranged as shown.
- B. Service: Design pumps and accessories for continuous service, 116 °C (240 °F) water, with flow rates ranging from maximum scheduled on the drawings (plus manufacturer's recommended recirculation) to 10 percent of maximum (plus manufacturer's recommended recirculation). Pumps shall be suitable for parallel operation without surging or hunting.
- C. Performance: Refer to schedules on drawings. Pump head-flow performance curve shall slope continuously upward to shut-off.
- D. Control - Boiler (HRSG) Feed: Flow rates will be controlled by automatic modulating feedwater valves on each HRSG . Pumps shall have variable frequency drives controlled by HRSG feed header pressure electronic control system which must be provided. Control the header pressure at value required by HRSG manufacturer. For VFD requirements refer to Section 26 29 11, MOTOR STARTERS.
- E. Construction:
 1. Rotating elements shall be designed and balanced to conform to sound and vibration limits specified in Section 23 05 51, NOISE and VIBRATION CONTROL FOR BOILER PLANT.
 2. Mechanical seals shall have sealing face materials of carbon and tungsten or silicon carbide.
 3. Design bearings for two-year minimum life with continuous operation at maximum pump operating load. Bearings and shaft seals shall be water-cooled if recommended by pump manufacturer for the service.
 4. Materials of Construction:
 5. Chambers: Stainless steel
 6. Impellers: Stainless steel
 7. Diffusers: Stainless steel
 8. Shaft: Stainless steel
 9. Suction-Discharge Chamber: Cast iron or stainless steel
- F. Recirculation Orifice: Provide stainless steel recirculation orifice selected by pump manufacturer to protect pump from overheating at shut-off and designed for low noise under the service conditions. Orifices must not

exceed sound level limits in Section 23 05 51, NOISE and VIBRATION CONTROL FOR COGENERATION PLANT.

- G. Spare Parts: Provide complete rotating assembly for each pump size and type suitable for field installation by plant personnel. Assembly shall include impellers, diffusers, chambers, shaft, seals, bearings.
- H. Shaft Couplings: Pump manufacturers standard. Provide coupling guard.
- I. Electric Motor Drives: High efficiency type, open drip proof. Select motor size so that the motor is not overloaded at any point on the pump head-flow performance curve. Design motor for 40 °C ambient temperature. For efficiency and power factor requirements refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- J. Interface with Computer Workstation: Provide devices to signal computer work station that motor is on or off.

2.4 COMPRESSED AIR SYSTEM

- A. Provide complete compressed air system to provide shop (cleaning and maintenance) air and to serve controls and instruments. Compressed air systems shall include compressors, motor drives, receivers, aftercoolers, filters, air dryers and accessories as scheduled, as shown on the drawings and as specified.
- B. Compressors:
 - 1. Type: Rotary-screw, air-cooled, intercooled, variable-speed drive.
 - 2. Performance: Shall be as shown on the drawings. Shall be suitable for continuous service.
 - 3. Construction:
 - a. Lubrication: Splash type with low oil level automatic shutdown switch, or pressure type with low oil pressure automatic shutdown switch.
 - b. Unloading: Provide automatic cylinder air pressure unloader to prevent compressor starting under load.
 - c. Inlet Filter: Dry-type with replaceable cartridge.
 - d. Cylinders: Shall be removable from crankcase.
- C. Receivers: Horizontal cylindrical tanks as shown on the drawings. Construct in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, with inspection under the rules of the National Board of Boiler and Pressure Vessel Inspectors. Design pressure 1025 kPa (150 psi) minimum.
- D. Compressor and Receiver Accessories:
 - 1. Water-cooled Aftercooler: Provide one for each compressor, designed to cool the compressor output air to within 7 °C (10 °F) of the cooling water temperature. Mount on or adjacent to compressor. Provide cooling water solenoid control valve. Valve shall automatically open when compressor starts and close when compressor stops.

2. Automatic Condensate Traps: Provide on lowest point of receiver and on aftercooler if required by type of aftercooler furnished. Size shall be suitable for compressor air delivery.
 3. Safety Valve: Provide on receiver, set pressure lower than receiver design pressure. Capacity of valve at set pressure shall be greater than maximum output of all compressors supplying receiver.
 4. Pressure Gauges: Provide on receiver and as shown. Refer to specification Section 23 09 11, INSTRUMENTATION and CONTROL FOR COGENERATION PLANT.
 5. Receiver Piping Connections: Shall include air in, air out, safety valve, automatic drain, valved manual drain and valved pressure gauge.
- E. Compressor Controls:
1. Compressors Serving Boiler Plant Controls or Instruments: Compressor package shall include an integral, industrial programmable logic controller (PLC), with LCD display, touchpad for local control and set point adjustment. The PLC controller shall feature Ethernet and/or Modbus communications link capabilities in order to interface with plant supervisory control and data acquisition (SCADA) and human machine interface (HMI) system. The communications link shall enable full start/stop, set point adjustment and alarm reporting functionality for the compressor package at the operators workstation and remotely. Refer also to Section 25 60 00, CHP Control System.
 2. Controls shall operate on 120 volts maximum. Provide "on-off-automatic" control for each compressor.
- F. Electrical Motors and V-Belt Drives: Motors shall be open drip proof designed for 40 °C ambient temperature. Select V-belt drives in accordance with manufacturer's recommendations for frequent start-stop service. Provide belt guard that encloses belts on all sides.
- G. Vibration Isolation: Refer to specification Section 23 21 11, COGENERATION PLANT PIPING SYSTEMS for isolators required in piping.
- H. Air Dryer: Shall be refrigerant-type with capacity sufficient for all pneumatic controls and instruments in the cogeneration plant. Cycling type which turns on and off in response to load. Base capacity ratings on 690 kPa (100 psi) inlet pressure; 38 °C (100 °F) air inlet temperature; 38 °C (100 °F) ambient air temperature. Unit shall maintain dewpoint at 2 to 4 °C (35 to 40 °F) at 690 kPa (100 psi) air pressure. Provide unit with "power on" light, automatic water drain trap. Provide reheat of output air by heat exchange with input air to decrease condensation on air pipes. Design unit for 1025 kPa (150 psi).
- I. Air Filter: Located in compressed air line between receiver and air dryer, coalescing type, designed to remove oil, entrained water mist, and dirt from the compressed air. Provide automatic drain valve piped to nearest drain. Size unit for maximum pressure drop of 3.5 kPa (0.5 psi) at normal air flow rate. Design unit for 1025 kPa (150 psi) air pressure.

J. Spare Parts:

1. Complete set of drive belts.
2. Two filter cartridges for each compressor intake filter.
3. Two filter cartridges for air dryer intake filter.

2.5 STEAM VENT SILENCER (MUFFLER)

- A. Type: Residential quality designed to attenuate low and high frequency sound generated by steam vented through a globe valve from a high pressure header.
- B. Service and Performance: Shall be capable of entire maximum steam output of the cogeneration/HRSG plant with superheated steam flowing through the silencer at 100 kPa (14.7 psi), 150 °C (300 °F). Steam in header will be 99.0 to 99.5 percent quality. Venting through globe valve to silencer will cause super-heating and pressure drop to near atmospheric. Unit will be a permanent installation and will be utilized to create steam loads to allow burner adjustments and boiler tests. Pressure loss through unit shall be low. Required attenuation listed below is the insertion loss. No credit is permitted for air absorption at the outlet.
- C. Minimum attenuation:
1. 12 dB minimum at 63 Hz
 2. 17 dB minimum at 125 - 250 Hz
 3. 25 dB minimum at 250 - 500 Hz
 4. 34 dB minimum at 500 - 8000 Hz
- D. Construction: Construct unit of steel with glass fiber or metallic wool acoustical packing. Protect glass fiber acoustical material from damage in high fluid impact areas. Line entire outer shell internally with acoustical material. Provide 104 kPa (150 psi) ANSI inlet and outlet flanges as shown on the drawings. Where flanges are not shown, provide butt weld connections.

2.6 BOILER WATER AND DEAERATOR WATER SAMPLE COOLERS

- A. Type: Factory-built shell and coiled tube heat exchanger with sample in tube, cooling water in shell, designed for wall mounting.
- B. Construction:
1. Shell and Head: Iron, steel or stainless steel shell, bolted or threaded into head. Head shall have wall mounting brackets and piping connections for sample in and out and cooling water out. Minimum design pressure for shell and head, 1025 kPa (150 psi). Shell removable without disturbing piping connections.
 2. Sample Coil: Shall be 6 mm (1/4-inch) outside diameter stainless steel tubing, 0.11 square meter (1.2 square feet) minimum heat exchange surface. Minimum design for 1025 kPa (150 psi), 188 °C (370 °F). Design coil to relieve stresses due to thermal expansion.

3. Arrangement: Shall be as shown on the drawings.

2.7 AUTOMATIC CONTINUOUS BOILER BLOWDOWN CONTROL SYSTEM

- A. Type: One factory-assembled system per boiler to automatically sense boiler water conductivity and operate automatic electric-powered blowdown valve to maintain desired total dissolved solids content in boiler water. Micrometer-type adjustable manual blowdown valve piped to bypass the automatic blowdown valve and conductivity sensor.
- B. Service: Design valves, sensors and piping for steam and water at 1035 kPa (150 psi), 186 °C (366 °F) minimum. Controller shall be suitable for 50 °C (120 °F) ambient and resist splashing water. Design automatic and manual blowdown valves for maximum blowdown flow rate equivalent to two percent of boiler steam output. System shall automatically maintain boiler water total dissolved solids at any set point between 1000 ppm and 4000 ppm.
- C. Operation: Programmable timer cycles to intermittently operate the blowdown valve to obtain conductivity samples, and to maintain the valve open for a time period until the conductivity of the boiler water reaches the set point. Provide an automatic temperature compensating circuit.
- D. Controller: Shall be microprocessor-based sealed unit mounted at the boiler.
 - 1. Indicators on Panel Front: One-half inch high digital display showing conductivity and indicating normal or out-of-range conditions. Valve status indicators.
 - 2. Membrane Keypad on Panel Front: Allows manual operation of the blowdown valve, setting of conductivity set points and alarm set points, setting of timers, calibration data input.
- E. Automatic Valve Construction: Carbon steel body, Type 316 stainless steel ball and stem, TFE coated stainless steel body seal. Electric actuator with NEMA-1 enclosure. Rated for 1025 kPa (150 psi) minimum saturated steam.
- F. Manual Valve Construction: Bronze or forged steel angle-type body, hardened stainless steel disc and seat, threaded ends, rising stem, union bonnet, graduated micrometer-type dial and pointer showing amount of valve opening. Rated for 1025 kPa (150 psi) minimum saturated steam. Furnish valve blowdown chart showing flow rate versus valve opening based on 125 psi boiler pressure.
- G. Provide gate valves and unions at inlet of conductivity sensor and outlet of automatic control valve so that these items can be removed from the system while maintaining the manual control valve in service. Comply with Section 23 21 11, COGENERATION PLANT PIPING SYSTEMS.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Feedwater Deaerator with Storage Tank and Accessories, Condensate Storage Tank, Blowoff Tank, Flash Tank.
 - 1. Coordinate location with structural requirements of the building.
 - 2. Location shall permit access to and removal of all internal and external features without removing other items of equipment or piping.
 - 3. Bolt to building as recommended by manufacturer or as shown. Comply with seismic requirements in Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS. Arrange anchorage to allow thermal expansion of unit.
 - 4. Clean interior of equipment before placing in service.
 - 5. Deaerator vent pipes must extend vertically through roof. Horizontal runs not permitted.
 - 6. All controls, safeties, set points, etc must conform to the most recent edition of the VHA Boiler Plant Safety Device Testing Manual.
- B. Boiler Feed Pumps:
 - 1. For base-mounted horizontal-shaft pumps, connect base drain to 20 mm (3/4-inch) pipe. Extend pipe to nearest open sight or floor drain.
 - 2. Align pumps and drivers at the factory. At job site, a millwright shall level, shim, bolt, and grout the base plates or base frames onto the concrete pads, and shall also check the alignments of flexible-coupled pumps and drivers and make corrections necessary. Check alignment when both pump and driver are at normal operating temperature.
 - 3. Where packaged deaerator-feed pump unit is required, boiler feed pump base plates shall be welded or bolted to deaerator support frame.
 - 4. If water-cooled bearings or quenched or flushed or water-cooled stuffing boxes are provided on pumps, contractor shall install on each pump valved 15 mm (1/2-inch) piping connections to cold water supply, and 15 mm (1/2-inch) drains to nearest open sight drain. Provide unions at all connections to pumps.
- C. Compressed Air System: Pipe all drain connections individually to nearest floor drain. Use 15 mm (1/2-inch) piping. Provide union at each drain connection on the equipment.
- D. Automatic Continuous Boiler Blowdown Control System: Locate controller on floor-supported angle at four feet above the floor at the boiler adjacent to the continuous blowdown valves. Keypad and indicator must face aisle.

3.2 STARTUP AND TESTING

- A. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the Resident Engineer and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.3 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS and related sections for contractor responsibilities for system commissioning.

3.4 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for four hours to instruct each VA personnel responsible in operation and maintenance of units.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS.

3.5 CONSTRUCTION WASTE MANAGEMENT

- A. General: Comply with Contractor's Waste Management Plan and Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.
- B. To the greatest extent possible, separate reusable and recyclable products from contaminated waste and debris in accordance with the Contractor's Waste Management Plan. Place recyclable and reusable products in designated containers and protect from moisture and contamination.

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(Add#01) 18 SEP 2013, Addendum No. 1

(Add#02) 07 OCT 2013, Addendum No. 2

SECTION 23 52 35

HEAT RECOVERY STEAM GENERATOR (HRSG)

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies packaged water tube heat recovery steam generator (HRSG) with trim and accessories, including natural gas duct burner), fuel trains, and emissions control. The heat recovery steam generator specified herein is part of an integrated 'co-generation' or combined heat and power (CHP) system consisting of the Combustion Turbine Generator (CTG), the Heat Recovery steam generator (HRSG), the CHP Plant control system, the natural gas compression system, and the continuous emissions monitoring system. It is the intent of these specifications that the CHP system be furnished complete by a single source of responsibility. Refer to packaging, system integration and single source responsibility requirements stipulated in Section 26 32 14, Combustion Turbine Generator for more specifics.
- B. This specification shall cover all systems and components from the outlet bellows at the combustion turbine generator to the exhaust termination at atmosphere. The complete system shall be integrated with and coordinated with the systems and equipment specified under Section 25 60 00, CONTROL OF CHP SYSTEM, Section 26 57 00, CONTINUOUS EMISSIONS MONITORING SYSTEM, Section 26 52 14, COMBUSTION TURBINE GENERATOR, and Section 23 12 34, FUEL GAS COMPRESSORS.
- C. Throughout Division 23 and other sections, the terms boiler plant, boiler or water-tube boiler are synonymous and defined as the heat recovery steam generator within the cogeneration plant.
- D. Heat Recovery Steam Generator and Associated Components and Systems:
 - 1. Evaporator(s).
 - 2. Economizer.
 - 3. Transition ductwork.
 - 4. Breeching and stack.
 - 5. Duct burner.
 - 6. SCR system.
 - 7. CO catalyst (if required to meet emission levels).
 - 8. Ammonia supply and dilution system.
 - 9. Field instruments and controls.
 - 10. Combustion control system.
 - 11. Furnace viewport construction, locations.
 - 12. Burner management system.

13. Flame scanner blower skid.

- E. The Manufacturer shall design, fabricate, assemble, factory test, deliver and provide startup and commissioning support and training for one (1) Heat Recovery Steam Generator (HRSG) system, complete with all components and design features, as specified herein, for installation at the new Cogeneration Plant at VA Palo Alto, CA. HRSG shall be installed indoors and onto the exhaust of a new gas fired Combustion Turbine Generator (CTG) set. The HRSG shall generate and control the production of steam. The HRSG system shall be the manufacturer's standard and shall be designed in accordance with the latest applicable codes and standards. The HRSG shall be preassembled in modules to the maximum extent possible and ready for immediate site mounting on the foundation and attachment of connections. It is the intention of this specification that the Manufacturer shall be solely and entirely responsible for the design, procurement of materials and components, fabrication and assembly, inspection and testing, preparation of equipment for shipment, delivery and guarantee of the performance of the equipment including subsequent startup, operation and maintenance support. The individual equipment packages of the HRSG system shall be integrated by the Manufacturer to form a completely functional system when connected to utilities, interconnection piping and wiring and appurtenances to form a complete functional and reliable system. The Manufacturer shall, as a minimum, furnish drawings, data and descriptive information for the HRSG system in detail, as specified herein.
- F. The HRSG system shall be complete with all required interconnecting ductwork, exhaust/flue, controls, piping, appurtenances and supports.

1.2 RELATED WORK

- A. Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT: Procedures and requirements for managing and disposing construction and demolition waste.
- B. Section 01 81 11.01, SUSTAINABLE DESIGN REQUIREMENTS: Sustainable design requirements including submittal requirements.
- C. Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS: Requirements for commissioning, systems readiness checklists, and training.
- D. Section 09 91 00, PAINTING.
- E. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
- F. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- G. Section 23 05 51, NOISE and VIBRATION CONTROL FOR COGENERATION PLANT.
- H. Section 23 21 11, COGENERATION PLANT PIPING SYSTEMS: Valves for boiler trim, non-return stop-check valve, piping for fuel and feedwater trains.
- I. Section 23 50 11, COGENERATION PLANT MECHANICAL EQUIPMENT; feed water pump, condensate receiver/pump, blowdown separator, flash tank economizer and compressed air system associated with cogeneration system.

- J. Section 25 60 00, CHP PLANT CONTROL SYSTEM: Burner controls, combustion control system, boiler water level control, pressure gages, thermometers.

1.3 QUALITY ASSURANCE

- A. Coordinate all new and existing equipment and conditions. This includes, but is not limited to: boiler, boiler trim, burner, fuel trains, gas pressure regulators and available gas pressure, burner control system, combustion control system, economizer, breeching and stacks.
- B. Provide written certification that the entire assembly has been coordinated to achieve the required performance and to provide the required features.
- C. Regardless of fuel input rating, the equipment, installation and operation shall conform to NFPA 85. Where conflicts exist between NFPA 85 and this specification, this specification will govern.
- D. HRSG manufacturer shall provide a minimum of five days job site technical assistance during off-loading, erection, cleaning and commissioning, including all travel and per diem expenses.

1.4 WORK INCLUDED

- A. A HRSG system, consisting of, but not limited to, the following major items:
1. Steam generator complete with evaporator and economizer heating sections, CO catalyst, SCR catalyst, steam and water drum(s), steam separators, drum internals and supports, internal insulation, refractory tube banks and headers, risers and downcomers, tube bank supports, anti-vibration detuning baffles if required, external trim, code feedwater piping assembly to economizer and from economizer to steam drum, etc.
 2. All air and gas ducts, transition sections, bends, expansion joints, duct supports, hangers, internal and external insulation and lining, etc. from the gas turbine exhaust expansion joint (expansion bellows) to the atmospheric termination of the exhaust including all necessary gaskets and hardware.
 3. Low NOx, supplemental firing duct burner at the inlet to the steam generator for supplementary firing with natural gas only, complete with main and pilot gas headers, scanner cooling air header, spark-ignited gas pilots, ignition transformer, scanner air blowers and scanners, burner management and combustion controls, fuel flow transmitters, shut off valves, vent valves and fuel metering valves, etc.
 4. Ammonia injection grid, SCR catalyst section, CO catalyst section and catalyst, ammonia process control unit and control system, and SCR catalyst. Ammonia Injection grid, SCR catalyst, and ammonia control system shall be designed as an integral system to meet the performance guarantees set forth herein.
 5. Duct burner piping rack and burner management system (BMS) control panel assembly supplied for field mounting adjacent to the burner assembly, including instrumentation, controls, protections and safety interlocks, including fuel shut-off and control valves, double

- block and bleed assembly etc. All rack mounted instrumentation shall be factory wired to junction boxes and/or the BMS/ Combustion Control panel as applicable.
6. All valves, relief valves, drains, vents, blowdown, chemical injection connections, sampling, and HRSG accessories in compliance with ASME Section 1 and ASME/ANSI B31.1, Power Piping Codes. All HRSG external piping defined to be within the ASME code sections jurisdictional limits.
 7. Adequate number of access ports and observation doors for HRSG for access and testing at the following locations.
 - a. Upstream and downstream sides of duct burner.
 - b. Upstream and downstream sides of economizer section.
 - c. Upstream and downstream sides of SCR and Ammonia Injection Grid.
 - d. Upstream and downstream sides of evaporator section(s).
 8. All necessary instrument tapping points in the steam, water, air and gas circuits shall be provided. Each sensing point shall have a duplicate test point. All instrument connections shall be provided with a root valve and an instrument isolating valve.
 9. All supporting steel for HRSG system and associated platforms, miscellaneous structural steel, operating platforms, ladders, walkways, handrails, and safety cages shall be provided to allow for safe access for maintenance, repair and observation of HRSG system, meeting all OSHA requirements. All valve operating platforms and ladders. Lifting lugs and lifting frames (if required) for shipping and installation of HRSG components.
 10. All HRSG instrumentation for control and monitoring of the steam generator parameters, including local instruments and control devices and gauges, switches, final control elements, I/P converters, solenoid valves, etc., installed and terminated in a local control panel as applicable.
 11. Gas path test ports between each major airside component.
 12. The major terminal points of the HRSG system shall be as follows:
 - a. Boiler code terminal points shall be set, in accordance with ASME Boiler and Pressure Vessel Code, Section I for multiple steam generators fed from a common feedwater source. Components to be furnished loose for field installation as part of this work include; Main steam non-return valve, steam outlet spool piece, main steam stop valve, feedwater control valve station designed for full range of expected operation (control valve to be removed and replaced with spool piece for shipping), final feedwater isolation and check valves, continuous and intermittent blowdown stop valves, instrument isolation valves within the ASME code piping envelope, etc. Additional boiler external piping (BEP) required shall be shipped loose to site for field installation. Field welding within the BEP code boundaries shall be kept to a minimum.
 - b. Instrument taps shall be provided with isolation valves, additional thermowells for testing and startup purposes shall be provided where required.

- c. Blow down - (Continuous and Intermittent) - From the discharge of the corresponding final blow down valve.
 - d. Fuel Gas - At the inlet to the Burner Fuel Train Skid.
 - e. Drains - Maximum Five feet above grade.
 - f. Turbine Exhaust - Connection to the CTG expansion joint outlet flange.
- 13. Provide all necessary gaskets, bolts, nuts, fasteners and other hardware required to erect and put into operation, the HRSG.
 - 14. HRSG build-out and field cleaning including labor, chemicals and disposal.

1.5 SOUND AND VIBRATION

- A. All equipment furnished by the Manufacturer in accordance with this specification shall not produce a cumulative sound level in excess of 85 dBA at 5 feet above floor in a free field environment as measured in accordance with ANSI Standards S1.2, "Method for the Physical Measurement of Sound" and S 1.4, "Specification for General Purpose Sound Level Meter".
- B. Any equipment, including accessories, furnished in accordance with this specification will, under normal operating conditions or under operating conditions specified produce either an individual or cumulative sound pressure level in excess of 85 dBA at 3 feet, the Manufacturer shall provide any noise suppression kit or enclosure required to bring noise level into compliance with specification requirements. Exhaust muffler shall provide minimum 15 dBA noise reduction.
- C. ANSI Standard shall apply to:
 - 1. Surface of HRSG.
 - 2. Surface of the expansion joints.
 - 3. Duct burner scanner blower.

1.6 SUBMITTALS

- A. Before executing any work, submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. LEED Submittals: Submit in accordance with Section 01 81 11.01.
 - 1. LEED submittals are in addition to other submittals. If submitted item is identical to that submitted to comply with other requirements, submit duplicate copies as a separate submittal to verify compliance with indicated LEED requirements.
 - 2. LEED Product Data Submittal Form: Submit completed product data form provided by the Contracting Officer's Representative; certified by vendor, installer, subcontractor, and/or manufacturer as appropriate.

C. HRSG:

1. Complete catalog information and outline drawing of HRSG and accessories with dimensions.
2. Arrangement and description of construction of pressure parts, casings, drum internals, drum handhole covers and yokes, and support frame.
3. Drum piping connection sizes, locations, construction.
4. Technical data including temperature ratings and arrangement of refractory and insulation.
5. Steam nozzle construction. Capability of steam nozzle and attachment to steam drum to withstand forces and moments imposed by connecting piping. Refer to table of forces and moments on the drawings.
6. Amount of heating surface, combustion volume.
7. Weight of boiler and burner assembly, empty and flooded.
8. Design pressures and temperatures.
9. Loading diagram of support frame. Evidence that boiler support requirements have been coordinated with foundation design.
10. Recommended anchorage of boiler support frame to foundation.
11. Dimensioned location of normal water line, lowest and highest permissible water level, set points of water level alarms and cutoffs.
12. Predicted surface temperature at front, rear and sides of boiler.
13. Seismic design data on HRSG and anchorage of HRSG to foundation. Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

D. HRSG Trim: Includes bottom blowoff valves, water column with conductivity probe assembly, water level gage with illuminator, auxiliary low water cutoff, piping, all valves and fittings furnished by HRSG manufacturer, feedwater control valve, safety valves, steam pressure gage, steam pressure switches.

1. Design, construction, arrangement on the boiler.
2. Pressure and temperature limitations.
3. ASTM numbers and schedule numbers of piping.
4. Type and pressure ratings of pipe fittings.
5. Flow and pressure drop data on feedwater control valve.
6. Scale ranges of gages, thermometers, and pressure switches.
7. Location of water level sensing and indicating devices in relation to normal water line of boiler and highest and lowest permissible water lines of HRSG.
8. Set pressure and capacity of safety valves.

E. Duct Burner System:

1. Catalog data and drawings showing construction of complete skid mounted, supplemental firing duct burner system including parts and assembly of complete system.
2. Drawings, with dimensions, showing burner overall size and mounting on the skid.
3. Drawings and catalog data on all equipment in duct burner system including burner, fuel trains, burner management and combustion controls, fuel supply manifolds, fuel flow transmitters, shut-off valves, vent valves, igniters, burners, and fuel metering valves, and main fuel trains.
4. ASTM number and schedule numbers on all piping.
5. Type and pressure ratings of pipe fittings.
6. Burner flow and pressure data:
 - a. Main burner fuel and flows at maximum required firing rate.
 - b. Igniter (pilot) fuel flow and burner pressure.
 - c. Natural gas main fuel pressure at outlet of burner-mounted pressure regulator.
 - d. Igniter fuel pressures (natural gas) at outlet of burner-mounted pressure regulators.
7. Full load efficiency and power factor of all motors.
8. Predicted sound level at maximum firing rate.
9. Weight of burner assembly.
10. Drawings showing location and arrangement of drive units and for controlling fuel and air flow.
11. Weight of burner assembly.

F. P&ID Diagrams.

G. Control Schematic Diagrams including control logic, list of safety permissive signals and list of interlocks with Turbine Generator.

H. Seismic data. Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

I. ASME "P" Forms, Manufacturer's Data Report, on boiler and economizer construction.

J. Pretest Data - Boiler, Burner, Controls: As required by Part 3.

K. Final Test Report - Boiler, Burner, Controls: As required by Part 3.

L. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS.

- M. Detailed structural drawings and calculations for all access platforms, railings, seismic anchorage and restraint systems.
- N. Exhaust muffler: Product data including sound reduction value measured in dBA.
- O. Air quality and environmental permits plus hazardous materials and fire/life safety permits required by local and state authorities. (Add#01)

1.7 PROJECT CONDITIONS:

- A. Fuels to be Fired, Main Duct Burner: Natural gas.
- B. Igniter (Pilot) Fuels: Natural Gas.
- C. Natural Gas: Heating value shall be assumed to be per PG & E Rule 2. Pressure provided to the inlet of the boiler-mounted regulators will be __approximately 172__ kPa (__25__psi) as maintained by the main gas regulator station.

1.8 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.
- B. ASTM International (ASTM):
 - 1. A182/A182M-11a Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and parts for High Temperature Service
 - 2. A193/A193M-12 Standard Specification for Alloy Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
 - 3. A194/A194M-12a Standard Specification for Carbon Alloy and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
 - 4. A312/A312M-11 Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
 - 5. E84-04 Standard Test Method for Surface Burning Characteristics of Building Materials
- C. American Society of Mechanical Engineers (ASME):
 - 1. Boiler and Pressure Vessel Code - 2007 Edition with Amendments.
 - a. Section I Power Boilers
 - b. Section II Material
 - c. Section VII Recommended Rules for Care of Power Boilers
 - d. Section IX Welding and Brazing Qualifications
 - 2. Performance Test Code (PTC):
 - a. PTC 4-2008 Fired Steam Generators

- 3. Code for Pressure Piping:
 - a. B31.1-2007 Power Piping
- D. Factory Mutual Engineering Corporation (FM)
 - 1. 2010 Approval Guide
- E. National Fire Protection Association (NFPA):
 - 1. 70-2008 National Electric Code
 - 2. 85-2007 Boiler and Combustion Systems Hazards Code
- F. National Board of Boiler and Pressure Vessel Inspectors (NBPVI):
 - 1. NB-23-2007 National Board Inspection Code
- G. Department of Health and Human Services, Food and Drug Administration (FDA):
 - 1. CFR 21, 173.310, Boiler Water Additives Permitted in Plants Where Steam Contacts Food
- H. Underwriters Laboratories (UL):
 - 1. UL 795, Commercial - Industrial Gas Heating Equipment

1.9 WARRANTY (Add#01)

- A. Work subject to the terms of the Article "Warranty of Construction", FAR clause 52.246-21. Provide manufacturer's and installer's specialty warranty as follows:
 - 1. Special warranty includes labor and parts for the ~~CHP Control~~ Heat Recovery Steam Generator System free from defects for the specified warranty period. (Add#02)
 - 2. The warranty shall include, but not be limited to, the following: Labor, travel, living expenses, parts replacement, system maintenance and testing, and software/hardware updates and revisions.
 - 3. Work shall have a single warranty date, even if the Government receives beneficial use due to early startup.
 - 4. Provide updates to project-specific software and firmware that resolve installer or Government identified software deficiencies at no additional charge during the warranty period.
 - 5. In the event that the installer service call work causes damage to additional equipment, the installer shall be liable for labor and material to restore the system to full operation.
- B. During the warranty period, the installer shall update the software free of charge as manufacturer's software is improved.
- C. Warranty Period: Four years from the date the system is completely installed, fully operational, and accepted by the Government. The Resident Engineer representing the Government shall verify in writing that the CHP

Control System has been tested and accepted in accordance with this specification. The date of acceptance shall begin the warranty period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Performance Conditions:

1. The following site conditions are utilized to develop output and emissions guarantees:
 - a. Location. Palo Alto, CA
 - b. Altitude. 50 Ft. ASL
 - c. ASHRAE 1% wet bulb. 69Deg F
 - d. ASHRAE 1% cooling dry bulb. 93 Deg F
 - e. Combustion air temperature. 93 Deg F
 - f. Natural gas LHV. Per PG & E Rule 2
quality(expected value 1020 +/- 20 btu/scf)
 - g. Turbine operating range. 95%- 100% load

B. Steaming Rate and Quality:

1. The Manufacturer shall guarantee that steam after the evaporator outlet will be 99.97% dry when the total solids concentration of the feedwater is maintained in accordance with ABMA recommended standards. Solids carry-over shall not exceed 1 PPM under all conditions, including start up and shut down.
2. Steaming rates shall be based upon the following parameters:
 - a. Steam pressure of 100 psig dry and saturated at the outlet of the steam non-return valve.
 - b. Feedwater temperature of 217 Deg. F. at the inlet to the economizer (feedwater comes from existing Plant, B/40).
 - c. Maximum blowdown rate of 2.2% (fired); 2.1% (unfired).
 - d. 100% load turbine exhaust gas (TEG) flow of 63,405 lbm/hr. @ 59 Deg. Ambient (unfired); 1558 Deg. F (fired).
 - e. 100% load turbine exhaust gas (TEG) temperature of 980 Deg. F.
 - f. Maximum stack temperature at 100% turbine loading of 280 Deg. F (unfired); 286 Deg. F (fired).
3. Based upon the conditions listed above, the Manufacturer shall guarantee the following minimum steam production rates:
 - a. Unfired steam production. 12,000 minimum lb/hr
 - b. Fully fired steam production. 18,000 minimum lb/hr

C. Duct Burner and Gas Side Performance:

1. The Duct burner shall provide stable operation for all operating points from 10% to 100% maximum continuous rating (MCR) coincident with turbine generator operation from 50% to 100% with no deleterious impingement on the HRSG system.

2. The following parameters shall be guaranteed by the Manufacturer:
 - a. Maximum gas side pressure drop of 10" w.c. from the inlet transition duct to the stack outlet. Manufacturer shall provide detailed draft loss breakdown by component.
 - b. Minimum duct burner turndown of 10 to 1.
 - c. Maximum duct burner heat input of 10.5 MMBtu/hr based on LHV.
 - d. Maximum Duct Burner NOx contribution of 0.06 lb/MMBtu from 50% to 100% MCR. Although the NOx contribution levels given in lb/MMBTU (HHV) can be higher at burner loads below 50%, at no point can the duct burner emissions at less than 50% MCR exceed the mass flow rates (lb/hr) produced at the 50% maximum continuous rating (MCR) operating point.

D. Emissions Performance:

1. The Manufacturer shall provide for the adequate removal of combustion emission byproducts from the combustion turbine and the duct burner in order to guarantee the following stack emission requirements set forth by the local air permitting district with the turbine firing on natural gas:
 - a. NOx emissions: 2.5 ppmdv corrected to 15% O2
 - b. CO emissions: 5.0 ppmdv corrected to 15% O2
 - c. Ammonia slip: 5.0 ppmdv corrected to 15% O2
2. The above required stack emissions are based upon the following Turbine Exhaust Gas (TEG) emissions guarantees from 95% to 100% of turbine generator loading :
 - a. NOx emissions: 15 ppmdv corrected to 15% O2
 - b. CO emissions: 50 ppmdv corrected to 15% O2

2.2 GENERAL DESIGN:

- A. Detail design of the entire HRSG system shall be the responsibility of the Manufacturer. The Manufacturer shall custom-design the HRSG. The string arrangement of gas turbine exhaust duct, duct burner, evaporator sections, CO Catalyst, Ammonia Injection Grid, SCR Catalyst and economizer shall be optimized to achieve the desired performance while meeting any dimensional requirements shown on the drawings.
- B. The difference of the temperature of the boiler exit gas from the saturation temperature of steam in the evaporation zone (which is defined as pinch point) shall be carefully chosen to result in an optimum design of the overall HRSG. The Manufacturer shall provide details of calculations of the pinch points, in both fired and unfired mode of operation. Similarly, the difference of evaporator saturation temperature and temperature of feed water inlet to the evaporative drum (which is defined as economizer approach) shall be optimized.
- C. The steam generator and all pressure vessel components shall be designed, fabricated, examined, inspected, and tested in accordance with Section I, Division 1 - Pressure Vessels, Section II - Material Specifications, and Section IX - Welding and Brazing Qualifications of the ASME Boiler and Pressure Vessel Code.

- D. The HRSG shall be inspected during construction in accordance with the requirements of ASME Boiler Code, and after completion shall be stamped with all identifying markings and symbols as required by the latest edition of the ASME Boiler Construction Code, including but not limited to, National Board (NB) registration and "S" stamp as required by the ASME Code. Stamping shall include National Board number with shop inspection by National Board Inspector.
- E. The HRSG system, including all applicable piping systems, shall be designed in accordance with ASME Boiler Code Section I and as follows:
 - 1. All drum and other connections required for proper operation shall be provided.
 - 2. ANSI 300 lb. and 150 lb. rated system connections shall be flanged, except for connection sizes 2" and smaller shall be either threaded or socket weld union-end, as required by applicable codes.
 - 3. The weight of each HRSG system shall be uniformly distributed to the maximum extent possible. The boiler section base shall be constructed of welded structural shapes of standard construction.
- F. HRSG will be connected to a gas turbine unit to harness the sensible heat contained in the exhaust. In addition, supplemental fuel (natural gas only) will be fired in the duct burner to produce additional steam.
- G. HRSG will be located indoors.
- H. Casing, piping, steam drums and other components shall be insulated and lagged for heat retention. All insulation coverings shall have a fire rating in accordance with ASTM E84 of 25 or less. Casing shall be constructed of 1/4 inch carbon steel outer casing internally insulated and lined with 14 gauge steel liner. Refer to Section 23 07 11, HVAC and COGENERATION PLANT INSULATION, for insulation types.
- I. Each HRSG will have only evaporator and economizer sections. There will be no superheaters.
- J. The Evaporator(s) shall be of the watertube type, working on the principle of natural circulation. Assisted or forced circulation designs will not be permitted.
- K. HRSG design shall permit easy access inside. Good maintenance aisles will be provided to gain access to the heat transfer tubes, so that tube elements may be removed, repaired or plugged.
- L. The gas turbine is expected to run fully loaded on a continuous basis.
- M. For better quality control, emphasis shall be given on maximization of shop assembled modular construction, with all welded features for pressure parts, tube banks, tube supports, stub connections into the drum, etc. Site fabrication work shall be minimized. Each portion of the HRSG system shall be provided with appropriate lifting eyes, hooks, frames, etc to promote the safe and efficient unloading and setting of the equipment. The design emphasis of the HRSG should be on high reliability and simplicity.

- N. HRSG shall be designed to provide ample evaporating tube surface for the maximum capacities specified and a sufficient number and size downcomers to assure proper circulation in all parts of the boiler, even under rapid start-up conditions.
- O. All equipment, ductwork, etc. provided by the Manufacturer shall be so designed to ensure that a average casing surface temperature of 140°F, considering a still surrounding air temperature of 100°F. However, it is recognized that certain areas will exceed this temperature limit due to the nature of the HRSG system design. These areas, as defined by the Manufacturer, are: ducting/boiler flanges, observation/test ports or anywhere that the duct/casing insulation is penetrated by anchors or stiffeners at the duct/casing attachment area. Provide protective insulation where required to protect personnel who could come in contact with hot surfaces.
- P. In accordance with the requirements of the ASME Boiler Code, HRSG shall be supplied complete with all valves and features required for a steam generating system consisting of multiple steam generators attached to a common feedwater supply and steam collection header. It is the intent of this specification that the HRSG be provided complete with all trim required, and that field assembly be kept to a minimum. All instruments, level columns, bridles, etc shall be provided with isolation valves in the piping connections so that the item, including any valve which may be integral with the item can be removed while the unit is operational. At a minimum, the following items of trim are to be provided.
 - 1. Double-valved mud drum (continuous) blowdown piping.
 - 2. Double-valved surface I (intermittent) blowdown piping.
 - 3. Drum internals for removing entrained water from steam.
 - 4. Water column for low-low, low, high and high-high level probes alarms with isolation valves and drain valves.
 - 5. Sightglass with drain valve.
 - 6. Mirrors (or equivalent system) so that sightglass can be clearly seen from grade level within reach of the blowdown valves.
 - 7. Drum pressure gauge.
 - 8. Chemical feed connections, isolation valves, and check valve.
 - 9. Auxiliary low-low water cutout (LWCO) level float switch with drain.
 - 10. Continuous blowdown with stop valve and automatic control valve.
 - 11. Main steam non-return valve and Main steam stop valve.
 - 12. Main steam spool with drain valves.
 - 13. Safety relief valves for drum.
 - 14. Safety relief valve(s) for economizer.
 - 15. Isolation valves for drum level transmitter.
 - 16. Complete feedwater control station including feedwater control valve with actuator and positioner, isolation valves, bypass gate valve and drain valves.

17. Feedwater stop valve and check valve.
18. Feedwater piping between control valve and economizer.
19. Economizer Isolation valves and bypass valve.
20. Economizer drain valve
21. Economizer inlet and outlet temperature (water side) indicators and connections for transmitters.
22. Economizer inlet and outlet temperature (gas side) indicators and connections for transmitters.
23. Connections for sample coolers (coolers by others).
24. Pressure point taps for the gas side of the HRSG for the following locations.
 - a. Upstream of duct burner.
 - b. Downstream of duct burner.
 - c. Between evaporator sections (if applicable).
 - d. Between evaporator sections and economizer.
 - e. Upstream and downstream of the SCR catalyst.
 - f. Upstream and downstream of the SCR catalyst.
 - g. Downstream of the economizer.

Q. Materials:

1. The Manufacturer shall indicate on his approval prints, what ASME specification grade number he will be furnishing for materials specified. Material shall be Manufacturer's standard for the application or as specified herein.
2. Nozzle, nozzle reinforcement plates and fittings shall be constructed of the same materials as the component which they are attached to.
3. No asbestos or asbestos bearing materials are permitted.

2.3 DETAIL DESIGN

- A. Each heat recovery steam generator (HRSG) shall generate the scheduled lbs/hr of dry saturated steam at 150 psig when operating in the unfired mode with the gas turbine operating at its full base load. In order to ensure efficient recovery of exhaust heat of the gas turbine, the pinch point differential shall not be less than 20 Deg. F. under this design condition.
- B. The HRSG design shall be developed on the basis of natural circulation only, i.e., it shall not rely on circulation pumps either in part (assisted circulation) or completely (forced circulation) to promote fluid flow through the hot tube path.
- C. The temperature of the exhaust gases leaving the HRSG shall be at least 20 Deg. F. above the dew points for all entrained condensable gases, under all operating conditions in the ranges defined as:
 1. Minimum load and full load on gas turbine.

2. No firing and full firing in duct burner.
3. Extremes of ambient air temperature from 0°F to 100°F.

D. Evaporator:

1. Each evaporator section of the HRSG shall be complete with a steam drum at the top and a mud drum (or a large size header) at the bottom.
2. The evaporator may be split into two subsections as seen appropriate to provide for an optimum operating temperature for the CO and SCR catalysts.

E. Drums:

1. The steam drum is to provide satisfactory steam/water separation, steam drying and maintenance of outlet steam quality within the specified limits under all operating conditions.
2. Drum and headers shall be located away from the hot exhaust gas. Drum shall be constructed of steel plates as per applicable codes of ASME with material properly selected for operation conditions.
3. Manufacturer shall provide an elliptical manhole in each head of each drum with a forged steel bolted manhole cover plate and forged steel yokes, with suitable gasket for each manhole opening. Manufacturer shall also provide insulation curbs for each manhole. The minimum size of the manhole clear opening for the steam and lower mud drum shall be 12" x 16".
4. Manufacturer shall furnish and install suitable internals for feedwater, chemical feed and continuous blowdown distribution in the steam drum. Furnish and install suitable dry pipe or separating device in the steam drum under the main steam outlet to separate entrained moisture from the steam to assure delivery of steam with a dry moisture content of 99.97% when boiler concentrations are maintained in accordance with ABMA recommendations. The drum internals along with steam separating device shall direct the flow of steam and water so as to obtain an optimum distribution of drum metal temperature over the entire operating range. Also, the internals and the separator used shall be of low loss type. The arrangement and fabrication of the drum internals shall permit easy removal and replacement through drum manholes. The feed water pipe(s) from the economizer entering the drum shall be spaced suitably so that there is no uneven distribution of flow over the entire length of the drum. Chemical feed and continuous blowdown connections shall be located on opposite ends of the drum.
5. The drum shall be sized to hold a minimum of 2 minutes storage (at MCR) of water inventory between the normal water level and the low-low water trip level. From the normal water level to empty, the drum shall be sized to hold a minimum of 5 minutes storage (at MCR) of water inventory. The calculation of holding capability shall include the effects of sizing the drum intervals and no quenching action of incoming feed water, assuming that the supply of the same has been completely cut off. The steam drum shall have adequate freeboard space to accommodate the swelling of water during start up, without flooding drum internals. At start up or during loss of steam load, no carryover of water droplets, along with generated steam, is permitted. Water

surge volume in steam drum shall be adequate to accommodate the swelling or shrinkage, resulting from a change in steam load of 20% of HRSG maximum continuous rating (MCR) in one (1) minute, without any water carryover or actuating high/low level alarms, or trips.

6. An adequate number of level and pressure instruments shall be provided. Two sets of tapping points with seal pots, valves, etc. at each end of the drum shall be provided for remote level measurement and control purposes in addition of the tapping points for one local level gauge glass. Provision shall also be made with T-off or by independent tappings for level column and level switches for alarm and HRSG trip on drum level LWCO, Low-Low, Low, High and High-High. Independent tappings for remote drum pressure control and measurement shall be provided on the steam piping. All nozzles shall be welded to the drum and headers and shall extend through the insulation where applicable. The drum shall have sufficient number of nozzles for drum auxiliaries, drain, vent, blowdown, air release, feedwater, chemical feed, steam safety valves, instruments, sampling connections, etc. as necessary.

F. Tubes:

1. The tubes shall be not less than 2" in diameter for the evaporators and 1-1/2 inches in diameter for the economizer, and the thickness shall conform to the ASME Code for the pressure specified. The tubes shall be made from electric resistance welded carbon steel. Fouling factors shall be 0.001 for outside fins and 0.001 for inside fins. Fin density shall be not greater than 6 per inch. Fins shall be attached to the tubes by a high frequency continuous welding method. Fin material shall be 409 SS for the leading evaporator and carbon steel for the secondary evaporator and economizer.
2. The tubes shall be bent to a true radius. Tubes that are distorted in bending, flattened or ridged will not be accepted. Tube holes in the drums shall be drilled, reamed and serrated. The design of the tubes shall permit both drums and all tubes to drain by gravity.

G. HRSG Enclosure, Insulation and Cladding:

1. The entire boiler shall be constructed to form a complete gas tight construction without any leakage of exhaust gas from within the setting under any condition of operation.
2. The design and construction of enclosure shall prevent distortion of steel work due to thermal expansion and deterioration of insulation. The wall construction shall be designed without permanent deformation. The pressure withstanding capability of the enclosure including interconnecting ductwork shall not be less than (+) 20 inch of water column at 67% of yield strength. The Manufacturer shall also check and confirm the design of the HRSG enclosure against any internal vacuum if created during sudden flame out. The primary objective of enclosure design shall be to achieve reliability and long life.
3. Observation ports, doors and all other openings shall be provided with sealing and cooling air to prevent hot gases from blowing out when these items are opened or operated. All inspection doors and access manholes shall be of the quick opening type and provided with safety features to prevent opening of the doors without seal air pressure

when the boiler is in operation. Sealing and cooling air shall be supplied from the LP blower system provided by the Manufacturer.

4. The HRSG pressure casing, steam drum, water/mud drum and all interconnecting ductwork between the gas turbine exhaust and economizer outlet transition, subject to hot exhaust gases shall be complete with a thermal insulation. The setting and insulation shall be so designed to ensure that an average casing surface temperature of 140°F, considering a still surrounding air temperature of 100°F, is not exceeded under any load conditions. The Manufacturer shall guarantee the design against overheating, warping or burning of the casing.
5. The boiler design shall utilize non-waterwall convective evaporator sections. Evaporator sections shall be constructed with internal mineral fiber insulation and lagging. Drum head will not be factory insulated. The remaining exposed parts of the steam and mud drums shall be insulated with mineral wool, and covered with 12 gauge embossed, corrugated aluminum jacketing. Steam drum shall be covered with 7 gauge lagging.
6. Boiler outer casing will be 1/4 inch thick carbon steel. For all temperature measurement within the boiler casing, the Manufacturer shall furnish temperature elements in respect of local as well as remote measurement. All necessary access, observation, and cleaning doors with frames for building into the casing shall be provided. The doors shall be insulated and be perfectly gas tight under all working conditions. The design and construction of the doors shall be rugged and shall ensure freedom from distortion.
7. At low locations of enclosures, drain pockets shall be provided to collect liquids. The drain pockets will be provided with normally closed valves.
8. Provide casing with capped washout drain fittings.

H. Ducts and Expansion Joints:

1. The complete ducting system, including the expansion joints, from turbine transition duct and bellows to the economizer outlet transition, and on through the roof to the final discharge shall be provided as part of this section and designed for an internal pressure and vacuum as required.
2. The ducting system leading into the duct burner and to the inlet of HRSG should be designed with a slow angle of divergence to reduce formation of eddies and turbulence. To improve the flow distribution, turning vanes or similar devices for correction of flow patterns may be employed.
3. Material of duct work, guide vanes, expansion joints and all other components of the system should be as follows:
4. Operating temperature not exceeding Deg. F listed below:

Carbon Steel	up to 800
Corten Steel	up to 900
Stainless Steel 309	up to 1200

Stainless Steel 304/316	up to 1600
Stainless Steel 310	up to 1700

- a. The thickness of duct wall shall be 1/4" minimum, and shall be of welded construction, properly reinforced. Continuous welding at joints shall ensure gas tightness. Flanged joints shall be provided at all field connections and terminations with other Manufacturers. Flanged connections to be field welded by others.
 - b. All material and construction shall be suitable for thermal cycling and continuous operation at the design temperature. Stress levels will be maintained at limits to ensure a minimum creep life of 100,000 hours at the design temperature.
5. All hot ducts shall be insulated and shall be provided with necessary ribs or attachments for proper fastening of insulation. The exposed surfaces of the ducts and other equipment shall be insulated or covered to limit the external surface temperature to a average of 140 Deg. F at 100 Deg. F. still ambient air condition and also to prevent the formation of condensed moisture or "sweat". Hot ducts shall be insulated with material suitable up to the operating temperature plus 20 Deg. F margin. Insulation at equipment openings and flanged joints shall be finished off with metal edges to allow removal of cover and joint bolts so that the equipment can be opened for access of servicing without damage to the insulation.
6. Suitable supports and anchors, expansion joints, access doors, adjustable spring hangers, flue gas sampling connections, gaskets, thermal insulation fasteners, etc. shall be furnished as required. Ductwork shall be reinforced with structures to eliminate any vibration or pulsation induced from flow dynamics. Provide guy supports on elevated stacks.
7. Low points of ductwork will be provided with drain pockets, suitably blanked off.
8. Expansion Joints:
 - a. Expansion joints shall be provided to absorb longitudinal expansion or contraction and shear movements due to temperature differential or misalignment and thus relieve stress levels from major equipment. Expansion joints shall be of reinforced heat resistant fabrics with internal stainless steel liner or all-metallic, suitable for the working environment, and shall be of bellows design to maintain leak tightness. Sliding or sleeve type expansion joints are not acceptable.
 - b. Welds on expansion joints shall be dye penetrant tested, after forming and welding.
 - c. The internal dimensions of the expansion joint shall match that of the main duct or boiler enclosure. The joints shall be covered with the internal plates to prevent eddies and turbulence. The expansion joints shall be lagged and clad separately from the main section of the duct.

I. Vents, Drains and Blowdown:

1. The HRSG shall be provided with all necessary vents, drains and blowdown systems required for the safe operation and maintenance of the HRSG plant.
2. Air vents shall be incorporated in HRSG steam and water circuits, and also on drum. All air vent lines shall be complete with separate isolation valves. Double isolation valves shall be provided if required to meet ASME pressure vessel code requirements for boiler external piping at the customer interface.
3. All piping and fittings associated with the water and steam circuits of HRSG shall be completely drainable.
4. Both continuous (CBD) and intermittent (IBD) blowdown piping and isolation valves shall be provided. CBD will be done as surface blow from top steam drum and the circuit shall be sized for a maximum rate of 3 percent of fired steaming capacity. IBD will be done from bottom water drum/headers to clear dirt, rust etc. which may be accumulated in boiler circulation circuit.
5. To provide for functional checks on the drum water level gauge, a blowdown arrangement shall be provided and terminated through the isolation valves.

J. Steel Work:

1. The Manufacturer shall supply all necessary structural steelwork for encasement support, bracing of the HRSG and its ancillary equipment and access rails, ladders, platforms and the like, to all maintainable or monitored sections including outdoor flue stack emissions and monitoring system.
2. The steelwork shall be provided in accordance with the general requirements for steelwork meeting relevant AISC specifications.
3. Steelwork shall be provided for Manufacturer provided piping and instrumentation mounting.
4. Structural steel shall be supplied in pre-fabricated form to minimize site erection work.
5. The design of the steel structures associated with the HRSG shall meet the following requirements:
 - a. The supporting structure shall be designed considering the internal forces and expansions.
 - b. Consideration shall be made that the steel structure can also accept forces of the pipes and ducts that will be eventually attached to the HRSG system.
 - c. In addition to this, the steel structure must be able to resist the forces resulting from water filling of the boiler and pipes during hydraulic test, or from other loads during erection.
 - d. Special care shall be given to the design of pipe racks or supports, as applicable, for steam and feedwater pipes, which must be able to also support these pipes during water filling (hydraulic test or acid cleaning).

- e. Ladders and platforms shall be supported so that no forces shall be introduced into the boiler body itself unless provided for by design.
- f. All nuts, bolts and washers must be galvanized or cadmium-coated, and properly protected against corrosion before installation.
- g. Other than the anchor bolts, Manufacturer shall supply all necessary foundation embedments, leveling plates, anchors, etc.
- h. Manufacturer to implement local seismic design conditions per CBC 2006.

K. Platforms and Ladders:

- 1. A complete system of ladders and platforms and shall be provided as required for proper operation and maintenance. The design shall meet requirements of OSHA standards. All platforms, walkways and stairways shall have a minimum clear width of 3 feet and be designed for a minimum load of 100 pounds/sq.ft.
- 2. A complete system of ladders and platforms and shall be provided as required for proper operation and maintenance. The design shall meet requirements of OSHA standards. All platforms, walkways and stairways shall have a minimum clear width of 3 feet and be designed for a minimum load of 100 pounds/sq.ft.
 - a. All operating valves.
 - b. Instruments.
 - c. Observation doors/ports/manways.
 - d. Steam drum manholes, water gauge glass and columns.
 - e. Safety relief valves.
- 3. Platform perimeters and major openings shall be protected with hand railings, constructed with tubular fittings and pipes. A minimum of 7 feet - 0 inches headroom shall be maintained for all walkways and platforms. Continuous kick plates, projecting above the platform elevation shall be provided around all openings and platform edges.
- 4. Vertical ladders shall be provided with a safety cage as required by OSHA. Bottom of ladders shall be prepared for proper anchorage, either to additional platforms or floor slab.
- 5. Provision shall be made in the HRSG casing and access platforms for the rapid and convenient installation of the inspection scaffolding furnished for maintenance and inspection.
- 6. All platforms and ladders shall be painted.

L. Pipe Sleeves, Instrument Connections and Test Ports:

- 1. Provide pipe sleeves in the walls of the boiler for combustion control, sampling and instrument connections.
- 2. Provide instrument connections in casing and flue outlet as required. All connections shall be properly sized, located and capped.
- 3. Provide test ports in the following locations: Upstream of duct burner, downstream of duct burner (before evaporator), between evaporator sections, upstream and downstream of ammonia injection grid and SCR catalyst and between the last evaporator section and

economizer. To the extent possible locate such ports in areas of clear unobstructed flow as far as possible from upstream and downstream obstructions.

4. At every test port provide a pad eye or hook welded to equipment/duct, rated for 300 pound load. Locate this support approximately 20 inches above the test port (or highest test port in a row of test ports).
- M. The Manufacturer shall furnish all miscellaneous steel, hangers, shoes, attachments, base plates and related items for hanging or supporting of their equipment, piping and accessories.

2.4 HRSG TRIM AND ACCESSORIES:

- A. The boiler trim shall include a self-contained water column with all necessary alarms, cut-offs, gauges, isolation valves, drains, vents, instrument taps, etc. The water column and its level must be clearly visible from the floor level next to the boiler feedwater control valve station. If the sight line to the sight glass is obstructed, a lighted mirror assembly shall be provided.
- B. All necessary continuous and intermittent blowdown, chemical feed, vent and drain connections shall be provided with isolation valves. Automatic Valve and Flow control of continuous blowdown shall be by others. Additional isolation valves shall be provided as per ASME B31.1 so that the customer interface, for all ancillary taps lies outside of the domain of Boiler External Piping.
- C. A minimum of two safety relief valves shall be provided and sized in accordance with the ASME code.
- D. Chemical feed connection with isolation valves shall be included.
- E. All main steam and feedwater components within the jurisdiction of ASME Code Section I, shall be code stamped. For the main steam section, the stop/check (non-return) valve shall be of angle type and the second stop valve shall be of straight-through type. Piping between these two valves shall be supplied and fitted with a visible and accessible drain valve.
- F. A feedwater piping system shall be designed and supplied by the Manufacturer. It shall be complete with a feedwater level control valve, a three valve bypass assembly, and feedwater stop and check valves shall be provided in a pre-fabricated piped assembly. The piping design shall be stress analyzed and provided with hangers, supports, hardware, etc. by the Manufacturer to allow for field installation (if so required) by others.
- G. The economizer trim shall be provided with means for isolation, including manual bypass, vent, drain and safety valves. If the economizer or its tubes are removable, specify location and dimensions of space required for its removal.
- H. The Manufacturer shall provide a complete list, including number, size, manufacturer and model number of the steam, feedwater, and economizer trim with his proposal. Trim shall be factory-mounted with all integral

connecting piping and drain lines terminating with a valve 3 feet above the operating floor level.

2.5 ECONOMIZER:

- A. The Manufacturer shall furnish an economizer arrangement for the HRSG complete with structural steel support, interconnecting single case duct from last evaporator section gas outlet to economizer gas inlet, and interconnecting feedwater piping from economizer feedwater outlet to boiler feedwater inlet. Economizer shall be designed for inlet flue gas temperature, and outlet flue gas and feedwater temperatures establish by the Manufacturer for optimal HRSG system performance based on an inlet feedwater temperature of 217 degrees F. Economizer shall be double cased and externally insulated.
- B. The unit shall incorporate lifting lugs to facilitate loading and unloading.
- C. The economizer internal casing shall be 10 ga. carbon steel seal welded, gas tight, and externally insulated, secured and externally lagged with 0.016" thick corrugated aluminum lagging.
- D. The gas side connections on the economizer shall be plate flange type with drilling for bolt holes for aligning to adjacent components. The water side connections shall be flanged.
- E. Fin tubes shall have maximum density of 6 fins per inch.
- F. The design, fabrication and construction of the economizer shall be in accordance with ASME Code Section I.
- G. The economizer shall be a non-steaming type.

2.6 LOW NO_x DUCT BURNER:

- A. The duct burner must be capable of operating safely and continuously between 10 percent and 100 percent of its design heat output, as a minimum.
- B. The duct burner system shall be pre-wired and assembled and tested at shop before shipment to project site to minimize field installation time. All piping trains, such as main and pilot gas, shall be mounted on a free-standing piping rack pre-wired to the flame safety system control cabinet/panel and/or a junction. The piping trains shall be provided in accordance with the requirements of NFPA, FM (approved components) and ASME/ANSI codes, as applicable. Internal piping and wiring shall be pre-assembled. External piping and wiring shall be by others. All duct Burner Management System controls and accessories shall be located on a self-contained, free standing, skid mounted on the gas piping rack to provide HRSG system status/monitoring and emergency stop.
- C. Electrical enclosures shall be NEMA-12 minimum. Entire system design shall comply with requirements of NFPA and FM standards.

- D. Gas line connections shall be flanged for connections 2-1/2 inches and larger. Connection sizes 2 inches and smaller shall be either threaded or socket weld union-end, as required by applicable codes. The gas piping rack shall be provided with a single inlet connection to feed both main and pilot gas lines. Valves shall be cast iron construction, as applicable.
- E. The frame of the duct burner shall be constructed of structural steel of 1/4 inch minimum thickness, primed with 3-4 mils of inorganic zinc primer and finish coat. The frame assembly will be provided with matching flanges for attachment to transition ductwork with the HRSG/gas turbine. Seal welding or bolting can be used to do field joining.
- F. The frame shall be internally insulated with 8 lb/cu. ft ceramic fiber blanket and lined with 316 SS. All thermal insulation or refractory material shall allow for thermal expansion or contraction, without cracking, detachment or any other injurious effects.
- G. Burner Elements:
 - 1. Burner elements coming in contact with the flame shall be constructed of stainless steel.
 - 2. Burner elements shall be secured to the burner frame to eliminate any vibration induced from fluid flow. The elements shall allow for thermal growth and contraction with variation of load.
 - 3. When multiple burner elements are used, distribution headers with isolation valves, pressure gauges, etc., shall be provided separately for fuel gas, and scanner cooling/purge air.
- H. Igniter Pilot:
 - 1. For ignition of natural gas, the Manufacturer shall provide high energy spark-ignited gas pilots of the interruptible type.
 - 2. If the pilot gas type igniter being provided is air-cooled, the igniter heads shall be made of stainless steel 304 or better. Pilots should be shielded from turbine exhaust gas flow to assure a stable flame, avoiding blow out of pilot flame. One pilot and ignition transformer shall be provided, as a minimum, for each burner element. - The burner pilot will be cast iron. Pilot firing tube to be constructed of 316SS.
- I. Flame Scanners and Flame Safety System:
 - 1. A minimum of one flame scanner and amplifier shall be provided for each burner element or runner. The flame scanners shall be of ultraviolet (UV) type or infrared (IR) type, or a combination of the two.
 - 2. Each flame scanner shall be located on a fixed base.
 - 3. The flame scanners shall be cooled and purged continuously to keep them clean of any particulate matter from combustion of fuel. If air is used as coolant, as well as purging agent, the same shall be supplied by the low pressure blower system.
 - 4. The flame safety system shall be enclosed in a free standing NEMA-12 enclosure.

J. LP Blower System:

1. The Manufacturer shall provide a duplex LP (low pressure) blower system to supply air to the scanner, igniter and observation ports for the HRSG system as required by the Manufacturer. The system shall be complete with all necessary controls, instrumentation, inlet filters, silencers, interconnecting piping and valves (i.e. isolation and check), common outlet flexible connection, etc.
2. This system shall be skid-mounted and shall be integrated by the Manufacturer to form a completely functional system such that the Contractor need only connect utilities, interconnection piping and wiring and appurtenances to form a complete functional and reliable system. The Manufacturer supplied system controls shall be designed to allow either manual or automatic start of a different blower as needed to provide continuous air supply to maintain HRSG system operation.

2.7 AMMONIA SUPPLY, DILUTION, AND CONTROL SYSTEMS:

- A. The intended supply source for ammonia to the SCR system is from bottle anhydrous ammonia. The work of this section shall include ammonia gas storage, including cabinet, ammonia bottles, manifolds, all valves and appurtenances plus piping between cabinet and ammonia process (flow) control unit.
- B. The supply of Ammonia Vapor to the Ammonia injection grid shall be controlled by a vaporization (as applicable), dilution and control skid. The Ammonia injection grid, SCR catalyst, and Ammonia dosing and control skid shall be designed and packaged by the HRSG Manufacturer to function as a seamless system. The control system shall receive a feedback signal from a NOx analyzer and utilize fuel flow signals provided from the HRSG Combustion Control system and the Turbine control system to determine the instantaneous flow rate of diluted ammonia vapor to provide to the injection grid.
- C. Control logic for the Ammonia dilution and control system shall be accomplished using a Programmable Logic Controller (PLC). Configuration of this PLC can be either as a dedicated SCR control PLC or can be accomplished as an integral part of the PLC based Combustion Control system.
- D. The following specific requirements shall apply and the following shall be provided:
 1. The anhydrous ammonia process control unit shall consist of Stainless Steel skid package with two redundant Dilution Air Blowers, Motor Starters, ammonia control piping & Instrument air piping, all skid mounted hardware, instrumentation and wiring. The process control unit shall have a minimum Metering and Dilution Capacity of 9 lbs/hr delivered at 32" W.C.
 2. The ammonia gas delivery and storage system shall be housed safely and in accordance with code and provided with a gas monitoring system. The manifold system shall be contained in a fire rated Class 1 Division 1 enclosure and provided with any heating required to ensure an adequate supply of ammonia during cold months. The enclosure shall provide for a means of containing and exhausting any leaks that may

occur from the cylinders via an explosion-proof fan and external ductwork that will operate if the gas monitor detects a leak. The gas monitor shall annunciate a local alarm beacon and horn and also tie into the cogen SCADA system within the building and additionally alarm through the FMCS DDC system. The manifold shall also have an emergency shutoff valve located just before the regulator on the control panel and controlled by a break box and via operator from the SCADA system and the gas detector. Each cylinder within enclosure shall be secured within the enclosure by two restraints, one of which shall be non-combustible. Alternate methods of securing cylinders shall be approved by the local fire department. (Add#01)

3. Provide the required number of cylinders to ensure an adequate supply and turn over for the local ammonia supplier so there is never any chance to run out, yet not exceed the code limit for storage within the room. A scale shall be provided to allow the users to determine the remaining product. Provide a nitrogen cross purge system to allow for the easy and safe change-out of cylinders. Provide the appropriate personal protective equipment required for start-up and cylinder changes for at least two personnel.
- E. Ammonia piping shall be ASTM A312, TP304/304L stainless steel, Schedule 40 with 3000 lb forged stainless steel fittings. ASTM A182-F304/304L, socket weld ends and 150 lb RF stainless steel flanges, ASTM A182-F304/304L, per B16.5, socket weld ends where mating to flanged equipment.
1. Flange bolts shall be ASTM A-193, B7 stud with 2, heavy hex nuts, ASTM A-194, Gr. 2H.
 2. Gaskets shall be spiral-wound, 304 SS/PTFE with stainless steel inner ring.
 3. Needle valves shall be 316SS body, stem and tip, FNPT connectors, hard seat, 6980 psig rated at 100 deg F.
- F. Nitrogen purge piping shall be ASTM A312, TP 316 stainless steel, or as otherwise recommended by manufacturer for application. Schedule 40, with 3000 lb. forged stainless steel fittings. Other components similar to ammonia piping section above.

2.8 AMMONIA INJECTION GRID AND SCR CATALYST:

- A. The Ammonia injection grid shall consist of multiple lances each featuring multiple spray nozzles to enable proper ammonia distribution across the exhaust gas profile.
- B. Lances and supply header shall be constructed of 304 stainless steel. Each lance shall feature an isolation valve, metering orifice and differential pressure indication for balancing flows.
- C. The design of the SCR Catalyst bed shall be at the Manufacturer's discretion to meet the specified performance requirements but must be appropriate for the installed temperature region and must conform to the overall dimension requirements specified herein.
- D. Catalyst Bed shall be designed for a minimum guaranteed life span of 3 years.

2.9 CO CATALYST:

- A. The design of the CO Catalyst section be at the manufacturer's discretion to meet the specified performance requirements but must be appropriate for the installed temperature region and must conform to the overall dimension requirements specified herein. Coordinate with emission performance of CTG furnished.

2.10 STACK

- A. The manufacturer shall size and provide a stack with internal flue to sit atop the economizer. The outer casing shall be A-36 carbon steel minimum of 1/4 inches thick. Internal flue shall be 304 stainless steel and 18 Gauge. Flue is to be insulated with minimum 2 inch thick, 3# C.F. fiberglass including accessible exterior sections (provide suitable weather proofing and jacketing). The stack is to be mounted on top of the economizer outlet transition and terminating at an elevation above the Cogeneration Plant roofline as noted on plans. The entire length of stack above the top of the economizer outlet transition should be assumed to be outdoors. Refer also to Section 23 07 11, HVAC AND COGENERATION PLANT INSULATION.
- B. The manufacturer shall provide a support assembly, fabricated from structural I-beams and channels to support the economizer, ductwork and stack from the operating floor at the boiler baseline. The stack shall be totally self supporting without use of guy wires.
- C. Two (2) 6 inch flanged EPA test ports and two 3 inch flanged CEMS port are to be provided in the boiler stack. Ports shall be located an adequate distance above the nearest flow disturbance to assure accurate measurement. Ports shall to be compliant with EPA requirements. In addition, two (2) 4 inch flanged Opacity monitoring ports shall be confirmed and provided if required by EPA Air Permit for the boiler stack.
- D. All interior and exterior surfaces of the outer casing are to be prepared to SSPC-6 specification. Apply one coat of zinc-enriched primer, minimum 3 mils. Apply one final coat, minimum 3 mils thickness.

2.11 INSTRUMENTATION AND CONTROLS

- A. The Cogeneration Plant Building, in which the steam generator will be incorporated, shall be equipped with a plant-wide Supervisory Control and Data Acquisition (SCADA) system or PLC. The HRSG package PLC shall be based on the same system for compatibility. The Steam Generator Combustion Control and Burner Management System panels shall be fully capable of independent operation and shall have an Ethernet/IP communication link to the SCADA system for safe and reliable supervisory control, monitoring, alarming, data storage and trending, and optimization of the plant operations under all conditions.
- B. Control Philosophy: The intent of the PLC-based Combustion Control System and Burner Management System is to have complete control and monitoring of each HRSG to be done via local control panels (adjacent to the Manufacturer's equipment). The HRSG controls will be interfaced with the

corresponding turbine generator controls for sequencing of startup and shutdown. The HRSG controls will be interfaced with a separate plant-wide control system for remote monitoring and supervisory control.

- C. All controls provided with the HRSG System shall include all necessary hardware, software, listing of addresses, etc. for implementing the Control Philosophy.
- D. Provide original licensed disks and original documentation for the development environments and runtime applications for all software furnished. Provide licensed copies of programming and configuration software for any programmable device such as PLCs and operator interface monitors.
- E. All instrumentation provided shall be "industrial/utility grade". All transmitters to be supplied with integral valve manifold (2-valve, 3-valve or 5-valve as most appropriate) and pipe mounting bracket for field mounting.
- F. All control valves shall be furnished with actuators and Digital Valve Controllers.
- G. Human-Machine Interface (HMI) to the PLC-based combustion control and burner management systems shall be via LCD color graphic touch screens where the various systems and control loops are presented in full graphic format.
- H. All combustion control and burner management control for each HRSG system shall be enclosed in a suitable NEMA 4 panel, with hinged door and lock, containing all necessary PLC components, relays, terminal blocks, fuse blocks, fuses, power supply, switches, and colored indicating lights. All instruments on the panel front shall be identified by nameplate. All wire terminations shall be numbered in accordance with the applicable wiring diagram. All wiring shall conform to the National Electric Code.
- I. Operating and Safety Controls: The unit shall be provided with a full complement of operating and safety controls, consisting of but not less than the following items and features:
 - 1. The HRSG system shall be designed in accordance with the applicable code requirements of NFPA 85.
 - 2. Automatic gas-electric ignition system for burner pilot.
 - 3. A UL listed Burner Management System based on PLC to provide proper pre-combustion purge, ignition, start, stop, post-combustion purge and safety shutdown, for gas firing. This BMS shall have Ethernet communication and shall be Manufacturer standard design.
 - 4. Combustion Control System with three element boiler feed water control, based on the same type of PLC as BMS to provide HRSG steam drum level and boiler master pressure control.
 - 5. High pressure safety interlock for steam pressure control.
 - 6. Level column with probes and a separate auxiliary low-low level water safety cutoff for steam drum and momentary electrical bypass push-button for sight glass blowdown function.

7. Instrument Air pressure safety switch.
 8. Turbine generator exhaust flue gas flow and temperature safety switches.
 9. The following valve trains shall be mounted adjacent to the burner. All electrical devices shall be pre-wired to terminals within a burner mounted junction box. The gas trains shall be made from Schedule 40 pipe. Sizes 2" and above shall be with butt welded fittings.
 - a. Each pilot gas train shall conform to Factory Mutual and NFPA-85 and be of the interruptible type consisting, as a minimum, of two (2) pilot gas solenoid block valves, one (1) pilot vent valve, one (1) manual shutoff valve, and a pilot gas pressure regulator.
 - b. Each main gas train shall conform to Factory Mutual and NFPA-85 and consist of, as a minimum, a fuel flow control valve, two (2) main gas block valves, one (1) vent valve, one (1) gas pressure regulator, one (1) gas pressure indicating transmitter, one (1) manual gas shutoff valve, high and low gas pressure switches and main gas train leak-test provisions.
 10. The fuel train shall be constructed with Schedule 40 piping and shall conform to Factory Mutual and NFPA-85 requirements.
 11. Electronic continuity tests shall be provided on all circuits to ensure minimal start up time.
- J. The following instrumentation shall be supplied by the Manufacturer:
1. Steam Drum Trim:
 - a. Water Column/Probes for Low-Low, Low, High, and High-High points.
 - b. Low-Low Level Cutout Switch.
 - c. Column & Cutout Switch BD Bypass Pushbutton.
 - d. Level Transmitter/Manifold.
 - e. Level Sight Glass.
 - f. Continuous Blowdown Valves.
 - g. Intermittent Blowdown Valves.
 - h. Chemical Feed Valves.
 - i. Steam Pressure Indicating Transmitter.
 - j. High Steam Pressure Switch.
 - k. Excess (High-High) Steam Pressure Switch.
 - l. Steam Pressure Gauge.
 - m. Vent Valve.
 - n. Non-Return Valve.
 - o. Steam Shut-off Valve.
 - p. Steam Flow Element.
 - q. Steam Flow Indicating Transmitter with Manifold.
 - r. Safety Valves.
 2. Combustion Air Duct Trim:
 - a. Pressure and Flow Switch(s).
 - b. Temperature Switches.

3. Feedwater Trim:
 - a. Shut-off Valve.
 - b. Check Valve.
 - c. Feedwater Flow Element.
 - d. Feedwater Flow Indicating Transmitter with Manifold.
 - e. Feedwater Flow Control Valve.
 - f. Feedwater Control Valve Manual Block & Bypass Valves.
 - g. Feedwater Gas Strainers/filters.
 - h. Feedwater Pressure Gauges.
 - i. Steam Pressure Indicating Transmitter.
 - j. High Steam Pressure Switch.
 - k. Excess (High-High) Steam Pressure Switch.
4. Main Fuel Gas Train:
 - a. Main Gas Pressure Regulator.
 - b. Main Gas Pressure Indicating Transmitter.
 - c. Main Gas Flow Control Valve with low fire limit switch.
 - d. Main Gas Flow Element.
 - e. Main Gas Flow Indicating Transmitter with Manifold.
 - f. Main Gas Double Block & Bleed safety block valves with limit switches.
 - g. Main Gas Manual Shut-off Valve.
 - h. Main Gas High and Low Pressure Switches.
 - i. Main Gas Strainers/filters.
 - j. Main Gas Pressure Gauges.
5. Pilot Fuel Gas Train:
 - a. Pilot Gas Pressure Regulator.
 - b. Pilot Gas Pressure Gauges.
 - c. Pilot Gas Double Block & Bleed safety block valves.
 - d. Pilot Gas Manual Shut-off Valve.
 - e. Flame Scanner Amplifier.
 - f. Ignition Transformer.
6. General Instrumentation:
 - a. Local Pressure Gauges.
 - b. Local Temperature Gauges.
 - c. Flame scanners Cooling Air provisions.
 - d. Strainers upstream of all Control Valves.
7. Burner Management System:
 - a. PLC and components.
 - b. Ethernet Data Communication.
 - c. Pre-wired Enclosure.
 - d. Human-Machine Interface screen, lights, buttons, etc.
 - e. Preloaded Software Logic.

8. Combustion Control System:
 - a. PLC and components.
 - b. Ethernet Data Communication.
 - c. Pre-wired Enclosure.
 - d. Human-Machine Interface screen, lights, buttons, etc.
 - e. Preloaded Software Logic.
- K. Burner Management System:
 1. A complete automatic Burner Management System shall be provided for safe operation of the burner.
 2. Logic provided with the burner management system shall:
 - a. Prevent the introduction of any igniter flame or main fuel flame to the furnace until the furnace, boiler passes and stack have been purged of all combustible gases.
 - b. Prevent the opening of the automatic shut-off fuel valves in the main fuel lines until the igniter flame is proven.
 - c. Limit the time for main fuel ignition to 10 seconds from the time the igniter flame is proven.
 - d. In the event of a flame failure, require an operator to manually reset the burner management controller prior to a restart.
 3. The locally mounted Burner Management System control panel shall contain all devices required. No field wiring shall be required except from terminal blocks to external equipment of turbine generator and combustion control. All electrical equipment shall be installed and tested at the factory while simulating complete operational sequence. All connections, terminals and wires shall be identified and marked with a number that can be cross referenced on a system drawing. This test may be witnessed by the RE or his representative.
- L. Combustion Control System:
 1. Combustion Control system shall be provided by Manufacturer to adjust fuel flow rate, as CTG exhaust gas flow mass and temperatures vary to prevent over temperature firing of the Duct Burner which may result in physical damage to the HRSG or excess steam pressure. The following minimum operating logic shall be implemented via Combustion Controls.
 - a. Steam Pressure Control.
 - b. Steam Flow Control.
 - c. Drum Level Control.
 - d. Feedwater Flow Control.
 - e. Duct Firing Temp. Limiting Control.
 2. The following hard-wired signals shall be included by the Manufacturer for interface between BMS and Combustion Control system.
 - a. Go to Purge Position.
 - b. Master Fuel Trip.
 - c. Release to modulate.
 - d. Go to Low Fire Position.

2.12 ELECTRICAL

- A. Motors shall be selected in accordance with the driven equipment requirement. The continuous nameplate rating shall be 15 percent greater than the maximum brake horsepower required by the driven equipment. Service factor ratings shall not be used to meet this requirement.
- B. The Manufacturer shall be completely responsible for the selection and application of the motor drives, so that the driven equipment shall perform satisfactorily under the specified conditions. The design and construction of all motors shall be fully coordinated with the mounting arrangement, alignment, connection, end play, direction of rotation, vibration and other applicable requirements of the driven equipment.
- C. Motor performance shall be coordinated with the required performance of the driven equipment. All motors shall have ratings suitable for the torque and WK2 characteristics of the driven equipment. The Design letter shall be in accordance with NEMA Standard MG1-1.12, and shall be furnished with the Motor Data Sheets.
- D. All AC motors 1/2 to 250 hp shall be premium-efficiency, constant-speed, squirrel-cage induction, TEFC, severe-duty (mill and chemical) type, rated 460 V, 3-phase, 60 Hz, with Class F insulation, and a 1.15 service factor. The motors shall have a corrosion-resistant nameplate, grease fittings, oversized conduit box and a corrosion-resistant paint system. Temperature rise above 40 Deg. C ambient throughout the motor shall not exceed NEMA specified values. Motors shall be designed, manufactured and tested per ANSI/NEMA Standards. The full-load efficiency index letter and power factor shall be stamped on the nameplate.
- E. Fractional-horsepower motors smaller than 1/2 hp shall be rated 115 V, single-phase, 60 Hz. Motors shall be totally enclosed, fan cooled, with Class "B" insulation or better and suitable for indoor/outdoor use.
- F. DC motors shall be rated 120 V, and shall be able to operate within a voltage range of 105 to 140 V dc.
- G. All AC motor-operated safety shutoff valves shall be rated 120V 1-phase, 60 Hz.
- H. Motor terminal box shall be provided with grounding terminals.
- I. Motors shall be painted per the manufacturer's standards.
- J. All motors shall be designed to provide a continuous horsepower output, equal to the rated horsepower multiplied by the 1.15 service factor, without exceeding the total limiting temperature rise for the insulation system and enclosure specified.
- K. All motors shall have a safe stall time equal to or greater than the maximum accelerating time under the minimum starting voltage conditions.
- L. Starting current at full-voltage shall not exceed 650 % of the motor full-load current for all AC motors. DC motors shall be rated for use with

starters that limit the starting current to a maximum of 400 % of motor rated full-load current.

2.13 CLEANING, PACKAGING AND TAGGING

- A. All vessels, components and subassemblies shall be thoroughly cleaned of all water, sand, grease, oil and other foreign materials prior to shipment.
- B. All flanged openings shall be covered with 3/8 inch thick plywood flange protectors; threaded openings shall be protected with plastic end caps or plugs.
- C. All caps, plugs and flange covers shall be sealed with tape to provide a dust-tight closure.
- D. The equipment shall be suitably skidded, crated, boxed, sealed or otherwise protected from damage during shipment.
- E. Each separate shipping crate, box or skid shall be clearly and indelibly labeled with equipment tag numbers. Letters shall be a minimum of 1" high.
- F. Each piece of equipment identified with an equipment number shall have a 304 stainless steel nameplate permanently attached to it and containing the following information:
 - 1. Equipment number.
 - 2. Purchase order number and date fabricated.
 - 3. Manufacturer's name and address.
 - 4. Manufacturer's serial number and model number.
 - 5. Equipment Data: Maximum working pressure and temperature, operating volume, etc.
- G. All information shall be embossed on the nameplate or otherwise permanently affixed.
- H. Motor nameplates shall be the responsibility of the Manufacturer and shall contain the motor manufacturer's standard information.
- I. The cleaning and packaging requirements of this section are minimum standards to be followed. The Manufacturer shall submit in writing, his standard procedures for cleaning and packaging for Engineer's review. In addition, the Manufacturer shall submit written recommendations for field storage, both indoor and outdoor.

2.14 PAINTING

- A. All components with carbon steel and iron surfaces shall be painted with one coat of zinc inorganic primer, followed by one finish coat of enamel. Color is to be approved by the RE or their representative. High temperature aluminum paint shall be used for uninsulated boiler components. Prior to painting, all surfaces shall be sandblasted to SSPC-SP6 or SP-3 as applicable. Color to be Manufacturer's standard. The Manufacturer shall

include a suitable amount of paint for each finish coat for field touch-up work.

2.15 SPECIAL TOOLS

- A. Deliver to the Contracting Officers Technical Representative (COTR)/Resident Engineer (RE) one set of special tools normally provided for the HRSG system proposed such as a drum manway wrench.

2.16 SPARE PARTS

- A. Deliver to the Contracting Officers Technical Representative (COTR) / Resident Engineer (RE) one set of special tools normally provided for the HRSG system proposed such as a drum manway wrench.
- B. Fuel Trains:
 - 1. One assembly of electrodes, transformer, and high voltage cable with end connectors for the igniter.
 - 2. One of each type and size of main and pilot fuel motorized and solenoid automatic safety shut-off valves and automatic vent valves.
 - 3. One atomizing steam admission solenoid valve.
 - 4. Complete set of filter elements and gaskets for each gas filter for each boiler.
 - 5. Complete set of all gaskets for each edge-type oil filter for each boiler.
- C. HRSG, Duct Burner, Trim, Feedwater Control Valve:
 - 1. Drum handhole gaskets, three complete sets for HRSG.
 - 2. Sufficient glass inserts and gaskets to re-equip all water level gage glasses on HRSG.
 - 3. One set of drive belts for each belt-driven apparatus on duct burner as appropriate.
 - 4. Valve and actuator complete for electrically-operated feedwater control valve.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC .
- B. Boiler, Duct Burner and Economizer Access Openings: Arrange all equipment and piping to allow access to openings without disassembly of equipment or piping.

- C. Drainage Facilities for Boiler Water Column, Gage Glass, Low Water Cutoffs, Water Level Alarms:
 - 1. After individual drain valves, combine all drains into one pipe with a sight flow indicator, gate valve and check valve. Pipe to boiler blowoff line.
 - 2. Locate and orient sight flow indicator on common drain line so that one person can view the fluid flow while simultaneously operating drain valves and low water cutoff shunt switch.
- D. Boiler Drum Level Transmitter for Feedwater Regulator System:
 - 1. Provide three-valve isolation and equalizing system rated for 1035 kPa (150 psi), 182 °C (360 °F).
 - 2. Provide valved drain on all level sensing lines. Connect to water column drain system upstream of sight flow indicator.
- E. HRSG Casing Flashing: Flash or seal all pipe penetrations in casing at steam drum to prevent leakage of water into boiler insulation.

3.2 CLEANING AND PROTECTION FROM CORROSION

- A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Boiler Cleaning:
 - 1. Upon completion of installation, the initial firing of the burner shall be performed to boil out, under supervision of boiler manufacturer, all internal surfaces with chemical solution recommended by boiler manufacturer, to remove all mill scale, corrosion products and other foreign material. Following boil out, boiler shall be washed and flushed until water leaving the boiler is clear. Inspect internal surfaces for cleanliness. Then, drain and refill boiler with softened and treated water or place boiler in dry storage as specified below.
 - 2. Refer to the paragraph at the end of PART 3, Article, INSPECTION AND TESTS "Internal Inspection of Pressure Parts and Furnace", for the requirements for cleaning the boiler after the operational tests are completed.
- C. Protection from Corrosion:
 - 1. Protect the HRSG and duct burner from corrosion at all times.
 - 2. Dry Storage: When the boilers are not filled with water, protect with a dry storage method recommended by either the HRSG manufacturer or the ASME Code, Section VII.
 - 3. Wet Storage: If, after water is placed in the HRSG, it is not fired for equipment adjustment or testing for more than two weeks, the HRSG shall be protected with a wet storage method recommended either by the HRSG manufacturer or the ASME Code, Section VII. If HRSG are not fired for equipment adjustment and testing for more than one month, drain the HRSG and place in dry storage.

4. Chemical Treatment: The quality of the water in the HRSG shall be maintained by a professional water treatment organization. This organization shall provide on-site supervision to maintain the required water quality during periods of boiler storage, operating, standby and test conditions. Furnish monthly reports, by the water treatment organization, to the Resident Engineer (RE). The Contractor shall provide all chemicals, labor and professional services until the boilers have been accepted by the Government for operation. All chemicals utilized must conform to FDA Regulation CFR 21, 173.310, guidelines applicable for steam used in food preparation.

3.3 INSPECTIONS AND TESTS

- A. The following tests and demonstrations, except pretests, must be witnessed by the RE or their representative and must prove that boilers, economizers, burners, controls, instruments, and accessories comply with requirements specified. When test results are not acceptable, corrections must be made and the test repeated at no additional cost to the Government. Pretests do not require the presence of the RE.
- B. Condition of HRSG, duct burner, catalyst/treatment system and Economizer. After Delivery, Rigging, Placement: After setting boiler on foundation and placing economizer on supports, and prior to making any connections to boiler and economizer, Contractor and RE jointly will inspect interior and exterior for damage. Correct damage by repair or replacement to achieve a like new condition. After completion of repairs, perform air pressure test of the boiler casing. The Contractor shall conduct these tests at no cost to the Government.
- C. Hydrostatic Tests:
 1. HRSG, Economizer: Conduct tests after the equipment is installed and connected for operation and prior to initial firing. Contractor shall provide inspector certified by National Board of Boiler and Pressure Vessel Inspectors (NB). Test pressure shall be 150% of the design pressure of the boiler held for a period required by the inspector. Provide written certification of the satisfactory test, signed by the inspector. Correct any deficiencies discovered during the testing, and retest equipment until satisfactory results are achieved and are accepted by the inspector.
 2. HRSG External Piping (as defined by ASME B31.1, Power Piping):
 - a. Refer to Section 23 21 11, COGENERATION PLANT PIPING SYSTEMS.
 - b. Test may be conducted concurrently with boiler and economizer testing.
 3. Identify and remove any connecting equipment which is not rated for the test pressure. Cap the openings left by the disconnected equipment. Reinstall the equipment after the tests are complete.
- D. Boiler Steam Safety Valves:
 1. Test each safety valve set pressure and blowdown pressure with boiler steam pressure. Perform accumulation test to verify that safety valves have sufficient capacity to relieve full boiler output at maximum firing rate of burner. Tests shall be performed with boiler isolated

from the main steam header and all generated steam exhausting through the safety valves.

2. Valve Popping Tolerance: Plus or minus three percent of set pressure for set pressures over 480 kPa (70 psi).
3. Valve Blowdown Tolerance: Reset at not less than six percent below set pressure of valve with the lowest set pressure. Minimum blowdown two percent of the set pressure.
4. Accumulation Test: With burner at high fire, the boiler pressure shall not rise more than six percent above the set pressure of the safety valve with the highest pressure setting and no more than six percent above the maximum allowable working pressure of the boiler.
5. Make repairs and adjustments in manner recommended by National Board (NB) Inspection Code, NB-23. Retest valves after completion of repairs and adjustments.

E. Shop Testing:

1. The Manufacturer shall provide for inspection and stamping required of the equipment in accordance with the requirements of the ASME Pressure Vessel Code, ASME B31.1 Power Piping Code, and applicable state and local code requirements.
2. The Purchaser and Engineer reserve the right to inspect the unit during fabrication at the Manufacturer's plant. Dates and times shall be mutually agreeable to the Manufacturer and the Engineer.
3. Inspection by the Engineer, or lack of, shall in no way relieve the Manufacturer of its responsibility to meet the requirements of the ASME Code, applicable state and local code requirements, and this specification.
4. All equipment and material shall be subject to the Manufacturer's standard shop tests in accordance with the applicable codes and this specification. Tests shall be carried out at the Manufacturer's facility during and after completion of the manufacture of component parts in accordance with requirement of ANSI/ASME Boiler and Pressure Vessel Code. Wherever not specified in the said regulations, the tests shall be carried out in accordance with the standards proposed by the Manufacturer and approved by the Engineer.
5. The Manufacturer shall specify that all shop tests to be performed comply with applicable requirements. The Manufacturer shall notify the Owner and Engineer no later than 5 working days prior to any testing, so that the Owner and/or Engineer may witness the testing.
6. As a minimum, the following shop tests shall be performed:
 - a. Hydrostatic pressure test of all pressure parts, piping, and valves in accordance with the ASME code.
 - b. All pressure-retaining finished welds shall be inspected using a non-destructive examination, as applicable by code for materials and welds, including 10 percent randomly tested by radiographic examination as required.
 - c. Calibration tests of final control elements.
 - d. Simulation test of the burner management system equipment. All limit devices shall be set and tested, all circuitry shall be

- checked through and complete programming checks, including testing of flame detectors shall be done.
 - e. Leak testing of control valves as per ANSI.
 - f. Functional tests on all solenoid, motor operated and pneumatically actuated valves and control valves.
 - g. Pneumatic leak testing of all gas and air piping systems at one and one half times operating pressure for the duct burner (minimum 6 hours).
 - h. Any other tests deemed necessary by the Manufacturer and inspecting authority.
7. The Manufacturer shall make all necessary adjustments or modifications required if shop and/or field testing identifies performance or design deficiencies.
8. Certified copies of all shop and field tests and examinations performed by the Manufacturer shall be provided to the Owner for record purposes. All test reports shall be countersigned by the inspecting authority where required by code.
- F. Field Testing and Preparation for Startup:
1. The Manufacturer shall submit procedures for field testing of items not covered by shop testing that are normally performed by others.
- G. Performance and Acceptance Testing:
1. Acceptance of the HRSG system by the RE or their representative shall be subject to a formal performance test at the site in accordance with ASME Power Test Codes, PTC 4.4, latest edition. The RE or their representative shall furnish water, power, and similar items incidental to the operation of the equipment, including regulation station personnel.
2. The Manufacturer shall identify and provide all taps required in the Manufacturer's piping or equipment necessary to perform this testing. Additionally, the manufacturer shall identify any special requirements, such as, but not limited to, highly accurate flow nozzles, for this testing that need to be incorporated into the piping system design.
3. Sufficient tests shall be run to determine actual performance of the unit under all guaranteed conditions. Requirement of the number of test runs and their duration will have to be agreed with the Engineer before conducting the tests. Such tests shall be conducted under conditions maintained as close to contract conditions as plant operations permit. Performance correction curves, which the Manufacture shall submit prior to testing, shall be used where necessary to correct variations in ambient temperature, fuel heating value, etc. Certified copies of all test data shall be submitted to the RE or their representative at completion of the tests.
4. A functional test, as performed by and/or under the immediate on site direction of Manufacturer, ("Functional Test") for purposes of demonstrating that the equipment and systems in the Supplier's Scope function as designed safely, reliably, and as part of an integrated

Plant system in accordance with good engineering practice. These tests shall include normal operations, such as emergency trips.

5. All tests shall be performed with permanently installed Plant instrumentation.
6. At least 75 days prior to scheduled Acceptance Testing, the Manufacturer shall submit, for approval by the Engineer, a complete Acceptance Test procedure that defines details such as protocol, type of tests, measurements to be taken, sample calculations and correction formulas.
7. The Manufacturer shall furnish all connections and instruments necessary for conducting the tests that are not required for operation of the HRSG system, such as, but not limited to, turbine exhaust gas flow measurement.
8. All the above tests shall be performed by a third party Commissioning Agent at the time of plant commissioning. In case these tests reveal any deficiencies with Manufacturer's equipment, the Manufacturer shall be required to rectify the deficiencies promptly and at his expense, so that they can be accepted by the Engineer.

3.4 INSTALLATION, COMMISSIONING AND STARTUP SERVICES

- A. The Manufacturer shall provide the necessary services to assist in the installation and assembly of the work provided and field commissioning and startup services to fully commission the equipment to achieve performance guarantees. This service shall include, but not be limited to, verification of proper installation, performance of all tests and procedures as stated in the startup and installation manuals, verification of the proper operation of the control panels to perform as designed, performance of all necessary adjustments and calibrations of all unit sensors and meters and necessary technical assistance to assure that the Manufacturer's equipment meets the performance guarantees. The Manufacturer shall make all reasonable efforts to ensure that the same service technician(s) are utilized for startup, training and commissioning for each of the Manufacturer's equipment packages (i.e. HRSG and duct burner) for the duration of the project.
- B. Provide written certification that the entire assembly has been coordinated to achieve the required performance and to provide the required features.

3.5 TRAINING

- A. The Manufacturer shall provide on-site training for up to 5 operating and maintenance personnel. Instructions shall include, but not be limited to, training materials, hands-on and classroom instruction and complete review of all manuals. Classroom training shall be performed for two groups of personnel in a maximum of 2-8 hour daily sessions. The hands-on instructions shall include start-up, operation (normal and expected transients), shutdown and maintenance of all HRSG systems.
- B. Additional hands on training shall be provided on an informal basis, as time permits, by the Manufacturer's representative during plant start up and commissioning.

3.6 PERFORMANCE AND ACCEPTANCE TESTING:

- A. Acceptance of the HRSB system by the RE or their representative shall be subject to a formal performance test at the site in accordance with ASME Power Test Codes, PTC 4.4, latest edition. The RE or their representative shall furnish water, power, and similar items incidental to the operation of the equipment, including regulation station personnel.
- B. The Manufacturer shall identify and provide all taps required in the Manufacturer's piping or equipment necessary to perform this testing. Additionally, the manufacturer shall identify any special requirements, such as, but not limited to, highly accurate flow nozzles, for this testing that need to be incorporated into the piping system design.
- C. Sufficient tests shall be run to determine actual performance of the unit under all guaranteed conditions. Requirement of the number of test runs and their duration will have to be agreed with the Engineer before conducting the tests. Such tests shall be conducted under conditions maintained as close to contract conditions as plant operations permit. Performance correction curves, which the Manufacturer shall submit prior to testing, shall be used where necessary to correct variations in ambient temperature, fuel heating value, etc. Certified copies of all test data shall be submitted to the RE or their representative at completion of the tests.
- D. A functional test, as performed by and/or under the immediate on site direction of Manufacturer, ("Functional Test") for purposes of demonstrating that the equipment and systems in the Supplier's Scope function as designed safely, reliably, and as part of an integrated Plant system in accordance with good engineering practice. These tests shall include normal operations, such as emergency trips.
 - 1. The functional test shall also include one hour each of unfired operation at 50 percent, 75 percent, and 100 percent load, as well as one hour each of fired operation with the duct burner at 10 percent, 25 percent, 50 percent, 75 percent, and 100 percent load.
- E. A four hour performance test without duct firing ("Unfired Performance Test") to demonstrate ability to maintain Guaranteed Steam output at specified temperature, pressure and dryness and to also run continuously for 24 hours without interruption.
- F. A four hour performance test with duct firing ("Fired Performance Test") to demonstrate ability to maintain Guaranteed Steam output at specified temperature, pressure and dryness continuously and to also run for 24 hours without interruption. (Depending upon timing for plant startup the Fired Performance Test may need to be deferred until the next heating season).
- G. A reliability test ("Reliability Test") to demonstrate ability to continuously run for five days. The Performance Test may be during the Reliability Test.
- H. All tests shall be performed with permanently installed Plant instrumentation.

- I. At least 75 days prior to scheduled Acceptance Testing, the Manufacturer shall submit, for approval by the Engineer, a complete Acceptance Test procedure that defines details such as protocol, type of tests, measurements to be taken, sample calculations and correction formulas.
- J. The Manufacturer shall furnish all connections and instruments necessary for conducting the tests that are not required for operation of the HRSG system, such as, but not limited to, turbine exhaust gas flow measurement.
- K. All the above tests shall be performed by a third party Commissioning Agent at the time of plant commissioning. In case these tests reveal any deficiencies with Manufacturer's equipment, the Manufacturer shall be required to rectify the deficiencies promptly and at his expense, so that they can be accepted by the Engineer.
 - 1. NOx emissions shall be tested with electronic analyzer reading in parts per million. Analyzer shall be calibrated at with certified test gas within three months prior to use and immediately after cell replacement. Analyzer shall be accurate to plus or minus 5 percent of reading. If local emissions authorities require different testing the more complete and time consuming of the two shall be utilized, and shall comply with local emissions testing criteria.
- L. Internal Inspection of Pressure Parts and Furnace:
 - 1. After all operational tests are satisfactorily completed, a Government retained licensed boiler inspector may be engaged by the RE to determine if the HRSG is free from corrosion and any other type of damage or defect.
 - 2. In preparation for the inspection, open all drum handholes and the furnace access opening, drain and clean the interior of all pressure parts and clean all soot and debris from the furnace.
 - 3. Any corrosion, damage or defect shall be corrected to a like new condition in the judgment of the boiler inspector.
 - 4. Hard carbonaceous deposits on heating surface or refractory are evidence of flame impingement and are not permitted. Remove all deposits, make corrections to burners and provide complete retest of boiler and burner performance.
 - 5. After the boiler inspector has approved the boiler, all handholes and furnace access openings shall be closed with new gaskets.
- M. Report: Furnish complete written report (three copies) that includes test data, calculations, results compared with requirements, list of personnel, and other pertinent information. Furnish report within three weeks after completion of tests.

3.7 STARTUP AND TESTING

- A. The Manufacturer shall provide on-site training for up to 5 operating and maintenance personnel. Instructions shall include, but not be limited to, training materials, hands-on and classroom instruction and complete review of all manuals. Classroom training shall be performed for two groups of personnel in a maximum of 2-8 hour daily sessions. The hands-on instructions

shall include start-up, operation (normal and expected transients), shutdown and maintenance of all HRSG systems.

- B. Additional hands on training shall be provided on an informal basis, as time permits, by the Manufacturer's representative during plant start up and commissioning.
- C. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the Resident Engineer and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.8 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS and related sections for contractor responsibilities for system commissioning.

3.9 DEMONSTRATION AND TRAINING

- A. Submit training plans and instructor qualifications in accordance with the requirements of Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS.

3.10 CONSTRUCTION WASTE MANAGEMENT

- A. General: Comply with Contractor's Waste Management Plan and Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.
- B. To the greatest extent possible, separate reusable and recyclable products from contaminated waste and debris in accordance with the Contractor's Waste Management Plan. Place recyclable and reusable products in designated containers and protect from moisture and contamination.

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(Add#01) 18 SEP 2013, Addendum No. 01

(Add#02) 07 OCT 2013, Addendum No. 02

SECTION 26 32 14

COMBUSTION TURBINE GENERATOR

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The combustion turbine generator (CTG) specified herein is part of an integrated 'co-generation' (co-gen) or combined heat and power (CHP) system consisting of the CTG, the Heat Recovery steam generator (HRSG), the CHP control system, the natural gas compression system, and the continuous emissions monitoring system. It is the intent of these specifications that the CHP system be furnished complete as a system with a single source of responsibility to coordinate the procurement, installation, start-up, testing and initial operation of the associated components to insure compatibility and performance, serve as the 'system packager' for all CHP systems and equipment, controls, interconnecting piping and ductwork and interface with the supporting systems such as structural, architectural, electrical and telecom to make sure the appropriate provisions have been included and located as required to enable the successful fabrication, installation, start-up and operation of the CHP system. This would include liaison with the air quality management authorities for permitting and testing and with the VA site operations and maintenance personnel for training and coordination of any utility interface, shutdowns etc. The system packager shall have more than 5 years experience in and specializing in the design, procurement, development, fabrication, installation and testing of combined heat and power systems utilizing combustion turbine generators in California. Contractor shall obtain all required permits to construct from the Bay Area Air Quality Management District (BAAQMD) and shall meet the required BACT limits at the time of bid, including all EPA requirements and California code sections that are applicable. ^(Add#01)
- B. The CHP system components shall be chosen from among the alternatives that meet the requirements of these specifications, and the selected components shall be those that provide the lowest cost of ownership over a 5 year period under the assumptions listed below. The component selection shall be made using cost and performance data, also listed below, obtained from the manufacturers of the components, including a quotation for an extended service agreement for a term of no less than five years, that covers all the components' quarterly inspections and overhauls, performed by factory-trained and -certified mechanics, and has a guarantee for a minimum 90% system availability on an annual basis. "System" refers to entire combined heat and power system, including CTG, CHP Plant Control System, HRSG, Gas Compressor, and Continuous Emissions Monitoring System.
- C. Cost of Ownership Assumptions:

Runtime, hr/yr:	8250
Natural Gas Btu HHV/scf:	1000
Cogen Natural Gas Cost 2012, per Therm HHV:	\$0.57
Boiler Natural Gas Cost 2012, per Therm HHV:	\$0.67

Natural Gas Inflation Rate, 2012-2033:	1%
Electricity Cost 2012, per kWh:	\$0.09
Electricity Inflation Rate, 2012-2033:	1%
Maintenance Cost Inflation Rate, 2012-2033:	1%
Discount Rate, 2012-2033:	6%
Auxiliary Loads other than gas compressor, kW:	125
Steam Enthalpy Btu per lb:	1000
Boiler Efficiency (BAU)	82%

D. Required Cost and Performance Data:

1. Generator terminal electrical output, kW.
2. Gas turbine fuel consumption, standard cubic feet per hour of natural gas at 1000 Btu/scf HHV.
3. Unfired HRSG steam production, pounds per hour 100 psig saturated steam produced from 225F feedwater at 150 psig pressure to connection to HRSG.
4. Gas compressor electrical input, kW, at 35 psig inlet pressure and at outlet pressure (5 psig above pressure required at connection to gas turbine package).
5. Equipment Purchase Cost for CHP components: CTG, Heat Recovery Steam Generator (HRSG), the PLC control system, the natural gas compression system, and the continuous emissions monitoring system (CEMS).
6. Annual cost for extended service agreement, covering CTG, HRSG, PLC control system, the natural gas compression system, and the continuous emissions monitoring system, including all the components' quarterly, semi-annual, and annual inspections as well as overhauls and replacements, performed by factory-trained and certified mechanics, with guarantee for minimum 90% system availability on an annual basis.
7. The spreadsheet for cost of ownership shall be on the basis of net present value (NPV) using the following inputs:
 - a. Initial cost.
 - b. Electrical output (savings).
 - c. Steam output (savings).
 - d. Fuel cost.
 - e. Extended service agreement maintenance cost.
 - f. Net cash flow.
8. The best NPV system shall be incorporated into the bid, with a summary calculation validating the selection process. The stipulated run time assumes maintenance down time associated with the normal service, inspection and the long term service agreement.
9. The cost of the long term service agreement shall be calculated into the NPV but not included in the bid price for the project. The VA however may wish to procure the service separately and thus the pricing based on the following criteria shall be listed in the analysis and guaranteed for one year..

10. NPV analysis shall include a long term service agreement (LTSA) for a period of 5 years covering the following components:
 - a. Combustion gas-turbine generator set.
 - b. Heat recovery steam generator.
 - c. Natural gas compressor.
 - d. Medium voltage switchgear.
 - e. Ammonia dilution system.
 - f. Continuous emissions monitoring system.
11. The LTSA shall include:
 - a. Remote monitoring and diagnostics.
 - b. Troubleshooting service calls.
 - c. Quarterly, semi-annual, and annual inspections and tests.
 - d. Lubricants, filters, gaskets, fasteners, belts, and other consumables.
 - e. Scheduled and unscheduled overhauls and replacements, except as listed.
 - f. Reporting required by regulatory agencies and utilities, including BAAQMD and City of Palo Alto.
 - g. One complete overhaul.
12. Excluded from LTSA are:
 - a. Routine operation and monitoring of system components.
 - b. Repairs and replacements needed due to negligence, abuse, or force majeure.
 - c. Work on interconnecting piping, electrical cabling, ductwork.
13. The VA's obligations are to operate the components per the training and to ensure the proper functioning of the following systems (by performing specified duties):
 - a. Natural gas (VA to provide and ensure proper volume and pressure).
 - b. Electrical (VA to maintain site high voltage distribution system, 480V to components).
 - c. Steam (VA to maintain distribution system).
 - d. Boiler feedwater (VA to provide proper volume, pressure, quality).
 - e. HVAC (VA to maintain ductwork for turbine air, enclosure air).
 - f. Ammonia (VA to purchase and replace bottles as needed).
 - g. Building.
14. Performance requirement: All covered components shall be available to operate at 100% capacity during at least 8,000 hours of every calendar year. Available means the system either operated at 100% capacity or was able to operate at that capacity but was not operated at that capacity at the customer's request. Downtime due to equipment failure, parts unavailability, time needed for repairs, time needed for inspections and testing shall all count as unavailable hours. LTSA Contract shall name the gas turbine manufacturer as the vendor and the VA as the Customer. LTSA shall include the cost of a performance bond for the entire amount of the contract.

E. Natural gas fired combustion turbine generator complete with the following:

1. Gas Turbine:
 - a. Gas turbine.
 - b. Combustor.
 - c. Gaseous fuel system.
 - d. Air inlet resistance temperature detectors (RTD).
 - e. Exhaust gas temperature thermocouples.
 - f. Engine bearing temperature monitoring or oil drain temperature.
 - g. Vibration probes and monitoring system for turbine main shaft vibration (may be proximity probe).
2. Start System
 - a. AC inverter drive motor with VFD.
3. Reduction Gearbox and Couplings
 - a. Main reduction gearbox.
 - b. Couplings.
 - c. Coupling guards.
4. Base Plate:
 - a. Single base plate of fabricated steel construction to support the gas turbine engine, reduction gearbox, and AC synchronous generator.
5. Gas Fuel System:
 - a. Ignition system.
 - b. Fuel gas manifolds.
 - c. Low fuel pressure switch.
 - d. Piping to skid edge.
 - e. Main shut-off valve.
 - f. Primary gas shut-off solenoid valve.
 - g. Fuel control valve.
 - h. Safety shut off valve.
 - i. Emergency open valve.
 - j. Emergency shut off valve.
6. Lube Oil System:
 - a. Lube oil reservoir.
 - b. Main lube oil pump.
 - c. Pre-post lube oil pump.
 - d. Duplex lube oil filter.
 - e. Lube oil cooler.
 - f. Thermostatic control valve to control oil temperature.
 - g. Lube oil reservoir breather and coalesced type mist eliminator.
 - h. Lube oil reservoir low level alarm switch.
 - i. Lube oil pressure transmitter.
 - j. Lube oil temperature transmitter.
 - k. On skid lube oil piping.

7. Compressor Wash System:
 - a. On skid spray nozzles and piping.
 - b. Portable water wash unit.
 - c. All fitting and interconnecting piping required to accomplish wash function.
8. Exhaust System and Make-Up Air System:
 - a. Exhaust expansion joint (to accommodate engine thermal growth only).
 - b. Exhaust duct flange.
 - c. Exhaust muffler.
 - d. Fans.
 - e. Duct and casings, plus supports.
 - f. Silencers.
 - g. All other components required for complete CTG enclosure ventilation/combustion air system.
9. Acoustic Enclosure:
 - a. Fitted over turbine, gearbox, and generator.
 - b. Painted mild steel construction.
 - c. Doors for personnel access.
 - d. Integral lifting beam for maintenance work.
 - e. Internal lighting.
 - f. Enclosure ventilation systems.
 - g. Ventilation inlet and outlet fire dampers.
 - h. Ventilation air fans.
 - i. Ventilation air silencers.
10. Fire and Gas Protection System (refer also to Section 21 21 13.13 - HIGH PRESSURE CARBON DIOXIDE FIRE EXTINGUISHING SYSTEMS):
 - a. CO₂ fire extinguishing bottles located off skid.
 - b. On skid extinguishing distribution piping and discharge nozzles.
 - c. Flame detectors.
 - d. Thermal detectors.
 - e. Combustible gas detector.
 - f. Extinguishing release (manual pull station and automatic).
 - g. Audible and visual alarms.
11. Generator:
 - a. AC synchronous generator rated 480V typical, 3 phase, 60 cycle.
 - b. Generator temperature detectors.
 - c. Generator stator winding temperature detectors.
 - d. Generator vibration detectors.
 - e. Generator supplied with sleeve or roller bearings. If forced lubrication bearings are provided, furnish all accessories and associated sub systems required.
 - f. Generator line side cubicle and generator neutral cubicle.
 - g. Generator grounding system.

12. Battery System:
 - a. Battery chargers.
 - b. D.C. batteries - lead acid or NiCad type batteries.
 - c. Floor standing cabinet to contain battery chargers and batteries.
13. Turbine Control Panel:
 - a. Floor standing or wall mounted control cabinet.
 - b. LCD display for operating parameters.
 - c. Push buttons and selector switches for turbine operation.
 - d. All cabinet name plates and LCD screen text in English.
 - e. Vibration monitor for monitoring of turbine, gearbox and generator.
14. Generator Control Panel:
 - a. Floor standing or wall mounted control cabinet.
 - b. Control switches for generator and switchgear.
 - c. All cabinet name plates in English.
 - d. Generator AC metering equipment.
 - e. Protection relay for generator protection.
 - f. Automatic and manual synchronizing equipment.
15. Testing:
 - a. Separate factory testing of turbine and generator at their respective factories and then as package at the place of assembly of the CTG skid package.
 - b. Provide all site testing as described elsewhere in this specification.

F. This Section is intended to be used in conjunction with Sections 23 12 34, FUEL GAS COMPRESSOR, Section 23 50 11, COGENERATION PLANT MECHANICAL EQUIPMENT, Section 23 52 35, HEAT RECOVERY STEAM GENERATOR (HRSG), Section 25 60 00, CHP PLANT CONTROL SYSTEM, and Section 26 57 00, CONTINUOUS EMISSIONS MONITORING SYSTEM, for a complete system. All sections shall be carefully reviewed to ensure a cohesive coordinated installation. *(Add#01)*

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA AND SAMPLES.
- C. Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.
- D. Section 01 811 1.01, SUSTAINABLE DESIGN REQUIREMENTS.
- E. Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS: Requirements for commissioning, systems readiness checklists, and training.
- F. Section 03 30 00, CAST IN PLACE CONCRETE.
- G. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON STRUCTURAL COMPONENTS.

- H. Section 21 21 13.13, HIGH PRESSURE CARBON-DIOXIDE FIRE-EXTINGUISHING SYSTEMS.
- I. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- J. Section 23 05 51, NOISE AND VIBRATION CONTROL FOR COGENERATION PLANT.
- K. Section 23 11 23, FACILITY NATURAL GAS PIPING.
- L. Section 23 12 34, FUEL GAS COMPRESSOR.
- M. Section 23 52 35, HEAT RECOVERY STEAM GENERATOR.
- N. Section 25 60 00, CHP PLANT CONTROL SYSTEM.
- O. Section 26 05 13, MEDIUM VOLTAGE CABLES.
- P. Section 26 13 14, PARALLELING MEDIUM VOLTAGE SWITCHGEAR.
- Q. Section 26 57 00, CONTINUOUS EMISSIONS MONITORING SYSTEM.
- R. See Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS for additional seismic performance criteria.

1.3 QUALITY ASSURANCE

- A. The manufacturer shall have at least:
 - 1. Two years of proven experience in the production of the model of CTG proposed.
 - 2. Fifty (50) or more CTG units of equal or comparable design in continuous duty service with a total combined operating experience of 500,000 hours.
- B. Combustion Turbine Generator manufacturer shall provide a minimum of six days job site technical assistance during off-loading, erection, cleaning and commissioning and four days training including all travel and per diem expenses. Assume a minimum of two separate trips.
- C. Factory Test: The Government shall have the option of witnessing the shop tests at the factory. The tests shall be performed on the specific combustion-turbine generator being manufactured for this project. The Government will pay all expenses for the Government representative's trip to witness these tests. The contractor shall notify the Resident Engineer 21 days prior to date of testing. The manufacturer shall furnish load banks, testing instruments, and all other equipment necessary to perform these tests.
- D. Coordination with electrical and interface with utility:
 - 1. Coordinate with other Division 26 sections and requirements of electrical drawings to ensure a fully coordinated and functional interface between the electrical power distribution and the combustion turbine generator and associated components and systems.

2. Coordinate with utility for interface requirements and rules on interconnection between generator and utility distribution.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. All non-proprietary design drawings, calculations, manuals, data sheets, etc., as a minimum, shall be submitted for review and approval and final certification as required. The Manufacturer shall submit an initial drawing submittal schedule, identifying drawing titles and numbers within two (2) weeks from the date the Contract is fully executed. All submittals shall be submitted as follows:
 1. Manufacturer will provide 3 standard drawing releases; "initial release", as "shipped", and "as installed". Manufacturer to submit the "initial release" to Resident Engineer for Review and Comment. Submittal shall be in DXF and PDF either e-mailed, or posted to the Manufacturer Website or FTP site, or one CD containing general arrangement drawings, as required for plant layout equipment. In addition, final "as-shipped" and "as-installed" Manufacturer drawing set to be submitted in DXF and PFD on CD; three CDs to Resident Engineer. Certified manufacturer drawings must be submitted for approval within a maximum of ten (10) weeks of the date the Contract is fully executed.
 2. Operating and Maintenance Manuals - will be provided on CD; three CDs to Resident Engineer.
 3. Drawings shall show, as a minimum, the following:
 - a. Dimensions (including major component weight and center of gravity.
 - b. Indicate materials shipped loose for contractor installation.
 - c. Define all mounting requirements.
- C. Drawing Requirements (not all-inclusive):
 1. Final equipment layouts shall include arrangement drawings, issue for construction, in plan and elevation, with all major components identified. Size, type and dimensions for locating tie-ins shall identify product and service tie-ins. Access clearances for service of equipment and removal of components shall also be shown. Mechanical, electrical and any other interfaces to other systems or utilities shall be clearly identified and dimensioned, including size and type of connection. Detailed location and characteristics of all terminal points, electric connection requirements, etc. shall be provided.
 2. Elevations and sections shall be provided as necessary to show full details of tie-ins, service access and control components.
 3. Overall dimensions and detailed floor loadings shall be shown.
- D. Contract Drawings: The following drawings will be issued for each contract:

Drawing Title	Issue Code	Submittal time (weeks)
Gas turbine package general arrangement	I	8
Package foundation loading/installation footprint	I	12
P + ID drawing, Gen set system	I	12
Turbine/Generator control panel arrangement	I	16
Battery/charger panel arrangement	I	16
A.C. single line diagram	A	16
A.C. schematic diagram	A	16
D.C. schematic diagram	A	16
Motor list	I	8
Interface wiring diagram	I	16
Mechanical interface table	I	8

Notes:

1. Drawings are provided in English.
2. Drawing submittal times are after receipt of firm order.
3. Drawing issue codes indicate if drawing is issued for approval or for information purposes only.
4. A = issued for customer approval. I = issued for information only.

E. Shop test reports.

F. Shop performance test procedure and reports.

G. Detailed electrical data and characteristics, as described herein.

H. Manuals for method testing and calibration of all instruments.

I. As-Built drawings.

J. Generator Information:

1. Manufacturer's technical particular data sheets.
2. Write-up along with Control Schematics for brush less excitation system.
3. A General Arrangement Drawing showing the location of phase and neutral side terminal boxes and all other auxiliary terminal boxes.

4. A General Arrangement drawing showing tagging for all terminal boxes.
 5. Characteristic curves for the generator:
 - a. Time vs. negative sequence current.
 - b. Capability curve.
 - c. Open and short-circuit characteristics.
 - d. Losses (fixed and variable) characteristics.
 - e. Estimated "V" curves.
 - f. Generator transient, sub-transient and synchronous reactance.
 6. Generator neutral mounted CT technical particulars and characteristics.
 7. Auxiliary System:
 - a. Single Line and Three Line Diagram showing metering, relaying and rating of all equipment.
 - b. Control schematic diagram.
 - c. Generator load control and synchronizing system.
 - d. Manufacturer's catalog cuts for all equipment.
 - e. Provide appropriate IEEE model block diagram of excitation system, governor system and power system stabilizer (PSS); need for PSS to be determined by Independent System Operator Study results.
 8. Battery and Battery Charger:
 - a. Schematic and wiring diagram of battery charger.
 - b. Technical leaflets on battery and battery charger.
 9. Acoustic Enclosure: Product data including sound rating for enclosure measured in dBA.
 10. Exhaust muffler: Product data including sound reduction value measured in dBA.
 11. Generator Inlet Sound Attenuating Devices: Product data including sound reduction value measured in dBA.
- K. LEED Submittals: Submit in accordance with Section 01 81 11.01.
1. LEED submittals are in addition to other submittals. If submitted item is identical to that submitted to comply with other requirements, submit duplicate copies as a separate submittal to verify compliance with indicated LEED requirements.
 2. LEED Product Data Submittal Form: Submit completed product data form provided by the Contracting Officer's Representative; certified by vendor, installer, subcontractor, and/or manufacturer as appropriate.
- L. Air quality and environmental permits. *(Add#01)*

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.
- B. All equipment shall comply with any California state, local, or municipal laws and regulations governing the location where the equipment is to be installed.
- C. In the event of conflict between codes, standards or regulations, the conflict shall be referred to the Resident Engineer for resolution.
- D. American Society of Mechanical Engineers/American National Standards Institute, Inc. (ASME/ANSI):
 - 1. B1.1-03 Unified Inch Screw Threads
 - 2. B16.1-98 Cast Iron Pipe Flanges and Flanged Fittings
 - 3. B16.5-09 Pipe Flanges and Flanged Fittings: NPS 1/2 through 24-Metric/Inch Standard
 - 4. B31.3-12 Process Piping
 - 5. PTC-22-05 Performance Test Code on Gas Turbines
- E. American Welding Society (AWS):
 - 1. D1.1-04 Structural Welding Code - Steel: For base plate welding
- F. Factory Mutual Engineering Corporation (FM)
 - 1. 2010 Approval Guide
- G. International Standards Organization (ISO) 9000
- H. National Electrical Manufacturer's Association (NEMA)
- I. National Fire Protection Association (NFPA):
 - 1. 12-2005 Carbon Dioxide Extinguishing Systems
 - 2. 37-2010 Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
 - 3. 70-2008 National Electrical Code
 - 4. 110-2005 Emergency and Standby Power Systems

1.6 AS-BUILT DOCUMENTATION

- A. The electronic documentation and copies of the Operations and Maintenance Manual, approved submittals, shop drawings, and other closeout documentation shall be prepared by a computer software program complying with Section 508 of the Rehabilitation Act of 1973, as amended (29 U.S.C 794d). The manufacturer or vendor of the software used to prepare the electronic documentation shall have a Voluntary Product Accessibility Template made available for review and included as part of the Operations

and Maintenance Manual or closeout documentation. All available accessibility functions listed in the Voluntary Accessibility Template shall be enabled in the prepared electronic files. As Adobe Acrobat is a common industry format for such documentation, following the document, "Creating Accessible Adobe PDF files, A Guide for Document Authors" that is maintained and made available by Adobe free of charge is recommended."

- B. Four sets of manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- C. Four sets of operation and maintenance data updated to include submittal review comments shall be inserted into a three ring binder. All aspects of system operation and maintenance procedures, including piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices such as damper and door closure interlocks shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the VA will be required to employ shall be inserted into the As-Built documentation.

1.7 WORK INCLUDED

- A. Each gas turbine generator set shall be a natural gas fired Dry-Low NOx type gas turbine power plant with a continuous full load output at generator terminals of a minimum of 1.2 MWe to 1.5 MWe (at ISO conditions) installed indoors, complete with all auxiliaries and accessories and consisting of the following major components:
 - 1. Gas turbine unit, as specified in this specification, including the following:
 - a. Turbine, compressor and combustion chamber(s).
 - b. Load gear and couplings.
 - c. Fuel firing system - natural gas only.
 - d. Starting and cool down systems of the combustion turbine.
 - e. Complete lubrication oil system for the turbine, generator and accessory gear.
 - f. Turbine governing and control system.
 - g. Thermal insulation for all hot parts, as required.
 - 2. Turbine electric generator, complete with all its auxiliaries as specified within this specification. The auxiliaries shall include, but shall not be limited to the following:
 - a. Brushless excitation system.
 - b. Synchronizing equipment.
 - c. Metering and control equipment.
 - d. Automatic voltage regulator.
 - e. Three (3) neutral side CTs (pre-installed in generator terminal box) and three (3) line side CTs (shipped loose for installation

- by others in the paralleling switchgear) for differential protection.
 - f. Surge capacitor and lightning arrestors.
 - g. One set of batteries and charger (120 volts).
 - h. Generator winding neutral grounding resistor with sensing current transformer and support stand.
 - i. Generator control panel housing with indicating metering, control, and auto synchronizing equipment.
 - j. All on-skid wiring, conduits and junction/terminal boxes for external connections.
3. Structural steel base for the gas turbine, electrical generator and all accessories. Equipment skid shall accommodate all components as required.
 4. Acoustic enclosure with lockable access doors, complete with ventilation system for the gas turbine enclosure, electric generator enclosure and accessories, with all necessary fans, filters, silencers, fire dampers, intake and exhaust hoods with insect screens, ducting etc.
 5. Air intake assembly for turbine combustion air consisting of intake filter, reverse air flow filter cleaning system, and drift eliminator all housed within a common enclosure suitable for installation indoors with air intake through a roof opening to and intake hood.
 6. Turbine exhaust expansion joint.
 7. Generator shall be an air-cooled design and shall include cooling air supply and exhaust system with filter, fan, and intake and exhaust hoods as required.
 8. Air cooled heat exchanger for lube oil system.
 9. Complete factory wiring and piping interconnection between all equipment mounted on skid.
 10. Complete instrumentation and PLC-based control system for the turbine generator package, including all local instruments such as gauges, regulators, indicators, sensors, switches, transmitters, final control elements, along with local control panels, junction boxes, power supplies, etc.
 11. A control panel for housing the PLC Human-Machine Interface (HMI) display, and associated instrumentation and control hardware.
 12. CO2 fire suppression system for the gas turbine, generator and accessory components designed in accordance with NFPA 12 and approved by Factory Mutual (FM). Mounted within the manufacturer's extended equipment skid.
 13. Combustible gas monitoring, fire detection and fire alarm systems for the gas turbine enclosure.
 14. Miscellaneous external components, as required, for completeness of the package, such as CO2 gas cylinders, lube oil vent mist eliminator, Remote Control Terminal operator PC station, battery and battery charging sub-system etc. shall be supplied by the Manufacturer and installed on the manufacturer's extended equipment skid.

15. Supply and application of priming, rust inhibiting, and final painting at the shop.
 16. Packing and shipping to job site.
- B. The following specialty items shall be supplied:
1. Water wash system with mixing tank for the compressor section.
 2. Handling gear for removal and re-installation of the gas turbine module.
 3. Special tools and tackle for maintenance and erection.
 4. Spare parts, lubricants and consumable for commissioning and start-up, 100 percent spare for expendable items such as filters, oil, etc.
- C. Shop performance tests, supervisory services for system checkouts, commissioning and initial operations such as alignment and startup at site will also be required.
- D. All necessary drawings, data, manuals and necessary software with backup disks.

1.8 SHOP TESTING

- A. All tests shall be conducted by the Manufacturer, at their expense, to demonstrate the capability, guarantees, performance and compliance with the specifications as described in the proposal. The Manufacturer shall furnish experienced operating supervisory and test personnel, all instruments, any temporary equipment, including their installation for all tests requirements and perform all calculations and submit copies of the final report for approval.
- B. Shop Tests:
1. In addition to the shop tests as specified below, all equipment and material shall be subjected to the manufacturer's standard shop tests. Tests shall be carried out at the manufacturer's works during and after completion of manufacture of different component parts in accordance with the requirements of ANSI/ASME/equivalent Codes.
 2. Shop tests for partly/fully assembled turbine and compressor shall include, but not be limited to:
 - a. Balancing of the turbine and compressor rotors. Alignment and alignment check.
 - b. Assembly and full load test using job electric generator to test the following:
 - 1) Vibration
 - 2) Temperatures
 - 3) Start and speed-up to rated speed automatically by the operation.
 - 4) Selector switch.
 - 5) Safety device testing:
 - a) Manual trip.

- b) Normal shutdown.
 - c) Emergency trip.
 - d) Vibration trip.
 - e) Over speed trip.
 - f) Fire detector alarms and CO2 system test per NFPA 12.
 - g) Continuous run at rated speed control system for 1 hour.
 - h) Simulation testing on pressure switches for the lube oil system, including the following:
 - 1) Low oil pressure alarm.
 - 2) Low oil pressure - emergency oil pump start.
 - 3) Normal lube oil pressure - auxiliary oil pump start.
 - i) Steady full-load performance (output and heat rate).
 - j) The methodology and procedure for the shop performance tests shall generally conform to ASME Power Test Code 22, 19.1, etc. as applicable. This test procedure, meets the general guidelines of the PTC codes. Detailed test procedure shall be submitted to the Resident Engineer at least two months before the tests for approval. The shop performance tests shall be conducted in accordance with this approved test procedure. The intent of the test will be to determine the kilowatt output at generator terminals and the heat rate (btu/kwh) when running with the Turbine Inlet Temperature (TIT) corresponding to its continuous full load rating. The test results shall be suitably corrected for any deviations from the guarantee conditions (including TIT deviations) before comparing with the guarantee performances.
 - k) Load transient testing, including 1/4 load, 1/2 load, 3/4 load and full load with a maximum of 17 percent voltage deviation with 2 second recovery to within .25 percent of their steady state value at each step. Test will include a 100 percent load rejection required without over speed or flameout.
- 6) The turbine auxiliary component shall be given a standard factory test and inspection before installation in its system. Auxiliary equipment, to the maximum extent possible, shall be tested as part of the factory test in an effort to operate as designed. These tests shall include the following:
- a) Pumps, compressors, blowers, exhauster and drives.
 - b) Starting.
 - c) Stopping.
 - d) Characteristics (head, capacity, efficiency).
 - e) Dynamic balance and vibration checks.
- 7) Each auxiliary system, after assembly, shall be given the following tests:
- a) Visual check.
 - b) Operational and adjustment test for controls.

- 8) Generator Tests:
 - a) Mechanical inspection and balance.
 - b) Rotor over speed at 120 percent for a minimum of 3 minutes.
 - c) Measurement of cold resistance of armature and field windings.
 - d) Insulation resistance of field and armature.
 - e) Dielectric tests of field and armature.
 - f) Voltage phase balance, phase sequence.
 - g) Open circuit saturation curve.
 - h) Generator fixed losses.
 - i) Measurement of rotor impedance.
- 9) Exciter Tests:
 - a) Balancing of rotor.
 - b) High speed run.
 - c) Measurement of cold resistance windings.
 - d) Commutation adjustments.
 - e) Measurement of saturation and voltage regulation.
 - f) Measurement of insulation resistance.
 - g) Dielectric tests. All other tests applicable to this type of exciter system shall be performed.
- 10) Copies of a certified test report, covering the following tests performed on the generator, shall be furnished for approval:
 - a) Short circuit saturation curve.
 - b) Heat runs.
 - c) Harmonic analysis and measurement of TIF.
 - d) Short circuit tests for determination of reactance and time constants.
 - e) Measurement of segregated losses.
 - f) Turbine/generator vibration measurements and alignment reports.
3. All running tests for turbine, generator and exciter shall be conducted at the voltage, current, phase, cycles, RPM, etc., that they will operate when installed.
4. Complete functional testing and calibration of all instrumentation, functional and simulation of PLC system to be carried out.
5. The Manufacturer shall give the Resident Engineer reasonable notice (at least 10 days) when the full load tests will be performed on equipment specified so that the Owner can have representatives present during such tests. The notification of the test should include date of test, location of test and person to contact at test site.
- C. The Manufacturer shall provide the Resident Engineer preliminary test data obtained during the factory test.

- D. The Manufacturer shall make all necessary adjustments or modifications required if shop and/or field testing identifies performance or design deficiencies.

1.9 FIELD TESTING AND PREPARATION FOR STARTUP

- A. After installation, the equipment will be subjected to various site tests to demonstrate stable and sound operation under various operating modes. All these tests shall be performed by others, but shall be supervised by the turbine Manufacturer.
- B. The equipment will be prepared for operation, including making of such operation checks and tests, as are required, to demonstrate readiness of the equipment supplied and proper functioning with other equipment furnished. Tests in conjunction with other equipment shall be made after required routine tests have been performed. Such work and tests shall include:
 - 1. Functional and operational tests of all accessories, appurtenances and systems.
 - 2. Continuity and correctness of all power and control wiring.
 - 3. Loop check/3-point/5-point calibration loops.
 - 4. Insulation resistance of main generator and exciter windings.
 - 5. Drying of generator windings, if deemed necessary.
 - 6. Meggar and high potential tests (at 75% of factory test potential) on main and field windings and on main power connections.
 - 7. Measurement of resistance of grounding system.
 - 8. Preliminary operational tests of complete assembly, including checking of performance, temperatures, noise and vibration.

1.10 PERFORMANCE & ACCEPTANCE TESTING

- A. Demonstrate the system performance in a 30 day long continuous run test in which key performance levels are measured.
- B. Demonstrate that the system is able to perform at the performance levels provided by the manufacturers of the major system components (combustion turbine-generator, heat recovery steam generator, natural gas compressor, ammonia dilution system) and submitted as part of the required submittals.
- C. Using the PLC controls and HMI BAS system, measure, record, and store electronically all key variables at least once per minute during the test, especially the following:
 - 1. Ambient air temperature.
 - 2. Combustion turbine inlet air temperature.
 - 3. Turbine inlet temperature.
 - 4. Combustion turbine inlet air pressure.
 - 5. Combustion turbine exhaust pressure at outlet flange.

6. Natural gas flow to combustion turbine.
 7. Natural gas pressure at combustion turbine.
 8. Natural gas temperature at combustion turbine.
 9. Combustion turbine generator electrical output.
 10. Combustion turbine lube oil supply temperature.
 11. Combustion turbine lube oil supply pressure.
 12. Electrical power input into gas compressor.
 13. Natural gas flow to duct burner.
 14. Natural gas pressure at duct burner.
 15. Natural gas temperature at duct burner.
 16. Steam flow from HRSG.
 17. Steam pressure at HRSG.
 18. Feedwater pressure at HRSG.
 19. Ammonia flow rate into dilution system.
 20. Diluted ammonia flow rate into combustion turbine generator.
 21. Stack exhaust temperature and levels of NO_x, CO, and ammonia from CEMS.
- D. Provide an electronic file of the recorded measurements, averaged for one hour intervals.
- E. Provide a written report documenting any forced shutdowns during the period and explaining the causes.
- F. Provide a written report summarizing the measured average, over the duration of the test period, of the following performance indices, adjusted to average site ambient temperature and altitude conditions using the manufacturers' data for the variation of system component performance with ambient temperature and altitude, and data from the City of Palo Alto or PG&E for the calorific value of the natural gas.
1. Combustion turbine generator electrical output.
 2. Combustion turbine generator heat rate (Btu HHV per kWh).
 3. Unfired steam output at 100 psig saturated.
 4. Stack levels of NO_x, CO, and ammonia (compare to levels allowed under BAAQMD permit).
 5. Gas compressor power consumption at 100 percent of combustion turbine generator rated output.
- G. Provide a written report comparing the average performance indices to the performance levels provided by the manufacturers of the major system components (combustion turbine-generator, heat recovery steam generator, natural gas compressor, ammonia dilution system) and submitted as part of the required submittals.

H. VA is responsible to provide only the following during the test:

1. Site natural gas supply.
2. Electrical load on generator sufficient to absorb rated generator output.
3. Steam load on HRSG sufficient to absorb rated output.
4. Boiler feedwater per design specs.
5. HVAC and other building services, not including fans and blowers included as part of system components.

1.11 PENALTIES FOR NOT MEETING GUARANTEED PERFORMANCE AT FULL LOAD

- A. For the installed unit demonstrated to be operating at the site operating conditions listed above under "Performance Conditions", the Vendor shall incur a one-time penalty of \$5,000 for every kW of generator output not achieved relative to the Vendor's submitted 100 percent load generator output.
- B. For the installed unit demonstrated to be operating at the site operating conditions listed above under "Performance Conditions", the Vendor shall incur a one-time penalty of \$500 for every additional BTU required to produce one kW relative to the Vendor's stated 100 percent load heat rate.

1.12 AVAILABLE GUARANTEE

- A. This article applies to CTG only)
- B. Availability Rate:
 1. The Vendor shall guarantee, in writing, their proposed equipment to have a minimum net availability rate of 95 percent. Availability shall be defined as the number of running hours plus the number of hours the unit is available to run divided by 8760 hours minus the scheduled maintenance hours and unscheduled maintenance hours.
 2. Number of hours available to run shall be defined as the number of hours the unit is intentionally down due to reduced electrical load plus the number of hours that the unit is unable to run due to a failure which is external to the Combustion Turbine Generator Scope of Supply.
 3. Unavailable hours shall, in the event of a failure, begin accumulating 24 hours after the Vendor's local service branch is notified of the failure. This is to account for service personnel travel time.
 4. Unscheduled maintenance downtime shall be that associated with the shutdown due to inability to meet emission standards and/or equipment failures outside of the CTG's responsibility. See paragraph 1.1.B in this Specification Section.
- C. Incentives and Penalties:
 1. In the event that the calculated availability rate shall fall below the guaranteed rate of 95 percent, then the vendor shall be imposed a penalty of 5% of the annual maintenance fee for every one percentage

point below the 95 percent availability. In the event that the calculated availability shall exceed the guaranteed availability rate then the Vendor shall receive a credit of 5% of the annual maintenance for every one percentage point above the 95 percent availability.

1.13 SOUND AND VIBRATION

- A. All equipment furnished by Manufacturer in accordance with this specification shall not produce a sound level in excess of 85 dBA at 1 meter from the enclosure surface and 1.5 meters above ground level and measured in a free field environment in accordance with ANSI Standards S1.2, "Method for the Physical Measurement of Sound" and S1.4, "Specification for General Purpose Sound Level Meter".
- B. The gas turbine along with the intake and exhaust system shall be provided with proper sound attenuation, such that the maximum noise level at a distance of 1 meter around the TG enclosure or from an air intake or exhaust, 1.5 meter above ground level or adjacent level, does not exceed an average of 85 dBA (in accordance with OSHA specified limit for 8 hour employee exposure without ear protection) in a free-field environment.
- C. Exhaust muffler shall provide minimum 15 dBA noise reduction.

1.14 SAFETY

- A. All mechanical equipment shall be fully guarded and interlocked with machine operations; i.e., exposed gears, chains, belts, sprockets and hazardous moving parts to meet current OSHA standards in effect at the time of delivery.
- B. Provide protective insulation on portions of system that could come in contact with personnel during routine observation or maintenance while system is running or in a hot condition.

1.15 INSTALLATION, COMMISSIONING AND STARTUP SERVICES

- A. The Manufacturer shall provide the necessary field startup services to fully commission the equipment to achieve performance guarantees. This service shall include, but not be limited to, verification of proper installation, performance of all tests and procedures as stated in the startup and installation manuals, verification of the proper operation of the control panels to perform as designed, performance of all necessary adjustments and calibrations of all unit sensors and meters and necessary technical assistance to assure that the Manufacturer's equipment meets the performance guarantees.
- B. Project meetings: The Manufacturer shall attend scheduled project meeting as required to properly provide information in supporting the equipment offered.

1.16 TRAINING

- A. The Manufacturer shall provide on-site training to maintenance personnel. This service shall include operating instructions and training for VA's

personnel. Instructions shall include, but not be limited to, training materials, hands-on and classroom instruction and complete review of all manuals. Classroom training shall be performed in a maximum of three 8-hour daily sessions. The hands-on instructions shall include start-up, operation (normal and expected transients), shutdown and maintenance of turbine generator system.

- B. Performance Warrantee: Contractor shall submit a price for a five year, all inclusive of material and labor warrantee for all scheduled and unscheduled maintenance to keep system performing at its specified levels. Included shall be one rebuild whether or not required within the 5 year period.

1.17 SPECIAL TOOLS

- A. In addition the to the tools normally required for erection, the Manufacturer shall also furnish one (1) complete and un-used set of special tools for the gas turbine generator set, suitably boxed, which are required for the operation and on-site maintenance of all equipment, including accessories.

1.18 WARRANTY (Add#01)

- A. Work subject to the terms of the Article "Warranty of Construction", FAR clause 52.246-21. Provide manufacturer's and installer's specialty warranty as follows:

1. Special warranty includes labor and parts for the ~~CHP~~
~~Control~~ Combustion Turbine Generator System free from defects for the specified warranty period. (Add#02)
2. The warranty shall include, but not be limited to, the following: Labor, travel, living expenses, parts replacement, system maintenance and testing, and software/hardware updates and revisions.
3. Work shall have a single warranty date, even if the Government receives beneficial use due to early startup.
4. Provide updates to project-specific software and firmware that resolve installer or Government identified software deficiencies at no additional charge during the warranty period.
5. In the event that the installer service call work causes damage to additional equipment, the installer shall be liable for labor and material to restore the system to full operation.

- B. During the warranty period, the installer shall update the software free of charge as manufacturer's software is improved.

- C. Warranty Period: Four years from the date the system is completely installed, fully operational, and accepted by the Government. The Resident Engineer representing the Government shall verify in writing that the CHP Control System has been tested and accepted in accordance with this specification. The date of acceptance shall begin the warranty period.

PART 2 - PRODUCTS

2.1 SITE CONDITIONS

- A. The following site conditions are utilized to develop heat rate and output guarantees:

Location	Palo Alto, CA
Altitude	50 Ft. ASL
ASHRAE 1% Wet Bulb	69 Deg. F.
ASHRAE 1% Cooling Dry Bulb	93 Deg. F
Combustion Air Temperature	93 Deg. F
Inlet Pressure Drop	4" H2O
Exhaust Pressure Drop	10" H2O
Natural Gas LHV	Per PG & E Rule 2 Quality (expected value 1020 ± 20); N2 = 1.4%, CH4 = 98%, C2H6 = 0.6%
Turbine Operating Level	95 percent - 100 percent load

- B. Guarantees for Heat Rate and Output at Full Load.

1. For the Operating Conditions listed in part A above, the Vendor shall guarantee the following operating parameters at 100% loading:

Gas Firing	Specified Value
(1) Load at generator terminals	1180 kWe Minimum
(2) Heat Rate	15,669 Btu/kWh Maximum +/- 3%

- C. Gas Fired Emissions Guarantee.

1. The vendor shall provide and guarantee, in writing, the following exhaust emission data in accordance with testing procedures that comply with U.S. EPA approved emission test procedures. Emissions shall be guaranteed from 95 percent to 100 percent MCR, not to exceed.

NOx	15 ppmv corrected to 15 percent O2 Dry
CO	50 ppmv corrected to 15 percent O2 Dry
UHC	10 ppmv corrected to 15 percent O2 Dry

2.2 GENERAL DESIGN

- A. Detail design of the entire system shall be the responsibility of the Manufacturer.

- B. Site Conditions:
- | | |
|------------------------------------|-------------------------------------|
| Minimum ambient temperature design | 0 deg. F |
| Maximum ambient temperature design | 104 deg. F |
| Relative humidity | 60 percent |
| Wind loading | 0 mph (indoors) |
| Seismic design | Per CBC 2007- Occupancy Category IV |
| Site elevation | 50 feet ASL |
- C. All pressure-retaining components shall be designed, fabricated, examined, inspected, and tested in accordance with Section I - Boiler and Pressure Vessels, Section II - Material Specifications, and Section IX - Welding and Brazing Qualifications of the ASME Boiler and Pressure Vessel Code.
- D. All equipment furnished by the Manufacturer shall be ready for field assembly. This includes, but is not limited to, matching marking of components.
- E. Materials:
1. Material shall be Manufacturer's standard for the application.
 2. No asbestos or asbestos bearing materials are permitted.
 3. Materials not specifically specified herein shall be of the best commercial quality.
 4. All materials shall be free from defects in workmanship and material used in their manufacture during the warranty period.

2.3 GAS TURBINE AND AUXILIARIES

- A. General:
1. Each gas turbine set shall be a heavy duty, skid mounted, industrial turbine generator suitable for continuous operation. However, the equipment shall be capable of quick starting from cold and rapid loading cycle even after long idle periods. Each Gas Turbine Generators is expected to run in a base loaded operating scenario in an electric load following mode, except when heat from HRSG cannot be fully utilized, then the CHP Plant control system shall initiate thermal load following mode and the GTG will run at part load.
 2. The entire assembly of the gas turbine, compressor, and generator is to be housed in an acoustical enclosure and designed on the concept of a self-contained package power plant. The assembly shall be installed indoors.
 3. The gas turbine set shall be suitable for unattended operation from the turbine control panel with a minimum requirement of operator interventions. Only the following permanent external connections are expected for each package (excluding connections with off-skid items included in supply scope):
 - a. Fuel gas supply.
 - b. Compressed air supply (instrument quality).
 - c. Generator power output.

- d. AC and DC junction boxes for power supply to skid-mounted auxiliaries.
 - e. Ethernet data communication links to the plant-wide Supervisory Control and Data Acquisition System (SCADA).
 - f. Vent and drains.
 - g. Turbine and Generator ventilation silencers.
4. Various specific details of the gas turbine generator set stipulated in the following sections are primarily intended to define the functional requirements and type of construction, supply scope, etc., for their various components. The Manufacturer should offer their standard packages meeting the above basic requirements, which have been thoroughly proven in at least five years of documented commercial operation. The intent is to require that the bidders determine which system will provide the VA with the best choice based on a set of reasonable assumptions, combined with the capital cost, performance, and long-term maintenance cost for the system. The calculations will necessarily be simplified, but should reduce the likelihood that the system selected would favor first cost over life cycle cost.

B. Compressor:

1. The compressor is a 2-stage centrifugal-flow type design.
2. The impeller shall be fitted on a shaft, which is initially turned by an electric starter through drive gearing.

C. Combustion System:

1. The combustion chamber geometry must ensure stable flame in the high velocity air stream. The combustion must be stable over the wide range of fuel flows required during ignition start-up, full power and reduced power.
2. The combustor liner's double wall design realizes effective cooling. In addition, a thermal barrier coating on the inner wall enhances long operating life by keeping the temperature of the cobalt-based alloy low. Separate external combustor casings enable easy inspection and maintenance.
3. The dimensions of the combustion chamber must be selected so as to ensure time to complete combustion reaction for the fuel to be burnt in the turbine and then dilute the combustion products with excess air to form a temperature profile acceptable to the downstream turbine components. The temperature profile of the hot gases entering the turbine section must be selected to ensure maximum life of turbine nozzles and buckets.
4. The combustion chamber(s) shall be provided with liners made of high temperature material.

D. Ignition System:

1. The ignition system consists of electronic ignition exciter units, high-tension cables and ignition plug.

E. Turbine:

1. The axial flow turbine shall consist of three stages. The turbine rotating blades shall be made from nickel-based alloy, designed for high resistance to creep at high temperatures. Turbine stationary vanes shall be made from a heat-resisting alloy, which demonstrates excellent characteristics against thermal impact and oxidation.
2. The blade material shall withstand the maximum firing temperature.
3. Blade design shall be such that at the operating speed, the frequency of the pulsating gas force acting on the blades is significantly away from the natural frequency of vibration of the blades. All blades shall be securely and adequately anchored. The rotor blading design shall minimize blade end leakage. Each rotating blade shall be weighted and numbered.
4. Turbine may be either a recuperative design or open cycle non-recuperative. If utilized, the recuperator shall consist of an air-to-air heat exchanger that transfers heat from a portion of the turbine exhaust gases and transfers it to the compressed combustion air prior to admission of fuel at the combustors.

F. Rotor Design

1. The rotor shall be of manufacturers' standard design and materials. The rotors shall be designed and dimensioned such that no critical speed occurs within + 20% of the normal operating speed.
2. Glands and seals shall be provided to prevent leakage of fuel into the gas passages and leakage of gas.

G. Bearings

1. The entire rotor shall be supported on an adequate number of amply proportioned bearings to maintain proper alignment under all load conditions.

H. Casing Design:

1. The gas turbine casing shall be of lightweight structure to enable ease of maintenance and inspection. Bore scope inspection holes to be included in the design to help further reduce time for maintenance and inspection. The casing to be supported by fixed support at the air inlet end.
2. The turbine and compressor casings shall be designed to withstand the pressure and temperature of the medium. The casing shall be as symmetrical in design as possible to minimize the effects of thermal stresses. Ductile cast iron may be used as a casing material, if the service temperature does not exceed 640 Deg. F. Where higher temperatures are to be encountered, suitable grades of alloy steel shall be used. The casing shall be so designed and keyed as to permit free radial and longitudinal expansion while maintaining the concentricity of the shaft and casing. The casing insulation shall be so arranged as to permit dismantling the casing without removing the insulation.

I. Intake and Exhaust:

1. The intake air system components shall consist of a properly designed inlet housing, inlet insect screen, barrier type air filter, and an in-line sound attenuating device, shipped loose to the project site for contractor installation. The entire system shall be constructed of 316L stainless steel suitable for coastal regions.
2. Enclosure ventilation system consisting of fans, ducts and casings, roof penetrations, curbs, supports, controls, filters, and the like.
3. Unless otherwise required by the gas turbine manufacturer, the intake system must ensure the following performance requirements:
 - a. Pressure drop in the entire air intake system; less than 4 inch of water column (with system defined from atmosphere to inlet flange of air compressor with clean filters).
 - b. Filtration efficiency: EU6 rating of 80 percent.
4. Intake Air Filter:
 - a. Intake air filtration shall be a media type combustion air filter. An intake hood and insect screen shall be provided ahead of the filter to arrest larger objects and to ensure a smooth air entry into the filter assembly. The air filter housing shall be designed for outdoor installation although it will be installed indoors.
5. Inlet Silencer:
 - a. A combustion air inlet silencer shall be provided. The silencer section shall be located following the inlet air filters. The silencer shall consist of an adequate number of acoustical baffles. All materials shall be selected by the Manufacturer and are to be of a high quality intended for long service life.
6. Exhaust Expansion Joint (Bellows):
 - a. An expansion joint of suitable design shall be provided between the gas turbine and the exhaust duct system to compensate for differential thermal movement between the two and to isolate vibration and load transfer.
 - b. The joint shall consist basically of stainless steel (type 321) liner plates and bellows. The design life of the complete expansion joint assembly shall equal or exceed that of the exhaust system installation. However, the expansion joint shall be of such design as to permit easy replacement of the flexible component and external insulation at site by others.
7. The exhaust system shall be designed to meet the maximum exhaust temperature and minimize stress due to thermal expansion.
8. Cooling of the turbine shall be accomplished by the use of forced air to obtain long service life at the desired temperature levels required for high performance. Suitable instrumentation and control shall be provided to maintain an efficient air-cooling system without excessive air temperature or reduction in airflow. All air handling circuits shall have suitable drain valves at their lowest points.

J. Motor Start System:

1. An inverter motor starter equipped to the main reduction gearbox shall be provided to start the gas turbine. The starting system shall be mounted on the main reduction gearbox.
2. The unit is controlled during the starting sequence by the turbine unit control panel.
3. The starting system shall permit cranking over extended periods as may be required for water wash or purge cycle.

K. Turning System:

1. A turning device is required to rotate the turbine shaft slowly, for a period of not less than 10 hours after shutdown to allow uniform cooling of the turbine shaft.
2. The 10-hour turning period is controlled automatically the PLC.

L. Reduction Gearbox:

1. The reduction gearbox used with the turbine generator shall be of proven design, rugged, industrial type and specifically designed for continuous operation at output speeds of 1800 rpm.
2. The reduction gearbox shall be of high efficiency (above 95.0 percent) epicyclical design, and lubricated with oil from the turbine lubrication system.
3. The gearbox shall include accessory pads to accommodate the starter, and lubricating oil pump.
4. Pressure-lubricated journal bearings shall be dual split-sleeve, oil lubricated type design, constructed of centrifugally cast tin based Babbitt on bronze or steel backing shall be provided to support all rotating shafts. However, the low speed output shaft shall be mounted on anti-friction ball bearings.
5. All gearing shall be totally enclosed in a cast iron or fabricated steel housing, dust and oil proof. The gear case shall drain directly to the main lube oil tank and be provided with a drain and all other features as required. An oil level gauge, fill vent, and dipstick shall be part of the lube oil tank.
6. The gearbox shall be capable of transmitting the maximum power developed by the set under any working conditions of operation via a shear coupling between the gearbox and generator. The couple shall be designed to shear at approximately four times the nominal loading when there is a generator fault loading. After failure coupling shall be repaired by installing new shear bolts. Gearbox shall be rated in excess of AGMA design factors for generator applications and be capable of withstanding 10 percent over speed under short-circuit conditions.
7. Service factor for gearing shall not be less than 1.1. Gearbox design shall be in accordance with AGMA 420 and 421, as applicable.
8. Gearing shall be designed for 100,000-hour gear life with 30,000 hours between major inspections.

M. Couplings and Guards:

1. The turbine engine, gearbox and driven generator shall employ couplings, which ensure compatibility between equipment. The high-speed coupling between the gas turbine and speed-reducing gearbox shall be a sun gear type or equal. The low speed coupling between the gearbox and electrical generator shall be a flexible diaphragm type with shear bolts.
2. Coupling guards shall be provided to protect personnel against accidental contact with rotating parts.

N. Fuel System:

1. The engine shall be supplied with a fully automatic fuel system, for operation on natural gas and or liquid fuels.
2. A strainer in the gas supply line shall be provided loose and installed by others. Natural gas shall be pipeline quality with heating value as specified herein.
3. Fuel Gas Specification.
 - a. Acceptable fuel quality specifications are defined as follows:
Temperature range: 32 Deg. F to 176 Deg. F (0°C ~ 80°C)
Lower heating value (LHV): Refer to paragraph 2.1.A in this Specification Section.
All particulate must be ≤ 10 micron in size.
Neither water nor liquid hydrocarbons are permitted.
Oil carryover from the fuel gas compressor must be ≤ 5 -ppm wt.
In addition, follow restrictions in item 4 above.
Pressure requirement: 199 to 206 psig at the inlet port of the fuel control valve.
4. A flow meter, for measuring of instantaneous and totalized gas flow (by PLC), for installation in the gas supply line to the gas turbine is included under Section 25 60 00- CHP Control System. Installation shall be provided as part of section. The flow meter shall have outputs for remote indication at the turbine control panel. The gas flow should be pressure and temperature compensated. Manufacturer shall specify meter requirements and provide as an optional price within their proposal. Primary and secondary shut off valves shall be provided and are to be automatically controlled by the Manufacturer's control system. Gas flow control valves shall be supplied and will receive a demand signal from the turbine governing and control system. A complete piping system consisting of piping, valves and fittings and any additional equipment required for the completeness of this system shall be provided.
5. On-Skid Fuel System Components:
 - a. The following on-skid fuel gas system components are provided:
 - 1) Ignition system.
 - 2) Fuel gas manifolds.
 - 3) Low gas fuel pressure switch.
 - 4) Piping to skid edge.

- 5) Main gas shut-off valve.
 - 6) Primary gas shut-off solenoid valve.
 - 7) Fuel control valve.
 - 8) Deleted (Add#01)
 - 9) Deleted (Add#01)
 - 10) Burner shut-off valve.
 - 11) Supplemental gas fuel control valve.
 - 12) Safety shut off valve.
 - 13) Emergency open valve.
 - 14) Emergency shut off valve.
6. Block and Bleed Valves:
- a. Block and bleed (vent) valves shall be supplied loose for field installation off-skid in the fuel gas supply piping.
7. A complete piping system consisting of piping, valves and fittings and any additional equipment required for the completeness of this system shall be provided. Coordinate with Section 23 12 34 - FUEL GAS COMPRESSOR. Provide a minimum of two lower exposure limit (LEL) detectors for gas sensing in the Cogen Building, and coordinate interface with shut down controls for turbine and compressor. (Add#01)

2.4 EMISSION CONTROLS

- A. Lean Burn Dry Low NO_x Combustor:
1. The Dry Low Emmissions (DLE) system is designed to achieve low NO_x emissions. Gas fuel and air are mixed before flowing into the combustor. CO and UHC unburned gases shall be reduced through supplementary combustion.

2.5 LUBE OIL SYSTEM

- A. A common pressurized lubrication oil system shall be provided for the gas turbine generator set to supply oil at the required pressure to the gas turbine, compressor, shaft driven gearboxes, coupling(s), governing system and all other equipment and/or systems that require forced lubrication.
1. The system shall include, but not be limited to the following:
 - a. A main lubricating oil pump, mechanically driven.
 - b. A motor driven pre/post lube oil pump, arranged to cut in automatically if the lubricating oil pressure falls to a preset level and during start-ups/shut-downs.
 - c. Starting and stopping of the motor driven pumps shall be automatic.
 2. Pressure gages permanently installed in the system or used for testing purposes shall be listed for compressed air service. For pressure gage requirements, see Section 220519, METERS AND GAGES FOR PLUMBING PIPING.
 3. The recommended turbine lubricating oil is synthetic base oil, complying with the following specifications:

HUE (ASTM) L 0.5

Viscosity (Cst, at 100F°(38°C)) D445	30- 39
Total Acidity (mg KOH/g) D974	≤ 0.5
Total Oil Stability Test (TOST) (Hr, 2mg KOH/g, 203°F(95°C)) D943	≥ 2500 hr.
Rotating Bomb Oxidation Test (RBOT) Value (min, 302°F(150°C)) D2272	≥ 80
Water Content (wt%)	≤ 0.1
Insoluble Matter (wt%, 0.8 micron)	≤ 0.2

B. Reservoir:

1. Lubricating oil reservoir of sufficient capacity, complete with breather, piping with flame arrestor and mist eliminator, level indicator, high/low level switches, thermostatically controlled immersion oil heaters, thermometers, temperature switches, other instrumentation as necessary, oil strainers and all other equipment/accessories to complete the system. The oil reservoir should be sized to hold the complete quantity of oil charge, and in addition to the above, it shall also be capable to supply oil for the direct AC start-up system.
2. Provide a lubricating oil reservoir, fabricated of stainless steel or rust-proof design with a permanent zinc-phosphate coating as an integral part of the base plate or other suitable location. The reservoir is equipped with an oil level sight gauge and a low-level alarm switch. A low temperature alarm switch and oil heater is available if site ambient conditions may result in oil temperature of <50 deg F.
3. The tank shall be designed and installed to allow it to be fully drainable by gravity or other acceptable means.
4. Lube Oil Filter:
 - a. Duplex filter system with manual transfer valve shall be provided. The elements shall be of disposable type with the bypass valve built into the filter element.
 - b. The filter elements are rated at 3 micron or as otherwise required by manufacturer.
 - c. Each filter element shall be contained in a steel housing with a ductile iron head lid. The lid shall be equipped with swing bolts for fast servicing.
5. A complete piping system consisting of pipes, valves, fittings and specialties shall be provided.
6. Lube Oil Cooler:
 - a. The lube oil cooler shall be an electric fan driven oil-to-air heat exchanger rated for required heat rejection and designed for operation in a maximum ambient air temperature of 104 deg F.
7. Thermostatic Valve:
 - a. Operating in conjunction with the oil cooler is a thermostatic bypass valve, which is fully open at oil temperatures less than 125 deg. F (52 deg. C) and is fully closed at oil temperatures

in excess of 149 deg.F (65 deg. C). The valve opening is proportional to the oil temperature within the 125 to 149 deg. F (52 to 65 deg. C) temperature band.

8. Oil Mist Eliminator:
 - a. The lube oil reservoir is allowed to breathe and vent. The tank operates at a negative pressure. Lube oil mist fumes are extracted from the reservoir by means of a blower fan and passed through a coalesced type filter. The separated oil drains back to the reservoir while the remaining vapor is vented to the atmosphere.
9. Lube Oil System Piping:
 - a. The majority of the system piping shall be type 304 stainless steel.

2.6 GENERATOR AND ACCESSORIES

A. Electric Generator:

1. The AC synchronous generator shall be a 4 pole, 1800 rpm (60 Hz), brush less AC generator, rated at from 480 V to 13. 8 kV and selected to enable full use of turbine power capabilities over the ambient temperature range.
2. Generator specifications are as follows (based on sea level unit):
 - a. Rating: Sufficient to get required KWe at generator terminals with power factor and efficiency corrections. Voltage 480 V
 - b. Power Factor: 0.8
 - c. Insulation: Class F (NEMA)
 - d. Connection: 3 PH
 - e. Enclosure: IP21 (IEC degree of protection provide by enclosures (IP code))
 - f. Efficiency: 95 percent at rated power and power factor
3. Bearings: The generator shall be supplied with standard bearings per generator manufacturer. The non-drive bearing shall be insulated to prevent the possibility of circulating shaft currents. A thrust bearing shall be contained in the gear box if standard with the manufacturer. XY vibration sensors or accelerometer sensors as appropriate shall be supplied on each bearing.
4. Rotor: The rotor shaft shall be constructed of high grade precision machined steel and shall carry the main field winding, the exciter armature, rotating diode assembly, and cast aluminum fan. The rotor shall be dynamically balanced to ensure minimum vibration.
5. The stator and rotor windings of the generator will have Class "F" insulation, with a temperature rise limited to that of Class "B" as per ANSI. The stator winding will be wye connected and all terminals shall be brought out into one (1) common terminal box.
6. Short Circuit Capability: The generator shall sustain at least 300 percent of the continuous rated current for 10 seconds under

conditions of a 3 phase symmetrical short circuit. This will provide adequate time for selective tripping of downstream circuit breakers. As per this specification, this generator shall be designed with a 120 percent load capability above standard rating.

7. Audible noise from the generator shall be compatible with gas turbine sound emission requirements. The generator shall be an air-cooled design. The generator shall be provided with anti-condensation space heaters. There shall be two (2) embedded temperature detectors (RTD's) per phase wound into the stator for winding temperature monitoring and high temperature shutdown.

B. Excitation System:

1. The generator shall have shaft-mounted main and pilot Permanent Magnet Generator (PMG) brush-less exciter complete with series redundant diodes. The exciter shall be suitably matched to the generator field requirements for the full range of generator operation.
2. The automatic voltage regulator shall be a completely static solid-state type. The regulator shall include a reactive droop compensation circuit for parallel operation.

C. Wiring System: Gas Turbine Generator Skid

1. All skid wiring shall be factory wired and shall meet the NEC requirements. All wiring shall be labeled.
2. Power Wiring: The generator output power wiring shall be terminated by Manufacturer in a separate dedicated junction box for external cable connections. Details of the connection between the generator output and this junction box shall be provided by Manufacturer. The junction box arrangements shall be finalized with the Resident Engineer designee for coordination with the external cabling. This box shall be top-entry with rear lead entry for the field connection of the generator output feeder. The junction box shall be of suitable size and construction to house the power cable splices and supports, differential relaying CT's, and CT connection wiring.
3. Control and Instrumentation Wiring: All control wiring, requiring external connections shall be terminated in a terminal box.
4. Generator Lead: Generator phase side power leads shall be terminated to a suitable terminal box for connections to Purchaser's shielded solid dielectric insulated copper cables. Current transformers shall be provided on the generator neutral side for generator differential protection. Current transformer secondary leads shall be brought out to suitable shorting type terminal blocks in dedicated CT terminal box for connection to respective relays.

D. Grounding:

1. Provision for connection to the ground grid via Purchaser's cables using standard NEMA two or four hole lugs shall be made on each of the gas turbine generator skids, at minimum two (2) copper or stainless steel ground pads at diagonally opposite locations. Low resistance grounding connection from skid to all electrical equipment mounted on the skid shall be provided with the skid.

E. Generator Surge Protection:

1. Surge capacitor and lightning arrestors shall be provided by the Manufacturer for the generator. This equipment shall be mounted on the TG skid. The rating shall suit the generator requirement with allowance for low resistance grounding of the neutral point.

F. Current Transformers:

1. The CTs shall be used for generator winding differential relay protection. The differential CT characteristic shall match with that of the CT at switchgear end and type of relay. The size of the CT lead shall be a minimum 10 AWG and the route length shall be a maximum of 300 feet (one way). Three CT's shall be mounted in the generator neutral terminal box. Three matching CT's shall be shipped loose to switchgear Manufacturer for installation in switchgear by switchgear Manufacturer.

G. Neutral Grounding Resistors:

1. Neutral grounding resistors shall be suitable for indoor or outdoor service and shall be mounted on permanent structures. The resistors shall be used to ground the combustion turbine generator winding neutrals and will be located adjacent to the turbine generators.
2. Provide ground current transformers as required or shown on the Single Line Diagram.
3. Resistor units shall be edge wound-type constructed of stainless steel with welded connections between units. The edge wound helix strap shall be wound around a refractory core reinforced by longitudinal steel supports. Each resistor element shall be individually supported at each end by ceramic insulators and shall be designed to permit thermal expansion.
4. The frame assembly for edge wound resistor units shall be constructed of corrosion resistant hot-dipped galvanized angle. All members shall be assembled using outdoor hardware and be of sufficient strength to withstand severe mechanical stress.
5. The grounding resistor shall be provided with a screened safety enclosure. It shall be suitable for indoor or outdoor pad mounting.
6. The neutral grounding resistor shall be provided with an outdoor safety enclosure. The enclosure will have a solid top, screened bottom, louvered or screened side covers, and top mounted eye-bolts for handling ease. The enclosure finish will be mill galvanized or ANSI 61 Gray unless otherwise specified. The enclosure will have 8-inch legs unless otherwise specified.
7. The resistor will consist of stainless steel stamped grid elements, double insulated. The resistor terminals must be stainless steel. All resistor end- frames, hardware, and non-current carrying spacers must be zinc plated steel. If more than one resistor frame is required, series connections must be solid copper bus. The resistor bank or banks will be mounted on porcelain standoff insulators with a rating equal to or greater than the line-to-voltage.
8. Resistor banks must be completely insulated from ground. No transit-type materials will be part of the resistor bank.

9. Neutral grounding resistors must be delivered to the job-site completely assembled and ready for installation.
10. The neutral grounding resistors shall be provided with an aluminum nameplate which shall be riveted to the exterior of the enclosure. Furthermore, each resistor bank must be identified with an aluminum nameplate riveted to the resistor bank end-frame.
11. Accessories to be provided.
 - a. Base insulators.
 - b. Entrance bushings and terminal lugs.
 - c. 90-inch high stand for floor mounting.
 - d. Open type frame.
 - e. Frame with cover and screen.

2.7 ACOUSTIC ENCLOSURE

A. Enclosure Construction:

1. The enclosure shall be fitted over the gas turbine, gearbox, and generator and mounted on the base plate.
2. The enclosure shall be constructed of a mild steel framework with doors and panels also constructed of mild steel.
3. The enclosure panels shall contain a sound absorbing material, which is retained by perforated sheet steel on the inside. Efficient seals are used to contain noise and prevent the entry of rain or dust. The material shall meet the applicable codes for smoke and fire rating.
4. The enclosure shall be completely primed and all exposed surfaces finish painted.
5. An integral lifting beam shall be provided to facilitate turbine maintenance.
6. Design of the enclosures and all electrical components housed in them shall be according to their respective hazard zone classifications, e.g., Class 1, Division 2 (Contractor shall confirm).
7. The enclosure shall be designed to accommodate inlet and exhaust ducting, all piping interconnections, ventilation ducting and shall be fitted with access doors and internal lights. Each door shall be equipped with a key-lock type latch.

B. Acoustic Design:

1. The enclosure is designed to attenuate the base plate mounted equipment to an average package noise level of 85 dB(A) at 3 feet (1 meter) from the enclosure and at a height of 4 feet (1.2 meters) above ground, in free field conditions.

C. The enclosure shall be equipped for mounting of a hoisting trolley of suitable capacity for removal of gas turbine components for maintenance. An external extension of maintenance frame trolley rail shall also be included.

D. Ventilation Air System:

1. The enclosure shall include a ventilation system to remove heat from the equipment when operating and to maintain the area classification. The system shall include A.C. electric motor driven fans, fire dampers, and a flow switch to assure continuous airflow through the enclosure. The turbine start sequence shall be inhibited when the ventilation fan is not running, and an interruption in the airflow through the enclosure will cause the turbine to alarm and shut down.
2. Cooling air shall be drawn into the enclosure with the A.C. driven induced draft fans and exhausted through a silenced opening at the engine end of the enclosure. If sections are separated from each other each compartment shall be supplied with its own ventilation system and CO2 fire dampers.
3. The ventilation system shall be designed to operate during normal operating conditions and when the combustible gas monitoring system detects hazardous conditions.
4. The ventilation discharge air shall be ducted to the outside of the enclosing building.

2.8 COMPRESSOR WASH SYSTEM

- A. A water wash system shall be provided for periodic cleaning of the compressor section for continued efficient operation of the gas turbine unit. The water wash system shall be suitable for both crank-soak wash and running wash operations. Necessary tank, pump, valves, etc., shall be mounted on a portable tank cart. Wash water connection between the cart and the skid shall be by a flexible hose with quick-disconnect couplings.
- B. Information on quality and quantity of water and detergent chemicals needed for water wash operation shall be provided by the Manufacturer. Water and detergent is provided by others.
- C. On-Skid Equipment:
 1. Two fine spray nozzles are located around the compressor inlet. The nozzles shall be piped to a quick connect cleaning fluid supply connection on the turbine skid. Drain lines with manual valves shall be piped from low points in the engine casing to a waste water tank located on the turbine skid.
- D. Piping shall be 316 stainless steel with compatible fittings for application.

2.9 FIRE AND GAS PROTECTION SYSTEMS

- A. Fire Protection system (Refer to Section 21 21 13.13 - HIGH PRESSURE CARBON DIOXIDE FIRE EXTINGUISHING SYSTEMS).
 1. The fire protection system shall be specifically designed for use on an acoustically enclosed, industrial gas turbine generator set. It shall be a completely automatic detection and extinguishing system with provision for manual release of the suppression agent. The system consists of both flame and thermal detectors. If a fire is

detected, audible and visual alarms are activated and the CO₂ agent release sequence will be activated. The enclosure ventilation louvers close when extinguishing is released to maintain the suppression agent concentration inside the enclosure.

2. All detector circuitry wiring to valves, detectors and pull stations shall be supervised. Any 'open' circuit is detected and displayed as a "FAULT" condition. This ensures the continuous integrity of all components necessary to the system.
3. The extinguishing system shall be designed to provide a CO₂ concentration of 50 percent within the enclosure and is designed in accordance with NFPA 12.
4. The CO₂ agent bottles may be mounted off-skid.

B. Fire Detection:

1. The fire detection system shall consist of IR flame detectors and thermal detectors located at strategic locations inside the acoustic enclosure.
2. The type IR flame detector shall monitor a minimum of three IR band channels. Only detection of radiation emissions matching the spectral fingerprint of fire shall produce an alarm, making this unit highly immune to false alarms.
3. The thermal detectors shall be a rate compensated design, combining the best features of both fixed temperature and rate-of-rise detectors. This design shall allow a fast response to an overheat condition, while being far less likely to cause false alarms due to transient thermal conditions than standard rate-of-rise detectors

C. Fire Extinguishing Piping:

1. A fully piped discharge system shall be provided with spray nozzles located inside the upper part of the acoustic enclosure. The pipe work shall be terminated on the enclosure with a flanged connection for connection to the off-skid CO₂ bottles.

D. Additional Equipment:

1. The following items are also provided:
 - a. Manual discharge station (outside enclosure).
 - b. (2) Alarm horn/strobes (outside enclosure).
 - c. (1) Alarm horn/strobes (inside enclosure).
 - d. CO₂ protected area signage.

E. Gas Detection System:

1. A combustible gas monitoring system shall be provided for the gas turbine enclosure.
2. A warning alarm shall be initiated if the gas concentration level reaches 20 percent LEL (lower explosive limit). If the concentration reaches 40 percent LEL, the unit is shutdown and the gas supply to the skid is shut-off.

2.10 BATTERY SYSTEM

- A. Provide control battery system to supply D.C. 100 to 120 V power for operation of the turbine control logic and operation of the pre-post lube oil pump.
- B. Provide NI-Cad or sealed, lead-acid batteries. The batteries shall be in a NEMA 1 floor standing cabinet, which also contains the battery charger.
- C. Input to the battery charger is 120/240 V 60 Hz single-phase powers.
- D. The battery charger shall be solid-state charger designed to float charge nickel-cadmium, and lead-acid batteries of the vented and valve regulated types. The charger is integrated into a floor standing NEMA 1 rack that is mounted off skid and indoors.
- E. Some features of the battery charger are:
 - 1. AC input circuit breaker.
 - 2. DC output circuit breaker.
 - 3. AC and DC surge suppressors.
 - 4. Automatic current limiting.
- F. The battery system shall be designed to support the turbine control system, emergency lube oil pumps and turning gear motor.

2.11 TURBINE-GENERATOR CONTROL SYSTEM

- A. Unit Control Panel Arrangement:
 - 1. The unit control panel shall be a floor standing or wall mounting cabinet off-skid designed for front access and suitable for indoor installation in a non-hazardous area.
 - 2. The control system shall provide for turbine engine control and protection, turbine speed control, fault monitoring, alarm annunciation, vibration and temperature monitoring. Generator excitation metering winding and bearing temperature shall be also provided.
- B. Turbine Control System:
 - 1. Programmable Logic Controller (PLC): The PLC based control system shall utilize a platform is a state-of-the-art, flexible, industrial-hardened system designed to withstand the vibrations, thermal extremes, and electrical noise associated with harsh industrial environments. The control system shall consist of a main PLC rack located in the turbine-control panel, and a remote I/O rack located in the gas turbine generator package. The remote I/O rack communicates with the main rack over a cable link. A PLC processor is plugged into the main I/O rack. The processor controls the gas turbine engine, and package auxiliary devices.
 - a. Start and stop sequence control: When the operation command (i.e. start/stop/purge) is provided, the PLC automatically controls

operation of the fuel valves, pumps and starting devices in the correct sequence to start or stop the engine.

- b. Engine safety devices: The PLC supervises the status of the turbine and each auxiliary system, then provides an alarm signal or trips the engine as conditions dictate.
- c. Acceleration, fuel control and speed governing: When starting the engine, the PLC not only controls acceleration of the engine but also prevents surging. It controls the fuel valve to reduce the thermal stress due to the sudden temperature rise. During steady state operation the PLC provides either droop or isochroous speed governing, depending on the application.
- d. Load control: When the generator is operating in parallel with the utility or with another generator or when the generator supplies the power only (Islanding operation) the following load controls are automatically performed by the PLC.
 - 1) Load transfer and parallel off control.
 - 2) Constant generator output power control.
 - 3) Constant turbine inlet temperature control and mechanical load limit.
 - 4) Constant import power control.
 - 5) Control of generator output.
 - 6) Constant frequency control under non-parallel operation.

2. Turbine Status Display:

- a. A Human Machine Interface (HMI) shall be provided which allows the operator to monitor most vital parameters in the system. The following information is displayed in the English language.
 - 1) Turbine speed.
 - 2) Exhaust gas temperature.
 - 3) Inlet air temperature.
 - 4) Lube oil supply temperature.
 - 5) Lube oil pressure.
 - 6) Enclosure exhaust flow switch.
 - 7) Combustion intake air filter differential pressure.
 - 8) Compressor discharge pressure.
 - 9) Compressor discharge temperature (optional).
 - 10) Governor output.
- b. Generator operating data is also displayed on the HMI. This is in addition to the electrical metering panel. The following parameters are displayed.
 - 1) Generator amps.
 - 2) Generator volts.
 - 3) Frequency.
 - 4) Power factor.
 - 5) kW/kVAR.

3. Turbine Controls and Status on HMI:
 - a. Turbine operator controls on HMI.
 - 1) Alarm silence.
 - 2) Reset.
 - 3) Turbine stop.
 - 4) Turning motor start.
 - 5) Turbine purge.
 - 6) Emergency stop push-button (hard wired).
 - 7) Engine operating mode selector.
 - b. HMI provides the following conditions:
 - 1) D.C. control power on.
 - 2) Turbine ready to start.
 - 3) Turbine start sequence on.
 - 4) Turbine running.
 - 5) Turbine stop sequence on.
 - 6) Turbine in cool down cycle.
 - 7) Turning motor running.
 - 8) Engine purging.
 - 9) System in auto.
 - 10) System in manual.
4. Vibration Monitoring:
 - a. A vibration monitoring system shall be provided to protect against unacceptable vibration levels in the turbine, main reduction gear, and generator. Vibration levels, warning and trip indications are displayed on the HMI.
 - b. The gas turbine engine shall be provided with a non-contact proximity probe at the turbine shaft to monitor turbine shaft vibration.
 - c. The reduction gearbox, and the electrical generator shall be each fitted with an accelerometer type sensor on the gearbox casing, and each generator bearing.
5. Turbine Control System Operation:
 - a. Start/stop sequencing: The system shall be designed to automatically control the starting and stopping of the turbine generator from a single operator command on the HMI. The system shall include all the interlocks necessary for lubrication and fuel systems to provide safe and reliable operation. The starting and stopping sequence also covers the purging of the acoustic enclosure by the ventilation system.
 - b. Pre and post lubrication control: The system shall be designed to automatically control the sequence of the pre-post lube pump during starting, stopping and cool down to ensure safe operation of the turbine generator.
 - c. Over speed protection: The PLC shall provide over speed protection of the rotating assembly by logic circuits. If engine speed exceeds 110 percent the engine protection logic shall

shutdown the engine. The over speed protection circuit shall use a magnetic pick-up speed sensor.

d. Speed governing:

- 1) Speed control shall be either droop or isochroous. In droop governing the speed droop control biases the speed schedule to decrease, proportional to the increase in load applied to the generator. Normally the speed droop is set to equal 3 percent at full rated load.
- 2) In isochroous governing, the PLC controls the engine speed to match the preset speed reference, by automatically modulating the speed command signal, allowing operation at any load with a zero steady state speed error.
- 3) Changeover from droop to isochroous shall reset the speed demand to give a bump less transfer at constant achieved speed. An interlock is provided to prevent inadvertent isochroous governing when the engine is in parallel with the utility.
- 4) The governing shall provide 0.5 percent maximum drift, \pm 0.25 percent stability at steady state, and 3 percent maximum droop no load to full load.

e. Power limit: This is a maximum limit to prevent excessive loads, particularly at low intake temperatures where the temperature limit would not prevent excessive power to be generated. The power limit is a maximum fuel valve position, which is a function of intake temperature.

f. Temperature limit: The temperature limit shall be a maximum set level to prevent engine over temperature. It is calculated as a function of exhaust gas temperature (EGT).

g. Temperature monitoring: Turbine temperatures shall be measured by thermocouples mounted on the engine exhaust duct. The control system uses multiple thermocouple signals to compute an accurate operating temperature and to assess the combustor performance, thereby assisting users to optimize turbine operation and obtain maximum life. Digitally set limit functions are built in to provide alarms on engine malfunction.

h. PLC/failure protection: The PLC employs a "watch dog" system, which consists of a re-trigger able logic circuit with a specified time-out period to detect a CPU failure. If the time between triggers is ever greater than the time-out period, the watchdog trips and the turbine is shutdown.

2.12 GENERATOR PROTECTION AND CONTROL

A. HMI Display Metering:

1. The following analog metering shall be provided. All metering shall be 1 percent class. Shall display the following information:
 - a. Generator volt.
 - b. Generator ampere.
 - c. Generator frequency.
 - d. Power factor.
 - e. Kilowatts.

f. Generator vibration levels.

B. Generator:

1. The PLC shall provide protection, metering, and monitoring functions for generator.
2. The PLC provides comprehensive generator AC protection.
3. The PLC shall have inputs for monitoring generator stator RTD's, providing thermal protection of the generator during running overload conditions.
4. The PLC shall have inputs for monitoring generator drive end and non-drive end bearing RTD's and vibration providing protection against bearing over temperature and high vibration.
5. The PLC shall be provided with complete metering functions. These shall include:
 - a. Current.
 - b. Voltage.
 - c. Power: kW, kvar, kVA.
 - d. Energy use: MWh, Mvarh.
 - e. Power factor.
 - f. Frequency.
6. The PLC will monitor the following and report any failures:
 - a. Breaker failure detection.
 - b. Trip coil supervision.
 - c. Voltage transformer fuse failure.
 - d. Self-test (both on power-up and during operation).

C. Operator Controls on HMI:

1. The following controls shall be provided on the HMI:
 - a. Voltmeter phase selector.
 - b. Ammeter phase selector.
 - c. Voltage raise/lower.
 - d. Frequency raise/lower.
 - e. Breaker control.

D. Synchronizing Controls:

1. For applications requiring parallel operation with the utility grid or other generator sets, synchronizing controls shall be provided. The control system will shall allow either automatic or manual paralleling.
2. The standard unit shall be configured for parallel operation with the utility grid and shall include the following equipment:
 - a. Microprocessor based automatic synchronizer.
 - b. Synchronizing check relay.
 - c. VAR/power factor controller.
 - d. Synchronizing manual off-auto control switch.

- e. Synchroscope.
- f. Bus voltmeter.
- g. Bus frequency meter.

E. Alarm and Shutdown Functions:

1. Turbine and Gearbox:

Description	Alarm (Indication Only)	Shutdown (Indication and Trip)
Abortive Start		X
Flameout		X
Misfiring		X
Overspeed		X
High Lube Oil Temperature	X Grade1	X Grade 2
Low Lube Oil Pressure	X Grade1	X Grade 2
High Exhaust Gas Temperature	X Grade1	X Grade 2
Lube Oil Filter Differential Pressure	X Grade1	X Grade 2
Emergency Stop		X
Gas fuel low pressure		X
Gas compressor failure		X
ESV Close		X
EOV open		X
Gen set fire		X
Auxiliaries fail		X
Low Oil Level	X	
Low Pre/post Lube Oil Pressure		X
Gas turbine power degradation	X	

2. Vibration Monitoring:

Description	Alarm (Indication Only)	Shutdown (Indication and Trip)
Turbine Shaft Vibration	X Grade1	X Grade2

3. Generator:

Description	Alarm (Indication Only)	Shutdown (Indication and Trip)
Generator Over voltage		X
Generator Under voltage		X
Stator Winding Temperature		X
Drive End Bearing Temperature		X
Non Drive End Bearing Temperature		X
Generator bearing Vibration	X Grade 1	X Grade 2

Generator Over current	X	
Generator Reverse Power	X	
Generator Ground Fault Over current	X	
Grid fail	X	
Auto synchronous fail	X	

4. Control System:

Description	Alarm (Indication Only)	Shutdown (Indication and Trip)
Control power failure		X
PLC Failure		X
Sensor Fail	X	
D.C. battery liquid low level	X	
Display fail	X	
Fire System Malfunction		X

5. Fuel System:

Description	Alarm (Indication Only)	Shutdown (Indication and Trip)
Low Fuel Gas Pressure		X
Gas fuel leak	X Grade 1	X Grade 2

6. Ancillary Systems:

Description	Alarm (Indication Only)	Shutdown (Indication and Trip)
Turning motor power fail	X	
Enclosure Ventilation Fan Failure		X
Auxiliaries fail	X	
Air inlet filter pressure differential high	X	

F. Control System Additional Components:

1. In addition to the visual display screen located in the unit control panel, remote monitoring shall be done through the FMCS. This system has the following standard features:
 - a. Color graphic screens to reflect the real-time operating status of the gas turbine generator set.
 - b. Alarm messages.
 - c. Alarm and event logging.
 - d. Real-time and historical trend charts.

2. A network interface shall be provided to allow interfacing the turbine control system with other reporting and monitoring systems.

PART 3 - EXECUTION

3.1 CLEANING, PACKAGING AND TAGGING

- A. All equipment, vessels, components and subassemblies shall be thoroughly cleaned of all water, sand, grease, oil and other foreign materials prior to shipment.
- B. All flanged openings shall be covered with 3/8" thick plywood flange protectors; threaded openings shall be protected with plastic end caps or plugs.
- C. All caps, plugs and flange covers shall be sealed with tape to provide a dust-tight closure.
- D. The equipment shall be suitably skidded, tarped, sealed or otherwise protected from damage during shipment.
- E. Each separate shipping crate, box or skid shall be clearly and indelibly labeled with Project No., P.O. No. and equipment No. Letters shall be a minimum of 1 inch high.
 1. At a minimum the nameplate shall contain the following information:
 - a. Equipment part number.
 - b. AGREEMENT number and date fabricated.
 - c. Manufacturer's name.
 - d. Manufacturer's model number and serial number if applicable.
 - e. Equipment data: Maximum working pressure and temperature, operating, volume, etc.
 2. All information shall be embossed on the nameplate or otherwise permanently affixed.
- F. The cleaning and packaging requirements of this section are minimum standards to be followed. Manufacturer shall submit written recommendations for field storage, both indoor and outdoor.

3.2 PAINTING

- A. Painting shall be per Manufacturer's Standard Paint Specification ES9-58. Color to be Manufacturer's standard. Manufacturer shall include a suitable amount of paint for each finish coat for field touch-up work.

3.3 INSTALLATION

- A. Install concrete of dimensions shown on the drawings.
- B. Installation of the gas turbine generator shall comply with manufacturer's written instructions and shall comply with NFPA 110 and NFPA 37. Installation including delivery to project site, un-crating, storage,

protection, lifting and setting, all mounting, external and internal connections start-up, check-out, testing and commissioning shall be personnel provided by the manufacturer or by factory authorized installers and technical.

C. Mounting:

1. Support the base of equipment pads generator on concrete equipment pad, each bolted to the pad per requirements delineated on structural drawings and specifications.

D. Install piping between gas turbine generator and remote components of cooling, fuel, and exhaust systems.

E. Connect all ducting required for ventilation.

F. Exhaust System Insulation:

1. Adhesive and insulation materials shall be applied on clean, dry surfaces from which loose scale and construction debris has been removed by wire brushing.
2. Fill all cracks, voids, and joints of applied insulation material with high temperature 2000 deg F insulating cement before applying the outer covering.
3. The installation shall be clean and free of debris, thermally and structurally tight without sag, neatly finished at all hangers or other penetrations, and shall provide a smooth finish surface.
4. Insulation and jacket shall terminate hard and tight at all anchor points.
5. Insulate completely from engine exhaust flexible connection through roof or wall construction, including muffler.

G. Visual Inspection: Visually verify proper installation of gas turbine generator and all components per manufacturer's pre-start installation checklist.

3.4 TESTING AND TRAINING

A. Furnish all natural gas, lubricating oil, liquid, water treatment, and other consumables required for testing.

B. The gas turbine shall be tested at the factory on gas fuel. The following tests shall be performed:

1. Visual inspection for leakage of fuel, lube oil and air.
2. Trim adjustments to control and operating parameters.
3. Motoring.
4. Shaft vibration.
5. Performance test, at various loads.
6. Cycle test (no load to full load and return to no load).

- C. During testing the operational limits shall be checked for the following functions:
 - 1. Rotating speed.
 - 2. Exhaust temperature.
 - 3. Flame detection.
 - 4. Start-up time.
 - 5. Acceleration and deceleration.
 - 6. Lubricating oil temperature and pressure.
 - 7. Vibration.
 - 8. Rotor position.
 - 9. Bearing temperature.
 - 10. VSV angle.
 - 11. Compressor pressure ratio.
- D. The generator shall be factory tested by the generator manufacturer standards:
 - 1. Cold winding resistance.
 - 2. Insulation resistance.
 - 3. Voltage balance.
 - 4. No load losses.
 - 5. High potential test.
 - 6. Phase sequence test.
- E. The turbine generator skid package shall be factory tested at gas turbine generator's manufacturing facility. The factory test shall include:
 - 1. Visual inspection.
 - 2. Insulation resistance check.
 - 3. Protection system check (partial).
 - 4. Start/stop sequence check.
 - 5. Mechanical running test.
 - 6. Load tests.
 - 7. Witnessing by VA and design engineer of record.
- F. Commissioning Tests: The manufacturer shall provide the appropriate number of trained field service technicians to perform field verification of the installation and to perform on-site start-up, performance verification and training.
 - 1. Inspection of the installation.
 - 2. Insulation resistance measurement.
 - 3. Protection system check.

4. Protection relay simulation check.
5. Start/stop sequence check.
6. Governor test and adjustment.
7. Parallel operation test.
8. Load test with actual site load, or load banks (provided by others).
9. Coordinate with Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS.

- G. Training: Unit familiarization, maintenance, and operating training for VA's maintenance personnel shall be done during the commissioning period stated above.

3.5 OPERATION AND MAINTENANCE MANUALS

- A. Manuals shall contain a minimum of the following items individually sectioned and referenced with an index:
1. Title page with set description and reference project name.
 2. Table of contents.
 3. Test reports.
 4. Generator set operating instructions.
 5. Engine operation/maintenance manual.
 6. Engine illustrated parts catalogue.
 7. Generator operation/maintenance manual including parts list.
 8. Voltage regulator equipment manual.
 9. Unit accessory equipment descriptive brochures and applicable instructions.
 10. Control panel component brochures.
 11. 4 sets 'As Built' mechanical drawings.
 12. 4 sets 'As Built' electrical drawings.

3.6 PRESERVATION AND SHIPPING

- A. After completion of factory testing at manufacturing facility, the gas turbine package shall be shipped to the site. All openings shall be suitably sealed to prevent entry of dirt, vermin, etc. The equipment shall be preserved for the transit period to the site only (short term preservation).

3.7 CONSTRUCTION WASTE MANAGEMENT

- A. General: Comply with Contractor's Waste Management Plan and Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.
- B. To the greatest extent possible, separate reusable and recyclable products from contaminated waste and debris in accordance with the Contractor's

Waste Management Plan. Place recyclable and reusable products in designated containers and protect from moisture and contamination.

3.8 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specifications will be tested as part of a larger system. Refer to Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS and related sections for contractor responsibilities for system commissioning.

- - - E N D - - -

(Add#01) 18 SEP 2013, Addendum No. 01

(Add#02) 07 OCT 2013, Addendum No. 02

SECTION 26 57 00

CONTINUOUS EMISSIONS MONITORING SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Performance.
- B. General Design.
- C. Continuous Emissions Monitoring System and Auxiliaries:
 - 1. NOx Analyzer.
 - 2. CO Analyzer.
 - 3. O2 Analyzer.
 - 4. Sample Probe and umbilical.
 - 5. Sample conditioning system.
 - 6. Data acquisition system.
 - 7. HMI interface.
 - 8. Remote terminal PC.
 - 9. Console enclosure with air conditioner.
 - 10. Span and zero gas systems.
- D. Cleaning, Packaging and Tagging.
- E. Painting.

1.2 RELATED DOCUMENTS

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- C. Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT: Procedures and requirements for managing and disposing construction and demolition waste.
- D. Section 01 81 11.01, SUSTAINABLE DESIGN REQUIREMENTS: Sustainable design requirements including submittal requirements.
- E. Section 01 910 0.01, GENERAL COMMISSIONING REQUIREMENTS: Requirements for commissioning, systems readiness checklists, and training.
- F. Section 23 52 35, HEAT RECOVERY STEAM GENERATOR.
- G. Section 25 60 00, CHP PLANT CONTROL SYSTEM.

H. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

I. Section 26 32 14, COMBUSTION TURBINE GENERATOR.

1.3 SCOPE OF WORK

- A. Provide one (1) Continuous Emissions Monitoring (CEM) System in accordance with the requirements contained within this Specification.
- B. Sole responsibility for the design, procurement of materials and components, fabrication, inspection and testing, delivery, and guarantee of the performance of the equipment.
- C. The continuous emissions monitoring system (CEMS) specified herein is part of an integrated 'co-generation' or combined heat and power (CHP) system consisting of the CTG, the Heat Recovery steam generator (HRSG), the CHP control system, the natural gas compression system, and the continuous emissions monitoring system. Refer to packaging and single source responsibility requirements in Section 26 32 14, Combustion Turbine Generator for specifics.

1.4 WORK INCLUDED

- A. Provide one Continuous Emissions Monitoring (CEM) system designed for proper monitoring of stack emissions for a cogeneration arrangement of a natural gas fired combustion turbine generator and a watertube Heat Recovery System Generator (HRSG). Each HRSG features a Selective Catalytic Reduction system and a CO oxidation catalyst. Each system shall include, as a minimum:
 - 1. Analyzer Console.
 - 2. Multi-point Stack analyzer probe with certification document.
 - 3. Heated Sample Umbilical.
 - 4. Sample filtering system.
 - 5. Sample conditioning system.
 - 6. Oxides of Nitrogen analyzer.
 - 7. Carbon Monoxide analyzer.
 - 8. Oxygen analyzer.
 - 9. Automatic calibration system.
 - 10. Zero and span gas systems.
 - 11. Programmable Logic Controller system.
 - 12. Remote PC and Data Acquisition system.
 - 13. Complete programming and configuration of system.
 - 14. Analog and digital alarm systems.
 - 15. Spare I/O terminals for interface with plant Supervisory Control and Data Acquisition (SCADA) system.

16. Third party certification, RATA testing, and quality assurance of the CEMS system.

- B. Provide initial cylinders of all required calibration gasses.

1.5 UTILITIES AVAILABLE

- A. Electricity: 120V/1hp/60Hz; 208V/1ph/60Hz; 208V/3ph/60Hz; 480V/3ph/60Hz.
- B. Compressed Air: 80 psig, dry.

1.6 QUALITY ASSURANCE

- A. Shop drawings shall indicate size and dimensional requirements of the equipment as well as any required service clearances.
- B. Manufacturer shall have in effect at all times a documented Quality Assurance and Quality Control program with clearly establishes the authority and responsibility for the Work and the Quality Assurance and Quality Control program.
- C. A permanent stainless steel nameplate shall be attached to the console and shall show the following information:
 1. Manufacturer's name.
 2. Serial number.
 3. Equipment Tag No.
 4. Materials of construction.
 5. Year built.
- D. The manufacturer shall provide for inspection of the unit in accordance with the requirements of all applicable codes and this Specification. Code inspection and testing, if required, shall be by an agency authorized by the designated code or authorities having jurisdiction. Inspection shall be conducted at the manufacturer's shop.
- E. Owner reserves the right to inspect the unit during fabrication at the manufacturer's plant. Dates and times shall be mutually agreeable to the manufacturer and Owner.
- F. Inspection by Owner, or lack thereof, shall in no way relieve the manufacturer of responsibility to meet the requirements of the applicable codes and standards, as well as any applicable Federal, state and local code requirements and this Specification.

1.7 SUBMITTALS

- A. The following requirements are in addition to the general submittal requirements in Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. LEED Submittals: Submit in accordance with Section 01 81 11.
 1. LEED submittals are in addition to other submittals. If submitted

item is identical to that submitted to comply with other requirements, submit duplicate copies as a separate submittal to verify compliance with indicated LEED requirements.

2. LEED Product Data Submittal Form: Submit completed product data form provided by the Contracting Officer's Representative; certified by vendor, installer, subcontractor, and/or manufacturer as appropriate.
- C. All non-proprietary design drawings, calculations, manuals, data sheets, etc., as a minimum, shall be submitted for review and approval and certification as required. The manufacturer shall submit an initial drawing submittal schedule, identifying drawing titles and numbers within two (2) weeks from the date the Contract is fully executed. All submittals shall be submitted as follows:
1. Manufacturer shall provide three (3) standard drawing releases: "initial release," "as shipped," and "as installed."
 - a. Manufacturer to submit the "initial release" to Resident Engineer (RE) for review and comment. Submittal shall be in DXF and PDF either e-mailed, or posted to the manufacturer website or FTP site, or one CD containing general arrangement drawings, as required for plant layout equipment.
 - b. In addition, final "as shipped" and "as installed" manufacturer drawings sets to be submitted in DXF and PDF on CD; one (1) CD to Resident Engineer and three (3) CDs to Owner. Certified manufacturer drawings must be submitted for approval within a maximum of ten (10) weeks of the date the Contract is fully executed.
 2. Operating and Maintenance Manuals: Shall be provided on CD; three (3) CD to Resident Engineer.
 3. All manufacturer drawings shall have the Project name.
 4. Drawings shall show, as a minimum, the following:
 - a. Dimensions (including major component weight and center of gravity.
 - b. Indicate materials shipped loose for Contractor installation.
 - c. Define all mounting requirements.
- D. Drawing Requirements (not all-inclusive):
1. Final equipment layouts shall include arrangement drawings, issue for construction, in plan and elevation, with all major components identified. Size, type and dimensions for location tie-ins shall identify product and service tie-ins. Access clearances for service of equipment and removal of components shall also be shown. Mechanical, electrical, and any other interfaces to other systems or utilities shall be clearly identified and dimensioned, including size and type of connection. Detailed location and characteristics of all terminal points, electric connection requirements, etc. shall be provided.
 2. Elevations and sections shall be provided as necessary to show full details of tie-ins, service access, and control components.

3. Overall dimensions and detailed floor loadings shall be shown.

1.8 SUBSTITUTIONS

- A. Unless approved in advance by the Resident Engineer, there shall be no substitutions for materials or components specified or previously approved.

1.9 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.
- B. All equipment shall comply with any California state, local, or municipal laws and regulations governing the location where the equipment is to be installed.
- C. In the event of conflict between codes, standards or regulations, the conflict shall be referred to the Resident engineer for resolution.
- D. American National Standards Institute, Inc. (ANSI)/Acoustical Society of America (ASA):
1. S1.2-62(R2001) Method for Physical Measurement of Sound
 2. S1.4-83(R2001) Specification for Sound Level Meters
- E. American National Standards Institute, Inc. (ANSI):
1. IC96.1 Temperature Measurement Thermocouples
- F. American Society for Testing and Materials (ASTM)
1. D635-10 Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
- G. National Electrical Manufacturer's Association (NEMA)
1. 250-08 Enclosures for Electrical Equipment (1000 Volts Maximum)
- H. National Fire Protection Association (NFPA):
1. 70-2008 National Electrical Code
- I. Institute of Electrical and Electronics Engineers (IEEE)
1. 422-12 Guide for the Design of Cable Raceway Systems for Electric Generating Facilities
- J. Volume 40, Part 60, of the Code of Federal Regulations (40 CFR 60)

1.10 SHOP TESTING

- A. All equipment and materials furnished shall be subject to the manufacturer's standard shop tests in accordance with the code and this

Specification. Wherever not specified in said regulations, the tests shall be carried out in accordance with the standards proposed by the manufacturer and approved by the Engineer.

- B. As a minimum, the following shall be performed:
 - 1. All equipment which utilizes a working fluid, control fluid, lubricating fluid, cooling fluid, or analyzer gas, shall be leak tested, as a system, in accordance with the Manufacturers standard practices to ensure their proper operation without leakage.
 - 2. All instruments provided shall be calibrated.
- C. All devices supplied, mounted, or wired, at the factory shall be verified. Tests shall be performed using appropriated simulated inputs. All test inputs shall be applied at a point furthest from the actual device terminals to check all wiring within scope of supply. The following tests shall be performed and documented:
 - 1. Each electrical switch or switching device shall be tested in each switch position to verify conformance to the required switch development. A detailed checklist shall be used for inspection, signed by the inspector(s), and date(s) of inspection annotated.
 - 2. Functional test of all control circuits where applicable, and ground check of all housings capable of carrying current.
 - 3. Screw tightness inspection, including terminal boards.
 - 4. Megger test - unless otherwise specified, all wires within each cabinet shall be tested to ground at 500 Volt dc. Resistance shall be 20 megohms or more.
- D. Electrical shop tests shall be deemed complete only once the following prerequisites have been satisfied:
 - 1. The equipment is completely assembled in working order, and evidence is provided showing it has been inspected by the manufacturer's quality control organization.
 - 2. In-progress quality control, megger-tests and continuity tests of wiring have been completed and documentation ready for review by the Owner.
 - 3. Record drawings are available and accurately depict the as-built condition.
 - 4. A list of a test instruments with dates of last calibration including the type, model, and manufacturer is available.
- E. Perform all necessary adjustments and modifications required if shop testing identifies performance or design deficiencies.
- F. Certified copies of all shop tests and examinations shall be provided to the Engineer for record purposes. All test reports shall be countersigned by the inspecting authority where required by code.

1.11 FIELD TESTING

- A. The Continuous Emissions Monitoring System shall be tested at the jobsite by the manufacturer to ensure compliance with the performance guarantees in accordance with this Specification. Functional and continuity tests shall be performed once all external connections have been made.
- B. The Contractor shall assure that the manufacturer makes all necessary adjustments or modifications required if field testing identifies performance or design deficiencies.
- C. Certified copies of all field tests and examinations performed shall be provided to the Resident Engineer for record purposes. All test reports shall be countersigned by the inspecting authority as required by code.

1.12 SOUND AND VIBRATION

- A. All equipment provided in accordance with this Specification shall not produce a cumulative sound level in excess of 85 dBA as measured in accordance with ANSI Standards S1.2, Method for the Physical Measurement of Sound, and S1.4, Specification for General Purpose Sound Level Meter.

1.13 COMMISSIONING AND STARTUP

- A. Provide the necessary field startup services to fully commission the equipment to achieve and demonstrate the specified performance. This service shall be provided by factory trained technicians and shall include, but not be limited to, verification of proper installation and performance of all tests and procedures as stated in the startup and installation manuals.

1.14 TRAINING

- A. Provide a full and comprehensive training program to the satisfaction of the Government in which qualified manufacturer's personnel conduct a one day training seminar intended to enable Governments operations personnel to fully and efficiently operate the CEMS system. The course shall cover all aspects of inspection, maintenance, troubleshooting, and operation of all equipment provided by this Specification.
- B. The training shall be performed using a textbook prepared specifically for the CEMS system provided. The training program shall include hands on experience with the provided equipment operational during or immediately following startup.
- C. An outline of the intended training course shall be submitted to the Resident Engineer for review.
- D. The training course shall be appropriate for all levels of operations and maintenance staff such as engineer, technician, supervisor, etc. A single comprehensive course shall be provided for up to 6 people with a target duration of one day.

1.15 SPARE PARTS

- A. Have on hand and identify all spare parts, including source, cost and identification of the manufacturer and associated model number, critical to initial startup that are recommended to have on-hand to minimize unplanned construction delays or equipment downtime, as well as a standard priced spare parts list for replacement of components as needed. The manufacturer shall recommend spare parts expected for replacement during 2 years of operation.

1.16 SPECIAL TOOLS

- A. Provide one set of new special tools normally provided for the equipment proposed, for maintenance and installation.

1.17 WARRANTY ^(Add#01)

- A. Work subject to the terms of the Article "Warranty of Construction", FAR clause 52.246-21. Provide manufacturer's and installer's specialty warranty as follows:
1. Special warranty includes labor and parts for the ~~CHP-~~
~~Control~~Continuous Emissions Monitoring System free from defects for the specified warranty period. ^(Add#02)
 2. The warranty shall include, but not be limited to, the following: Labor, travel, living expenses, parts replacement, system maintenance and testing, and software/hardware updates and revisions.
 3. Work shall have a single warranty date, even if the Government receives beneficial use due to early startup.
 4. Provide updates to project-specific software and firmware that resolve installer or Government identified software deficiencies at no additional charge during the warranty period.
 5. In the event that the installer service call work causes damage to additional equipment, the installer shall be liable for labor and material to restore the system to full operation.
- B. During the warranty period, the installer shall update the software free of charge as manufacturer's software is improved.
- C. Warranty Period: Four years from the date the system is completely installed, fully operational, and accepted by the Government. The Resident Engineer representing the Government shall verify in writing that the CHP Control System has been tested and accepted in accordance with this specification. The date of acceptance shall begin the warranty period.

PART 2 - PRODUCTS

2.1 OPERATING CONDITIONS

- A. The Continuous Emissions Monitoring System (CEMS) specified herein will be used to monitor the stack emissions from the natural gas fired Combustion Turbine Generator and the supplemental fired Heat Recovery Steam Generator

featuring a Selective Catalytic Reduction System utilizing Anhydrous Ammonia as the reduction agent and a CO oxidation catalyst. The system shall be stand alone but monitored by the PLC control for the CHP system, for reporting, and shall include interface points as described herein.

- B. The analyzer console shall feature an air conditioning module and be designed for indoor installation in unconditioned space with an indoor temperature range of 0 degrees F. to 120 degrees F.
- C. All equipment provided shall be designed for installation in Seismic Design Category "F," with a system Importance Factor of 1.5. See Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS for additional seismic design criteria.

2.2 GENERAL DESIGN

- A. The Continuous Emissions monitoring System (CEMS) shall analyze and monitor the emissions of oxides of nitrogen (NOx), Carbon Monoxide (CO, and Oxygen (O2) in the exhaust stack. The system shall utilize a dry extractive process and incorporate an automatic calibration procedure utilizing EPA Protocol 1 gases.
- B. The CEMS system shall comply with EPA 40 CFR 60, Appendix B, Specification 2 for NOx and Specification 3 for Oxygen at NOx concentrations of 2.0 to 5.0 ppm.
- C. The CEMS system shall be a stand-alone system consisting of all required equipment and materials necessary to analyze, monitor and alarm.
- D. The available electrical services to supply the CEMS are identified in PART 1 of this Specification Section. Should manufacturer elect to utilize equipment utilizing a different voltage, the manufacturer shall supply the required transformer to obtain that voltage. Unless the CEMS load size is 10 kVA or less in a balanced three phase configuration, the supply voltage will be 480 volts, 3 phase.

2.3 SAMPLING PROBE AND UMBILICAL

- A. The stack sample probe shall be a multi-point unit type and shall be certified to EPA Specification EMTIC GD-031 (March 1995). The multi-point probe must be designed to be easily attached to the 48 inch diameter stack and provide adequate sampling accuracy with a minimum of two (2) upstream duct diameters.
- B. Provide sampling probes that incorporate particulate filters with compressed instrument air purge. All portions of the probe and filter exposed to ambient conditions shall be heat traced and insulated. The sample gas temperature shall not drop below its dew point under any operating conditions.
- C. All piping or tubing (umbilical) and intermediate equipment between the analyzer probe and analyzer console shall be heat traced and insulated.

2.4 SAMPLE CONDITIONING AND ANALYSIS CONSOLE

- A. Provide a sample conditioning and analysis console complete with all material, instrumentation, and equipment required to condition and analyze the sample gas from the stack. Analysis shall be performed to determine the concentrations of Oxygen, Carbon Monoxide, and oxides of Nitrogen.
- B. The Analysis console shall include the following components:
 - 1. Oxygen (O₂) analyzer with less than one minute response time. No optical alignments shall be required for the analyzer or any of its modules.
 - 2. O₂ analyzer software to analyze and manage O₂ data collection.
 - 3. Carbon Monoxide (CO) analyzer with less than one minute response time. No optical alignments shall be required for the analyzer or any of its modules.
 - 4. CO analyzer software to manage and convert raw data to reporting requirements in parts per million by volume dry corrected to 15 percent O₂.
 - 5. Nitrogen Oxides (NO_x) analyzer with less than one minute response time. No optical alignments shall be required for the analyzer or any of its modules.
 - 6. NO_x, CO, and O₂ analyzer software to manage and convert raw data to reporting requirements in parts per million by volume dry corrected to 15 percent O₂, pounds per hour, pounds per million BTU, and tons per year.
 - 7. CEMS controller shall have the capability to control and monitor external devices though the use of isolated discrete and analog signals and digital communications links such as Ethernet/IP or Modbus RS-485.
 - 8. All necessary mounting hardware, calibration devices, and initial charge of calibration gases.
 - 9. Human Machine Interface (HMI) in the form of an manufacturer-produced display as well as a dedicated CEMS PC workstation in the control room.
- C. The analysis console shall provide the following alarms:
 - 1. System failure or trouble.
 - 2. Sample contaminated by moisture.
 - 3. Sample line obstructive.
 - 4. Probe filter unit unplugged.
 - 5. Failure of heat tracing.
 - 6. Analyzer console power failure.
 - 7. High analyzer console temperature.
 - 8. Low analyzer console temperature.
 - 9. Low instrument air pressure.

10. Low zero gas pressure.
 11. Low span gas pressure.
 12. Failure of analyzer calibration.
 13. High and high-high emission levels for each measured parameter.
- D. The PLC based analysis console shall receive the following analog 4-20 mA inputs from the Cogen system:
1. Instantaneous Turbine fuel flow - fuel gas.
 2. Instantaneous Duct Burner fuel flow - fuel gas.
- E. The PLC based analysis console shall provide continuous digital readout instruments and provide isolated, 4-20 mA signals for use by others for the following:
1. Exhaust stack oxides of Nitrogen in ppmv, dry, measured.
 2. Exhaust stack Carbon Monoxide in ppmv, dry, corrected.
 3. Exhaust stack Oxygen in percentage.
 4. Provide at least 8 spare 4-20 mA outputs for future use.
- F. The PLC based analysis console shall include a programmable Logic Controller (PLC) to provide the following functions:
1. Manual and automatic controls of the sampling and analytic functions.
 2. Automatic calibration of each gas analyzer.
 3. Automatic range change capability.
 4. Automatic purging and cleaning of the sampling system.
 5. Automatic correction of output for loss of calibration.
 6. Automatic conversion of units of measure.
 7. Self analysis, diagnosis, and outcome display.

2.5 PANEL DESIGN AND CONSTRUCTION

- A. The panel enclosure shall be dust-tight, NEMA 12 construction, fabricated from sheet steel with a minimum thickness of 11 gauge. The sheet steel shall be selected for flatness and smoothness, and shall be free of surface defects on all exposed panel surfaces.
- B. Panel shall be a free-standing configuration, designed for mounting directly on a concrete housekeeping pad. The panel shall be self-supporting, with structural steel framing and welding. Bolt-on steel components may be used as floor channels, top sheets and end trim. The bottom of the panel shall have an angle frame for floor mounting with holes for anchor bolts. Suitable lifting lugs, eyes or other means to facilitate handling shall be provided.
- C. Suitable framing members and braces shall be provided to ensure adequate strength and rigidity to withstand all stresses incident to shipping, installation and operation, without distortion of or damage to the cabinet,

- injury to the instruments, or reduction of electrical clearances. All structural members shall be steel.
- D. Field wiring cables shall enter the panel from above and below. Gasketed, removable plates for cable entrance shall be provided.
 - E. All components shall be constructed of fire-retardant materials. Every effort shall be made to use inherently flame-retardant components, consistent with practical and safe electrical considerations. All non-metallic components shall have self-extinguishing characteristics in accordance with ASTM D635, Test for Flammability of Self-Supporting Plastics.
 - F. The exterior surfaces of the panel shall be ANSI 61 light gray color finish. The interior surface of the panel shall be white color finish. Furnish paint material for field touchup sufficient to cover approximately 5 percent of the surface.
 - G. Control and indicating devices and any other devices requiring regular attention or use by an operator shall be mounted flush or semi-flush on the front panel, with terminal blocks, relays, and similar equipment located internally. Indicating instruments shall be grouped at the top with control devices below, but not less than 30 inches from the bottom. Arrangement of instruments, controls, and nameplates shall be subject to review by Owner. All devices shall be easily accessible for maintenance and adjustment. All wiring requiring external connections shall be wired to terminal blocks. All piping requiring external connections shall be run to bulkhead fittings.
 - H. Panel shall be provided with a thermostatically controlled thermoelectric refrigeration system to maintain the interior space of the panel at a temperature suitable for the most temperature sensitive component contained within the console. The ambient environment in which the analyzer console is located is not a conditioned space.
 - I. Panel shall be provided with one duplex, 3 wire, grounded convenience outlet rated 120 V. 1 phase, 20 a, and one locally switched light fixture. The air conditioner, convenience outlet, and lighting circuit shall be protected by a suitably rated molded case circuit breaker located in the enclosure.
 - J. Front and rear access doors shall be provided to facilitate servicing of all panel mounted equipment. Rear doors shall be provided only if panel mounted equipment requires rear access for servicing.
 - K. Doors shall be capable of making a minimum swing of 175 degrees from the closed position. Hinges for rear doors shall be concealed liftoff type. Hinges for front doors shall be concealed piano type, and removable.
 - L. Panel doors shall be equipped with locks. Four (40 milled keys shall be provided to the Owner.
 - M. The control panel and all equipment located on the front of the panel shall be identified by individual nameplate immediately below the device.

Nameplates shall be engraved, noncombustible phenolic with black letters on a white background. Size of letters shall be approximately 3/16 inch for component nameplates, and 3/4 inch for panel nameplates. Nameplate mounting screws shall be slotted to permit thermal expansion. Equipment located on the front of the panel shall be identifiable from the rear by means of an indelible flame-retardant stencil-marking device. Equipment located inside the control panel shall be identified by means of a suitably inscribed metal tag affixed by screws.

2.6 DATA ACQUISITION SYSTEM AND INTERFACE WITH PLANT SCADA SYSTEM

- A. The analysis console shall be provided with the following input signals from the plant SCADA system (refer to Section 25 60 00, PLC CONTROL OF CHP EQUIPMENT) in the form of 4-10 mA analog inputs or via an Ethernet communications link:
 - 1. Fuel gas flow rate to the Combustion Turbine Generator.
 - 2. Fuel gas flow rate to the duct burner.
- B. Provide Data Acquisition System and software to manage and convert raw fuel gas data to generate the following reports:
 - 1. Turbine startup with date and time stamp and timer to mark exception from emission limits.
 - 2. Turbine shutdown with date and time stamp and timer to mark exception from emission limits.
 - 3. Duration of turbine startups and shutdowns in a calendar year.
 - 4. Hours of operation.
 - 5. Total cubic feet of natural gas burned in the turbine and duct burner on an hourly basis. The hourly fuel consumption shall be converted to MMBtu per hour based on a heating value provided for the natural gas supply.
 - 6. Total cubic feet of natural gas burned in the turbine and duct burner in a calendar year. The hourly fuel consumption shall be converted to MMBtu per hour based on a heating value provided for the natural gas supply.
 - 7. The CEMS shall convert the raw concentrations from the analyzer in ppmvd to ppmvd at 15 percent O₂, pounds per hour, and pounds per million Btu utilizing the F factor method specified in USEPA Method 19 and fuel flow data from the burner.
 - 8. The emissions shall be converted to the following averages:
 - a. 1 hour block average.
 - b. Three hour rolling average based on 1 hour block averages.
 - c. Calendar day averages.
 - 9. The annual gas consumption in cubic feet per year and MMBtu per year shall be computed on a 12 calendar month rolling average based on 1 month block averages.

- C. The Data Acquisition System shall have the capability to calculate emissions of Sox, TSP, PM10, and VOC based upon fuel consumption data and lb/MMBtu emission factors provided by the equipment manufacturers.
- D. The CEMS manufacturer shall ensure that all calculations performed by the Data Acquisition System are being executed properly prior to live functional performance testing.
- E. The CEMS Data Acquisition System shall record and log emissions during all operating scenarios including startup and shutdown in order to integrate these emissions into daily and annual averages.
- F. The Data Acquisition System shall comply with the requirements of 40 CFR Part 60, Appendix F, including, but not limited to, performing, logging, and recording daily calibrations, calibration drift assessment, and identification of "out of control" periods.
- G. The CEMS Data Acquisition System shall be capable of reporting all information potentially required by the Air Quality Management District including, but not limited to:
 - 1. Source operating hours.
 - 2. Analyzer operating hours.
 - 3. Source downtime (start, end, duration).
 - 4. Analyzer downtime (start, end, duration).
 - 5. Periods of excess emissions (start, end, magnitude, duration).
- H. The Data Acquisition System shall allow the operator to enter reasons for the source downtime, analyzer downtime and emissions exceedance.
- I. The CEMS Data Acquisition System shall be provided with adequate removable media backup such as a CDR recorder or DVD+R and DVD-R drive to ensure data security.

2.7 CEMS DESKTOP PC WORKSTATION

- A. A PC workstation shall be provided to be located in the plant central control room to act as remote HMI interface to the CEMS analyzer console.
- B. The CEMS workstation shall have the following minimum hardware requirements:
 - 1. 2.8 GHz Pentium 4 or Xeon processor.
 - 2. 32 GB RAM.
 - 3. Minimum of 750 GB hard drive capacity in a redundant RAID array (mirror).
 - 4. Ethernet 10/100 MBPS network interface card.
 - 5. 56K v.92 data/fax modem.
 - 6. DVD+/-RW optical drive.
 - 7. 3.5" 1.44 MB diskette drive.

8. Minimum one (1) serial, one (1) parallel, and four (4) USB 2.0 ports.
9. 21" diagonal SVGA color LCD monitor with speakers.
10. Keyboard.
11. Pointing device.
12. Microsoft Windows XP Professional operating system, or equal.

2.8 ELECTRICAL

A. General:

1. Terminal blocks shall have at least 6 inches of wiring space around and between blocks. Twenty percent spare terminal positions shall be provided. Terminal blocks shall be in vertical rows.
2. Extra flexible wire shall be used for wiring devices located on an enclosure hinged door to terminal blocks or devices within the enclosure.
3. Panel shall be provided with adequate wireways to accommodate internal wiring, with a maximum 40 percent fill of cross sectional area. Terminal blocks may be located on the rear of the front panel and on side panels. The terminal blocks shall be arranged in vertical lines and be so located as to not interfere with inspection of connections to other devices or removal and replacement of such devices. For free standing panels, the bottom end of the lowest terminal block shall not be less than 12 inches above the floor surface; the top end of the uppermost block shall not be less than 12 inches from the top of the panel. These clear areas shall be reserved for external cabling. The distance from the center of a row of terminal blocks to the edge of the panel upon which it is mounted shall not be less than 8 inches. The distances between the centers of parallel rows of terminal blocks shall not be less than 10 inches, unless no external or field wiring is to be installed in this space.

B. Conductors and Terminal Blocks:

1. Control wiring shall consist of not less than No. 14 AWG single conductor, 600 V class stranded copper wire, having 41 strands of 10 mils. In general, 90 C rated cross-linked polyethylene insulation shall be used (i.e., THHN/THWN type).
2. Terminal blocks shall be provided for termination of all interconnecting and external wiring. Terminal blocks shall be sliding link terminal blocks.
 - a. Minimum conductor size for power wiring shall be No. 12 AWG. THHN/THWN stranded copper. Connectors used for terminating cable tape shield and drain wire shall be tinned copper, compression type, non-insulated. The connector shall provide for connection of the shield and drain wire to a No. 14 insulated copper wire. The continuous temperature rating of insulation shall be 90 degree C for all wiring, flame resistant, self extinguishing, tested per IEEE 422.
 - b. Instrumentation wiring including low level signals and thermocouples shall be shielded twisted pairs. The shielding for

cables, unless otherwise specified, shall be aluminum-mylar tape with 50 percent minimum overlap and no thinner than 1.5 mils. A stranded, tinned, copper drain wire, no smaller than NO. 18 AWG, shall be helically applied in the same direction and lay as the twisted wire so as to be in continuous contact with the metal side of the foil tape. Maximum lay of twist for pairs shall be 3 in. Maximum lay of twist for triplets or quads shall be 4 to 5 in. In multiple pair cables, all shields shall be isolated from each other. Thermocouple wire color coding shall be in accordance with ANSI IC96.1, Temperature Measurement Thermocouples.

- c. All wiring shall be terminated with full tongue compression type terminals which firmly grip the conductors and which have insulated compression sleeves to grip the wire insulation, and identified.
- d. Each cable shield shall be terminated on a separate ungrounded terminal adjacent to the related cable wire terminals. Continuity of cable shields shall be maintained throughout intra-panel wiring.
- e. No more than two wires shall be connected to any one terminal point. Splicing of wire connections or use of wire nuts is prohibited.

C. Wiring Methods, Enclosure and Grounding:

- 1. Non-current carrying metallic parts of electrical equipment and other metallic equipment that may come into contact with energized conductors shall be grounded in accordance with the National Electrical Code. All equipment requiring grounding shall be provided with the means for attaching a grounding cable to the enclosure with matching bolts, and a two-hole lug for copper cable. Hold down bolts shall not be used for attaching grounding cables.
- 2. Extend all ground connections on the equipment unit to a copper ground bus. The ground bus shall be a minimum of 1/2 inch square in cross-sectional area, flat copper bus bar and furnished with bolted type lugs capable of accepting a #1/0 to #4/0 AWG bare copper grounding cable at each end for connection to the plant ground grid.
- 3. A permanent nonmetallic wire-marking system, such as embossed slip-on-fire-retardant, shall be furnished. Each individual wire shall be identified at each connection point. Adhesive wire labels are not acceptable. The wire identification numbers shall correspond to that shown on the Elementary and wiring diagrams.
- 4. No solder shall be used in connection with any wiring. All wiring shall be free of abrasions and tool marks and all bends in the wire shall not be less than 6 inch radius. All fastenings of wire-supporting devices shall be by thread fasteners.

PART 3 - EXECUTION

3.1 CLEANING, PACKAGING FOR SHIPMENT AND TAGGING

- A. All components and subassemblies shall be thoroughly cleaned of all water, sand, grease, oil and other foreign materials prior to shipment.

- B. All flanged openings shall be covered with 3/8 inch thick plywood flange protectors; threaded openings shall be protected by plastic end caps or plugs.
- C. All caps, plugs and bulkhead fittings shall be sealed with tape to provide a dust-tight closure.
- D. The equipment shall be suitably skidded, crated, boxed, sealed or otherwise protected from damage during shipment.
- E. Each separate shipping crate, box, or skid shall be clearly and indelibly labeled with equipment tag numbers. Letters shall be a minimum of 1 inch high.
- F. Each piece of equipment identified with and equipment tag number shall have a 304 stainless steel nameplate permanently attached to it. The nameplate shall contain the following information, embossed or otherwise permanently affixed:
 - 1. Equipment number.
 - 2. Shop order number and date fabricated.
 - 3. Manufacturer's name and address.
 - 4. Manufacturer's serial number and model number.
 - 5. Equipment Data: Maximum working pressure and temperature, operating volume, etc.
- G. The cleaning and packaging requirements of this section are minimum standards to be followed. In addition, the manufacturer shall submit written recommendations for field storage, both indoors and outdoors.

3.2 PAINTING AND CLEANING

- A. Surface Preparation: SSPC-SP6, Commercial Blast Cleaning, for all external surfaces.
- B. Surface Coating: All carbon steel and cast iron surfaces shall be primed and finish coated as follows:
 - 1. Prime Coat: Zinc Primer, 1-2 mils dry film thickness.
 - 2. Finish Coat: 4-8 mils Polyurethane finish, color to be ANSI 61 light grey exterior and white interior.
 - 3. Coating application, testing, and repair shall be in accordance with the coating manufacturer's recommended instruction.

3.3 CONSTRUCTION WASTE MANAGEMENT

- A. General: Comply with Contractor's Waste Management Plan and Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.
- B. To the greatest extent possible, separate reusable and recyclable products from contaminated waste and debris in accordance with the Contractor's Waste Management Plan. Place recyclable and reusable products in

designated containers and protect from moisture and contamination.

3.4 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specifications will be tested as part of a larger system. Refer to Section 01 91 00.01, GENERAL COMMISSIONING REQUIREMENTS and related sections for contractor responsibilities for system commissioning.

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(Add#01) 18 SEP 2013, Addendum No. 01

(Add#02) 07 OCT 2013, Addendum No. 02

SECTION 32 05 23

CEMENT AND CONCRETE FOR EXTERIOR IMPROVEMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section shall cover site work concrete constructed upon the prepared subgrade and in conformance with the lines, grades, thickness, and cross sections shown. Construction shall include the following:
- B. Curb, gutter, and wheel stops.
- C. Pedestrian Pavement: Walks and wheelchair curb ramps. *(Add#01)*
- D. Integrally colored cast-in-place concrete.
- E. Concrete for stone veneer walls. *(Add#01)*
- F. Vehicular Pavement.
- G. Equipment Pads: transformers.

1.2 RELATED WORK

- A. Laboratory and Field Testing Requirements: Section 01 45 29, TESTING LABORATORY SERVICES.
- B. Sustainable design requirements and procedures including submittal requirements: Section 01 81 11.01, SUSTAINABLE DESIGN REQUIREMENTS.
- C. Procedures and requirements for managing and disposing construction and demolition waste: Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.
- D. Color Additives Specified: Section 09 06 00, SCHEDULE FOR FINISHES
- E. Subgrade Preparation: Section 31 20 00, EARTH MOVING.
- F. Concrete Materials, Quality, Mixing, Design and Other Requirements: Section 03 30 00, CAST-IN-PLACE-CONCRETE.
- G. Deleted *(Add#01)*

1.3 DESIGN REQUIREMENTS

- A. Design all elements with the latest published version of applicable codes.

1.4 WEATHER LIMITATIONS

- A. Placement of concrete shall be as specified under Article 3.8, COLD WEATHER and Article 3.7, HOT WEATHER of Section 03 30 00, CAST-IN-PLACE CONCRETE.

1.5 SELECT SUBBASE MATERIAL JOB-MIX

- A. The Contractor shall retain and reimburse a testing laboratory to design a select subbase material mixture and submit a job-mix formula to the Resident Engineer, in writing, for approval. The formula shall include the source of materials, gradation, plasticity index, liquid limit, and laboratory compaction curves indicating maximum density at optimum moisture.

1.6 SUBMITTALS

- A. In accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, furnish the following:
1. Submit two full-scale mock-up (minimum 4' by 4') sample panels of all concrete finishes and color. The samples shall include curing compound if any is to be used, and include an expansion joint and a score joint, as indicated on the Drawings. Approved samples shall be kept at the job site to serve as a prerequisite for all finishes until acceptance of the Work. ^(Add#01)
- B. LEED Submittals: Submit in accordance with Section 01 81 11.01.
1. LEED submittals are in addition to other submittals. If submitted item is identical to that submitted to comply with other requirements, submit duplicate copies as a separate submittal to verify compliance with indicated LEED requirements.
 2. LEED Product Data Submittal Form: Submit completed product data form provided by the Contracting Officer's Representative; certified by vendor, installer, subcontractor, and/or manufacturer as appropriate.
- C. Manufacturers' Certificates and Data certifying that the following materials conform to the requirements specified.
1. Expansion joint filler
 2. Hot poured sealing compound
 3. Reinforcement
 4. Curing materials
 5. Pigments.
- D. Data and Test Reports:
1. Select subbase material:
 - a. Job-mix formula.
 - b. Source, gradation, liquid limit, plasticity index, percentage of wear, and other tests as specified and in referenced publications.
 2. Aggregate Base:
 - a. Sources, gradation, liquid limit, plasticity index, percentage of wear, and other tests required by the Caltrans Standard Specifications.

1.7 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Refer to the latest edition of all referenced Standards and codes.
- B. American Association of State Highway and Transportation Officials (AASHTO):
1. M031MM031-07-UL Deformed and Plain Carbon Steel Bars for Concrete Reinforcement (ASTM A615/A615M-09)
 2. M055MM055-09-UL Steel Welded Wire Reinforcement, Plain, for Concrete (ASTM A185)
 3. M147-65-UL Materials for Aggregate and Soil-Aggregate Subbase, Base and Surface Courses (R 2004)
 4. M148-05-UL Liquid Membrane-Forming Compounds for Curing Concrete (ASTM C309)
 5. M171-05-UL Sheet Materials for Curing Concrete (ASTM C171)
 6. M182-05-UL Burlap Cloth Made from Jute or Kenaf and Cotton Mats
 7. M213-01-UL Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Type) (ASTM D1751)
 8. M233-86-UL Boiled Linseed Oil Mixer for Treatment of Portland Cement Concrete
 9. T099-09-UL Moisture-Density Relations of Soils Using a 2.5 kg. (5.5 lb) Rammer and a 305 mm (12 in.) Drop
 10. T180-09-UL Moisture-Density Relations of Soils Using a 4.54 kg (10 lb.) Rammer and a 457 mm (18 in.) Drop
- C. California Department of Transportation Standard Specifications (Caltrans). ^(Add#01)
- D. American Society for Testing and Materials (ASTM):
1. C94/C94M-09 Ready-Mixed Concrete
 2. C143/C143M-09 Slump of Hydraulic Cement Concrete

1.8 DELETED ^(Add#01)**PART 2 - PRODUCTS****2.1 GENERAL**

- A. Concrete shall be as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE, with cement and water factors for 3,000 psi minimum 28-day compressive strength and air-entrainment per Table I, with the following exceptions:

TYPE	MAXIMUM SLUMP*
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Curb & Gutter	75 mm (3")
Pedestrian Pavement	75 mm (3")
Vehicular Pavement	50 mm (2") (Machine Finished) 100 mm (4") (Hand Finished)
Equipment Pad	75 to 100 mm (3" to 4")
* For concrete to be vibrated: Slump as determined by ASTM C143. Tolerances as established by ASTM C94.	

- B. Concrete pedestrian and vehicular pavements: 3,000 PSI 28 day strength, 3/4" x #4 aggregate size. ^(Add#01)
- C. Concrete landscape walls: 4,000 PSI 28 day strength, 3/4" x #4 aggregate size. ^(Add#01)

2.2 REINFORCEMENT

- A. The type, amount, and locations of steel reinforcement shall be as shown on the drawings and in the specifications.
- B. Welded wire-fabric shall conform to AASHTO M55.
- C. Dowels shall be plain steel bars conforming to AASHTO M31. Tie bars shall be deformed steel bars conforming to AASHTO M31.

2.3 AGGREGATE BASE

- A. Aggregate base shall conform to the requirements of Section 26-1.02B of the Caltrans Standard Specifications, Class 2 Aggregate Base, 3/4" maximum grading. Where the term "Engineer" or "Commission" is referenced in the Caltrans Standard Specifications, it shall mean the VA Resident Engineer.

2.4 FORMS

- A. Use metal or wood forms that are straight and suitable in cross-section, depth, and strength to resist springing during depositing and consolidating the concrete, for the work involved.
- B. Do not use forms if they vary from a straight line more than 3 mm (1/8 inch) in any 3000 mm (ten foot) long section, in either a horizontal or vertical direction.
- C. Wood forms should be at least 50 mm (2 inches) thick (nominal). Wood forms shall also be free from warp, twist, loose knots, splits, or other defects. Use approved flexible or curved forms for forming radii.
- D. For Exposed Smooth Form-finished Concrete: Use Medium Density (or better) Overlaid Concrete Form Exterior (MDO), to provide continuous straight, smooth, exposed surfaces without grain patterns. Furnish in largest practicable sizes to minimize number of joints and to conform to a joint system as approved by Resident Engineer. ^(Add#01)

2.5 COLOR ADDITIVES (Add#01)

- A. ~~Concrete~~ All pedestrian concrete paving shall be integrally colored. (Add#02)
- B. Color Additives/Pigments: Insoluble minerals, light fast, at least 95 percent passing #325 sieve complying with ASTM C979. Color as indicated in Section 09 06 00 SCHEDULE FOR FINISHES.
- C. Color additives containing carbon black are not acceptable.

2.6 CURING COMPOUNDS FOR COLORED CONCRETE (Add#01)

- A. Curing Compound for Colored Concrete: Water-base acrylic type, free of permanent color, oil or wax, complying with ASTM C309 and compatible with color additive/pigment.

2.7 CONCRETE CURING MATERIALS

- A. Concrete curing materials shall conform to one of the following:
1. Burlap conforming to AASHTO M182 having a weight of 233 grams (seven ounces) or more per square meter (yard) when dry.
 2. Impervious Sheeting conforming to AASHTO M171.
 3. Liquid Membrane Curing Compound conforming to AASHTO M148 (ASTM C309), Type 2 and shall be free of paraffin or petroleum.
- B. Deleted (Add#01)

2.8 DAMPPROOFING (Add#01)

- A. Required where walls retain more than 18" of soil and conforming to Caltrans Standard Specifications, Section 54.

2.9 EXPANSION JOINT FILLERS

- A. Fiber Expansion Joint: A non-extruding resilient filler, saturated with high quality bituminous materials having preserving characteristics. Conform to ASTM-D1751-04.

2.10 DELETED (Add#01)

PART 3 - EXECUTION

3.1 SUBGRADE PREPARATION

- A. Prepare, construct, and finish the subgrade as specified in Section 31 20 00, EARTH MOVING.
- B. Maintain the subgrade in a smooth, compacted condition, in conformance with the required section and established grade until the succeeding operation has been accomplished.

- C. Watering, spreading, and compacting of aggregate base shall be done in conformance with Sections 26-1.03 of the Caltrans Standard Specifications.

3.2 SETTING FORMS

A. Base Support:

- 1. Compact the base material under the forms true to grade so that, when set, they will be uniformly supported for their entire length at the grade as shown.
- 2. Correct imperfections or variations in the base material grade by cutting or filling and compacting.

B. Setting:

- 1. Set forms sufficiently in advance of the placing of the concrete to permit the performance and approval of all operations required with and adjacent to the form lines.
- 2. Set forms to true line and grade and use stakes, clamps, spreaders, and braces to hold them rigidly in place so that the forms and joints are free from play or movement in any direction.
- 3. Forms shall conform to line and grade with an allowable tolerance of 3 mm (1/8 inch) when checked with a straightedge and shall not deviate from true line by more than 6 mm (1/4 inch) at any point.
- 4. Do not remove forms until removal will not result in damaged concrete or at such time to facilitate finishing.
- 5. Clean and oil forms each time they are used.

- C. The Contractor's Registered Professional Land Surveyor, specified in Section 00 72 00, GENERAL CONDITIONS, shall establish and control the alignment and the grade elevations of the forms or concrete slipforming machine operations.

- 1. Make necessary corrections to forms immediately before placing concrete.
- 2. When any form has been disturbed or any subgrade or subbase has become unstable, reset and recheck the form before placing concrete.

3.3 EQUIPMENT

- A. The Resident Engineer shall approve equipment and tools necessary for handling materials and performing all parts of the work prior to commencement of work.

- B. Maintain equipment and tools in satisfactory working condition at all times.

3.4 PLACING REINFORCEMENT

- A. Reinforcement shall be free from dirt, oil, rust, scale or other substances that prevent the bonding of the concrete to the reinforcement.

- B. Before the concrete is placed, the Resident Engineer shall approve the reinforcement, which shall be accurately and securely fastened in place with suitable supports and ties. The type, amount, and position of the reinforcement shall be as shown.

3.5 PLACING CONCRETE - GENERAL

- A. Obtain approval of the Resident Engineer before placing concrete.
- B. Remove debris and other foreign material from between the forms before placing concrete. Obtain approval of the Resident Engineer before placing concrete.
- C. Before the concrete is placed, uniformly moisten the subgrade, base, or subbase appropriately, avoiding puddles of water.
- D. Convey concrete from mixer to final place of deposit by a method which will prevent segregation or loss of ingredients. Deposit concrete so that it requires as little handling as possible.
- E. While being placed, spade or vibrate and compact the concrete with suitable tools to prevent the formation of voids or honeycomb pockets. Vibrate concrete well against forms and along joints. Over-vibration or manipulation causing segregation will not be permitted. Place concrete continuously between joints without bulkheads.
- F. Install a construction joint whenever the placing of concrete is suspended for more than 30 minutes and at the end of each day's work.
- G. Workmen or construction equipment coated with foreign material shall not be permitted to walk or operate in the concrete during placement and finishing operations.

3.6 PLACING CONCRETE FOR CURB AND GUTTER, PEDESTRIAN PAVEMENT, AND EQUIPMENT PADS

- A. Place concrete in the forms in one layer of such thickness that, when compacted and finished, it will conform to the cross section as shown.
- B. Deposit concrete as near to joints as possible without disturbing them but do not dump onto a joint assembly.
- C. After the concrete has been placed in the forms, use a strike-off guided by the side forms to bring the surface to the proper section to be compacted.
- D. Consolidate the concrete thoroughly by tamping and spading, or with approved mechanical finishing equipment.
- E. Finish the surface to grade with a wood or metal float.
- F. All Concrete pads and pavements shall be constructed with sufficient slope to drain properly.

3.7 DELETED (Add#01)

3.8 PLACING CONCRETE FOR VEHICULAR PAVEMENT

- A. Deposit concrete into the forms as close as possible to its final position.
- B. Place concrete rapidly and continuously between construction joints.
- C. Strike off concrete and thoroughly consolidate by a finishing machine, vibrating screed, or by hand-finishing.
- D. Finish the surface to the elevation and crown as shown.
- E. Deposit concrete as near the joints as possible without disturbing them but do not dump onto a joint assembly. Do not place adjacent lanes without approval by the Resident Engineer.

3.9 CONCRETE FINISHING - GENERAL

- A. The sequence of operations, unless otherwise indicated, shall be as follows:
 - 1. Consolidating, floating, straight-edging, troweling, texturing, and edging of joints.
 - 2. Maintain finishing equipment and tools in a clean and approved condition.

3.10 CONCRETE FINISHING CURB AND GUTTER

- A. Round the edges of the gutter and top of the curb with an edging tool to a radius of 6mm (1/4 inch) or as otherwise detailed.
- B. Float the surfaces and finish with a smooth wood or metal float until true to grade and section and uniform in textures.
- C. Finish the surfaces, while still wet, with a bristle type brush with longitudinal strokes.
- D. Immediately after removing the front curb form, rub the face of the curb with a wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed. Brush the surface, while still wet, in the same manner as the gutter and curb top.
- E. Except at grade changes or curves, finished surfaces shall not vary more than 3 mm (1/8 inch) for gutter and 6 mm (1/4 inch) for top and face of curb, when tested with a 3000 mm (10 foot) straightedge.
- F. Remove and reconstruct irregularities exceeding the above for the full length between regularly scheduled joints.
- G. Correct any depressions which will not drain.

- H. Visible surfaces and edges of finished **curb** and **gutters** shall be free of blemishes, form marks, and tool marks, and shall be uniform in color, shape, and appearance.

3.11 CONCRETE FINISHING PEDESTRIAN PAVEMENT

- A. Sandblast Finish: Perform in as continuous an operation as possible, utilizing the same work crew to maintain continuity of finish. ^(Add#01)
 - 1. Use an abrasive grit of the proper type and gradation to expose the aggregate and surrounding matrix surfaces to match sample panel, as follows:
 - 2. Light Cut: approximately 1/16" depth
 - 3. Medium Cut: approximately 1/8" to 3/16" depth
- B. Deleted ^(Add#01)
- C. Finish the surfaces to grade and cross section with a metal float, trowled smooth and finished with a broom moistened with clear water.
- D. Brooming shall be transverse to the line of traffic.
- E. Finish all slab edges, including those at formed joints, carefully with an edger having a radius as shown on the Drawings.
- F. Unless otherwise indicated, edge the transverse joints before brooming. The brooming shall eliminate the flat surface left by the surface face of the edger. Execute the brooming so that the corrugation, thus produced, will be uniform in appearance and not more than 2 mm (1/16 inch) in depth and non-slip in conformance with ABAAS and VA requirements. ^(Add#01)
- G. The completed surface shall be uniform in color and free of surface blemishes, form marks, and tool marks. The finished surface of the pavement shall not vary more than 5 mm (3/16 inch) when tested with a 3000 mm (10 foot) straightedge.
- H. The thickness of the pavement shall not vary more than 6 mm (1/4 inch).
- I. Remove and reconstruct irregularities exceeding the above for the full length between regularly scheduled joints.
- J. Deleted ^(Add#01)

3.12 CONCRETE FINISHING FOR VEHICULAR PAVEMENT

- A. Accomplish longitudinal floating with a longitudinal float not less than 3000 mm (10 feet) long and 150 mm (6 inches) wide, properly stiffened to prevent flexing and warping. Operate the float from foot bridges in a sawing motion parallel to the direction in which the pavement is being laid from one side of the pavement to the other, and advancing not more than half the length of the float.
- B. After the longitudinal floating is completed, but while the concrete is still plastic, eliminate minor irregularities in the pavement surfaces by

means of metal floats, 1500 mm (5 feet) in length, and straightedges, 3000 mm (10 feet) in length. Make the final finish with the straightedges, which shall be used to float the entire pavement surface.

- C. Test the surface for trueness with a 3000 mm (10 foot) straightedge held in successive positions parallel and at right angles to the direction in which the pavement is being laid and the entire area covered as necessary to detect variations. Advance the straightedge along the pavement in successive stages of not more than one half the length of the straightedge. Correct all irregularities and refinish the surface.
- D. The finished surface of the pavement shall not vary more than 6 mm (1/4 inch) in both longitudinal and transverse directions when tested with a 3000 mm (10 foot) straightedge.
- E. The thickness of the pavement shall not vary more than 6 mm (1/4 inch).
- F. When most of the water glaze or sheen has disappeared and before the concrete becomes nonplastic, give the surface of the pavement a broomed finish with an approved fiber broom not less than 450 mm (18 inches) wide. Pull the broom gently over the surface of the pavement from edge to edge. Brooming shall be transverse to the line of traffic and so executed that the corrugations thus produced will be uniform in character and width, and not more than 3 mm (1/8 inch) in depth. Carefully finish the edge of the pavement along forms and at the joints with an edging tool. The brooming shall eliminate the flat surface left by the surface face of the edger.
- G. The finish surfaces of new and existing abutting pavements shall coincide at their juncture.

3.13 CONCRETE FINISHING EQUIPMENT PADS

- A. After the surface has been struck off and screeded to the proper elevation, give it a smooth dense float finish, free from depressions or irregularities.
- B. Carefully finish all slab edges with an edger having a radius as shown in the Drawings.
- C. After removing the forms, rub the faces of the pad with a wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed. The finish surface of the pad shall not vary more than 3 mm (1/8 inch) when tested with a 3000 mm (10 foot) straightedge.
- D. Correct irregularities exceeding the above.

3.14 JOINTS - GENERAL

- A. Place joints, where shown, conforming to the details as shown, and perpendicular to the finished grade of the concrete surface.
- B. Joints shall be straight and continuous from edge to edge of the pavement.

3.15 CONTRACTION JOINTS

- A. Cut joints to depth as shown with a grooving tool or jointer of a radius as shown or by sawing with a blade producing the required width and depth.
- B. Construct joints in curbs and gutters by inserting 3 mm (1/8 inch) steel plates conforming to the cross sections of the curb and gutter .
- C. Plates shall remain in place until concrete has set sufficiently to hold its shape and shall then be removed.
- D. Finish edges of all joints with an edging tool having the radius as shown.
- E. Score pedestrian pavement with a standard grooving tool or jointer.

3.16 EXPANSION JOINTS

- A. Use a preformed expansion joint filler material of the thickness as shown to form expansion joints.
- B. Material shall extend the full depth of concrete, cut and shaped to the cross section as shown, except that top edges of joint filler shall be below the finished concrete surface where shown to allow for sealing.
- C. Anchor with approved devices to prevent displacing during placing and finishing operations.
- D. Round the edges of joints with an edging tool.
- E. Form expansion joints as follows:
 - 1. Without dowels, about structures and features that project through, into, or against any site work concrete construction.
 - 2. Using joint filler of the type, thickness, and width as shown.
 - 3. Installed in such a manner as to form a complete, uniform separation between the structure and the site work concrete item.

3.17 CONSTRUCTION JOINTS

- A. Locate longitudinal and transverse construction joints between slabs of vehicular pavement as shown.
- B. Place transverse construction joints of the type shown, where indicated and whenever the placing of concrete is suspended for more than 30 minutes.
- C. Use a butt-type joint with dowels in curb and gutter if the joint occurs at the location of a planned joint.
- D. Use keyed joints with tiebars if the joint occurs in the middle third of the normal curb and gutter joint interval.

3.18 FORM REMOVAL

- A. Forms shall remain in place at least 12 hours after the concrete has been placed. Remove forms without injuring the concrete.
- B. Do not use bars or heavy tools against the concrete in removing the forms. Promptly repair any concrete found defective after form removal.

3.19 CURING OF CONCRETE

- A. Cure concrete by one of the following methods appropriate to the weather conditions and local construction practices, against loss of moisture, and rapid temperature changes for at least seven days from the beginning of the curing operation. Protect unhardened concrete from rain and flowing water. All equipment needed for adequate curing and protection of the concrete shall be on hand and ready to install before actual concrete placement begins. Provide protection as necessary to prevent cracking of the pavement due to temperature changes during the curing period. If any selected method of curing does not afford the proper curing and protection against concrete cracking, remove and replace the damaged pavement and employ another method of curing as directed by the Resident Engineer.
- B. Burlap Mat: Provide a minimum of two layers kept saturated with water for the curing period. Mats shall overlap each other at least 150 mm (6 inches).
- C. Impervious Sheeting: Use waterproof paper, polyethylene-coated burlap, or polyethylene sheeting. Polyethylene shall be at least 0.1 mm (4 mils) in thickness. Wet the entire exposed concrete surface with a fine spray of water and then cover with the sheeting material. Sheets shall overlap each other at least 300 mm (12 inches). Securely anchor sheeting. ^(Add#01)
- D. Liquid Membrane Curing:
 - 1. Apply pigmented membrane-forming curing compound in two coats at right angles to each other at a rate of 5 m²/L (200 square feet per gallon) for both coats.
 - 2. Do not allow the concrete to dry before the application of the membrane.
 - 3. Cure joints designated to be sealed by inserting moistened paper or fiber rope or covering with waterproof paper prior to application of the curing compound, in a manner to prevent the curing compound entering the joint.
 - 4. Immediately re-spray any area covered with curing compound and damaged during the curing period.
- E. Curing for Integrally Colored Concrete:
 - 1. For colored concrete, refer to CURING COMPOUNDS FOR COLORED CONCRETE above in PART 2 - PRODUCTS. Apply as recommended by manufacturer. ^(Add#01)
 - 2. Deleted ^(Add#01)
 - 3. Deleted ^(Add#01)
 - 4. Deleted ^(Add#01)

3.20 DAMPPROOFING (Add#01)

- A. Mop apply one heavy coat of asphalt dampproofing to soil side of retaining walls and planter walls from top of footing to a minus 2 inches below finish soil grade.

3.21 CLEANING

- A. After completion of the curing period:
 - 1. Remove the curing material (other than liquid membrane).
 - 2. Sweep the concrete clean.
 - 3. After removal of all foreign matter from the joints, seal joints as herein specified.
 - 4. Clean the entire concrete of all debris and construction equipment as soon as curing and sealing of joints has been completed.

3.22 PROTECTION

- A. The contractor shall protect the concrete against all damage prior to final acceptance by the Government. Remove concrete containing excessive cracking, fractures, spalling, or other defects and reconstruct the entire section between regularly scheduled joints, when directed by the Resident Engineer, and at no additional cost to the Government. Exclude traffic from vehicular pavement until the concrete is at least seven days old, or for a longer period of time if so directed by the Resident Engineer.

3.23 FINAL CLEAN-UP

- A. Remove all debris, rubbish and excess material from the Station.

3.24 CONSTRUCTION WASTE MANAGEMENT

- A. General: Comply with Contractor's Waste Management Plan and Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.
- B. To the greatest extent possible, separate reusable and recyclable products from contaminated waste and debris in accordance with the Contractor's Waste Management Plan. Place recyclable and reusable products in designated containers and protect from moisture and contamination.

- - - E N D - - -

(Add#01) 18 SEP 2013, Addendum No. 1
(Add#02) 07 OCT 2013, Addendum No. 2

SECTION 32 90 00

PLANTING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This work consists of furnishing and installing all planting materials required for landscaping hereinafter specified in locations as shown.

1.2 TESTING LABORATORY SERVICES

- A. Materials testing activities and inspection services required during project construction to be provided by a Testing Laboratory retained and paid for by Contractor.

1.3 EQUIPMENT

- A. Maintain all equipment, tools and machinery while on the project in sufficient quantities and capacity for proper execution of the work.

1.4 RELATED WORK

- A. Sustainable design requirements and procedures including submittal requirements: Section 01 81 11.01, SUSTAINABLE DESIGN REQUIREMENTS.
- B. Procedures and requirements for managing and disposing construction and demolition waste: Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.
- C. Section 32 84 00, PLANTING IRRIGATION.
- D. Section 01 57 19, TEMPORARY ENVIRONMENTAL CONTROLS.

1.5 SUBMITTALS

- A. Product Data: Manufacturer's current catalog cuts and specifications of the following:
 - 1. Erosion Control hydroseed Mix
 - 2. Native wildflower hydroseed Mix
 - 3. Fertilizers
 - 4. Tree Tie and Stake
 - 5. Tree Root Barrier
 - 6. Iron Sulfate
 - 7. Tree Guy Material
 - 8. Filter Fabric
 - 9. Erosion Control Netting

10. Perforated Drain Pipe
- B. LEED Submittals: Submit in accordance with Section 01 81 11.01.
 1. LEED submittals are in addition to other submittals. If submitted item is identical to that submitted to comply with other requirements, submit duplicate copies as a separate submittal to verify compliance with indicated LEED requirements.
 2. LEED Product Data Submittal Form: Submit completed product data form provided by the Contracting Officer's Representative; certified by vendor, installer, subcontractor, and/or manufacturer as appropriate.
- C. Samples: Submit following samples along with certificates of compliance / analytical data from approved laboratory for degree of compliance:
Plants: Submit typical sample of each variety or entire quantity to site for approval by Resident Engineer.
 1. Organic Mulch: Submit 1-pint sample with list of ingredients.
 2. Organic (Soil) Amendment: Submit 1-pint sample with Technical Data Sheet and STA certification.
 3. Permeable Backfill (Filter Rock): Submit 1-pint sample.
 4. Bioswale Mineral Component (soil) Backfill: Submit 1/2-pint sample
 5. Bioswale Yard Waste Compost: Submit 1-pint sample Technical Data Sheet and STA certification.
 6. Bioswale Mulch: Submit 1-pint sample
 7. Imported Planting Soil: Submit 1-pint sample
 8. Bioswale Mineral Component (soil) Backfill . Submit ½ gal. sample of mineral component to soil and plant laboratory for analytical packages as specified in Part 2 - Products below. Upon approval of the Laboratory's recommendations by the Resident Engineer, the recommendations in the report shall become a part of the Specifications.
 9. Bioswale Yard Waste Compost (organic amendment for Bioswale).
 10. Submit 1 quart sample of composted organic amendment along with composter's Compost Technical Data Sheet and STA certification to soil and plant laboratory for analytical packages as specified in Part 2 - Products below. Upon approval of the Laboratory's recommendations by the Resident Engineer, the recommendations in the report shall become a part of the Specifications.
- D. Delivery Receipts
 1. Provide delivery receipts for quantities of organic soil amendments delivered to the site.
- E. Topsoil Analysis (Soil Management) Report
 1. After approval of rough grading and topsoil placement, obtain minimum of four representative one quart samples of topsoil taken from accepted site locations at depth of 4" to 6" below finish grade and

submit to an accredited Soils Laboratory for evaluation of physical and chemical properties of soil including all major nutrients; pH, salinity, boron, sodium, micronutrients, copper, zinc, manganese and iron; and infiltration rate, soil texture and organic content, along with a summary describing the degree of compliance with the specified requirements. The report shall also include recommendations for modification of the soil for agricultural suitability.

2. Upon request by Owner, submit documentation verifying implementation of soil analysis report recommendations to the local agency with Certificate of Completion as required by the State of California Model Water Ordinance

F. Subsoil Analysis

1. Besides the above required soil samples, take one representative sample of any subgrade soil that is to receive a layer of imported planting soil over it. The laboratory report shall include the subgrade soil's total combined silt and clay content for determining the total desirable combined silt and clay content of the final imported planting soil cover specified herein.

G. Imported Planting Soil Analysis

1. See Imported Planting Soil Analysis requirements elsewhere in this specification for comparison to existing soil analysis.

H. Approval of Laboratory Report

1. Upon approval of the Laboratory's report by the Resident Engineer, the recommendations in the report shall become a part of the Specifications and the quantities of soil amendment, fertilizer and other additives shall be adjusted to conform with the report at no additional cost to the owner. Request Testing Laboratory to send one copy of test results directly to Resident Engineer. Note that there is a minimum quantity of organic amendment specified elsewhere in this specification section.

1.6 PROJECT/SITE CONDITIONS

- A. Site Visit: At beginning of work, visit and walk the site with the Resident Engineer to clarify scope of work and understand existing project/site conditions.
- B. Deleted (Add#01)

1.7 WARRANTY AND REPLACEMENT,

- A. Pre-Emergence Weed Killer: Warrant the work against weed growth for a period of four (4) months after application.
- B. Warrant all plants and planting to be in a healthy, thriving condition until the end of the maintenance period, and deciduous trees beyond that time until active growth is evident.

- C. Replace all dead plants and plants not in a vigorous condition immediately upon discovery and as directed by the Resident Engineer at Contractor's expense. Install replacement plants before the final acceptance at the size specified.
- D. Warrant all plant material for a period of one year after final acceptance of the maintenance period against plant materials with defects at the time of installation.
- E. Warrant plant installation and maintenance by Contractor against defects for a period of one year.
- F. Samples: Submit the following samples for approval before work is started:

Inert Mulch	2 quarts of each type to be used.
Organic Mulch	2 quarts of each type to be used.

- G. Certificates of Conformance or Compliance: Before delivery, notarized certificates attesting that the following materials meet the requirements specified shall be submitted to the Resident Engineer for approval:
 - 1. Plant Materials (Department of Agriculture certification by State Nursery Inspector declaring material to be free from insects and disease).
 - 2. Fertilizers.
 - 3. Membranes
- H. Manufacturer's Literature and Data:
 - 1. Erosion control materials
 - 2. Pre-emergent herbicide
 - 3. Filter Fabric
- I. Soil laboratory testing results and any soil amendment recommendations from the Contractor.

1.8 DELIVERY AND STORAGE

- A. Delivery:
 - 1. Notify the Resident Engineer of the delivery schedule in advance so the plant material may be inspected upon arrival at the job site. Remove unacceptable plant material from the job site immediately.
 - 2. Protect plants during delivery to prevent damage to root balls or desiccation of leaves. Protect trees during transport by tying in the branches and covering all exposed branches.

3. Deliver fertilizer to the site in the original, unopened containers bearing the manufacturer's warranted chemical analysis, name, trade name or trademark, and in conformance to state and federal law.
4. During delivery: Protect seed from contamination.

B. Storage:

1. Keep fertilizer in dry storage away from contaminants.
2. Store plants not installed on the day of arrival at the site as follows:
 - a. Shade and protect plants from the wind when stored outside.
 - b. Keep plants in a moist condition until planted.

1.9 LIME TREATMENT OF SUBSOIL

1. Refer to PART 3 -EXECUTION for mitigation of any lime treatment of soils.

1.10 PLANTING INSTALLATION CONDITIONS

- A. Perform planting operations after the irrigation system is installed, tested, and approved.
- B. No work shall be done when the ground is too wet or in an otherwise unsuitable condition for planting. Special conditions may exist that warrants a variance. Submit a written request to the Resident Engineer stating the special conditions and proposal variance.

1.11 PLANT ESTABLISHMENT PERIOD

- A. The Establishment Period for plants shall begin immediately after installation, with the approval of the Resident Engineer, and continue until the date that the Government accepts the project or phase for beneficial use and occupancy. During the Plant Establishment Period the Contractor shall:
 1. Water all plants to maintain an adequate supply of moisture within the root zone. An adequate supply of moisture is the equivalent of 25 mm (1 inch) of absorbed water per week either through natural rainfall or augmented by periodic watering. Apply water at a moderate rate so as not to displace the mulch or flood the plants.
 2. ~~Prune plants and replace mulch as required.~~ Prune trees and plants as directed by the Resident Engineer and under the direct supervision of a foreman certified by Western Chapter of International Arboriculture Society (WCIAS) and in accordance with WCIAS standards.
(Add#02)
 3. Replace mulch as needed to maintain required depth. (Add#02)
 - ~~3.4.~~ Replace and restore stakes, guy wires, and eroded plant saucers as required.
 - ~~4.5.~~ In all planting areas including hydroseeded areas, remove grass, weeds, and other undesired vegetation, including the root growth, before they reach a height of 75 mm (3 inches).

- ~~5-6.~~ Spray with approved insecticides and fungicides to control pests and ensure plant survival in a healthy growing condition, as directed by the Resident Engineer.
- ~~6-7.~~ Remove plants that die during this period and replace each plant with one of the same size and species.
- ~~7-8.~~ Hydroseed: Contractor shall inspect the site with the Resident Engineer, 90 days after the first hydroseeded application and shall reseed any areas bare with soil larger than 4 square feet.

1.12 PLANT WARRANTY

- A. All work shall be in accordance with the terms of the Paragraph, "Warranty" of FAR clause 52.246-21, including the following supplements:
 - 1. A One Year Plant Warranty will begin on the date that the Government accepts the project or phase for beneficial use and occupancy. The Contractor shall have completed, located, and installed all plants according to the plans and specifications. All plants are expected to be living and in a healthy condition at the time of final inspection.
 - 2. The Contractor will replace any dead plant material immediately. A one year warranty for the plants that was replaced, will begin on the day the work is completed.
 - 3. Replacement of relocated plants, that the Contractor did not supply, is not required unless they die from improper handling and care during transplanting. Loss through Contractor negligence requires replacement in kind and size.
 - 4. The Government will reinspect all plants at the end of the One Year Warranty. The Contractor will replace any dead, missing, or defective plant material immediately. The Warranty will end on the date of this inspection provided the Contractor has complied with the work required by this specification. The Contractor shall also comply with the following requirements:
 - a. Replace dead, missing or defective plant material prior to final inspection.
 - b. Mulch and weed plant beds and saucers. Just prior to this inspection, treat these areas to a second application of approved pre-emergent herbicide.
 - c. From plants having been installed for one year, remove stakes, guy wires and any required tree wrappings.
 - d. Complete remedial measures directed by the Resident Engineer to ensure plant survival.
 - e. Repair damage caused while making plant replacements.

1.13 APPLICABLE PUBLICATIONS

- A. The publications listed below, form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.
- B. Ordinances and Regulations: All local, municipal and state laws, codes and regulations governing or relating to all portions of this work are

hereby incorporated into and made a part of these Specifications. Anything contained in these Specifications shall not be construed to conflict with any of the herein listed codes, regulations or requirements of the same. However, when these Specifications and Drawings call for or describe materials, workmanship or construction of a better quality, higher standard than is required by the above mentioned codes and regulations, the provisions of these Specifications and Drawings shall take precedence. Furnish without extra charge additional materials and labor required to comply with above rules and regulations

- C. American National Standards Institute (ANSI) Publications:
 - 1. Z60.1-04 Nursery Stock
 - 2. Z133.1-06 Tree Care Operations-Pruning, Trimming, Repairing, Maintaining, and Removing Trees and Cutting Brush- Safety Requirements
- D. Hortus Third, A Concise Dictionary of Plants Cultivated in the U.S. and Canada.
- E. Contractor shall be familiar with and follow the State of California Model Water Ordinance, California Code of Regulations, Title 23 Waters, Division 2, Department of Water Resources, Chapter 2.7. Also, the Contractor is responsible to follow all local water ordinances and the Soil Management/Analysis Report with verifying implementation.
- F. American Society for Testing and Materials (ASTM) Publications:
 - 1. C136-06 Sieve Analysis of Fine and Coarse Aggregates
- G. Turfgrass Producers International:
 - 1. Turfgrass Sodding.
- H. U. S. Department of Agriculture Federal Seed Act.
 - 1. Rules and Regulations
- I. American Wood Protection Association (AWPA):
 - 1. C2-02 Lumber, Timbers, Bridge Ties and Mine Ties, Pressure Treatment
- J. "Sunset Western Garden Book," Lane Publishing Co., Menlo Park, California; current edition.
- K. Alameda Countywide Clean Water Program (ACCWP) or member agency having jurisdiction over the project work
- L. US Composting Council Compost analysis Program (CAP)
- M. Test Methods for the Evaluation of Composting and Compost (TMECC)
- N. International Society of Arboriculture, Guide for Plant Appraisal, latest version.

- O. United States Composting Council (USCC) Seal of Testing Assurance (STA) program.
- P. TMECC: Refers to "Test Methods for the Examination of Composting and Compost," published by the United States Department of Agriculture and the United States Compost Council (USCC)
- Q. References to "Caltrans Standard Specifications" shall mean the Standard Specifications of the State of California, Business and Transportation Agency, Department of Transportation, CALTRANS.
- R. Manufacturer's recommendations

PART 2 - PRODUCTS

2.1 GENERAL

- A. All plant material shall conform to the varieties specified or shown in the plant list and be true to botanical name as listed in Hortus Third.

2.2 PLANTS

- A. Plants shall be nursery grown in containers and in accordance with ANSI Z60.1, except as otherwise stated in the specifications or shown on the plans. Where the drawings or specifications are in conflict with ANSI Z60.1, the drawings and specification shall prevail.
- B. Plant the variety, quantity and size indicated. The total quantity tabulated on the drawings are considered approximate and furnished for convenience only. Contractor shall perform his/her own plant quantity calculations and shall provide all plants shown on the Drawings.
- C. Tag plants of the type or name indicated and in accordance with the standard practice recommended by the American Association of Nurserymen.
- D. Install healthy, shapely and well rooted plants with no evidence of having been root-bound, restricted or deformed.
- E. Take precautions to ensure that the plants will arrive at the site in proper condition for successful growth. Protect plants in transit from windburn and sunburn. Protect and maintain plants on site by proper storage and watering.
- F. Substitutions will not be permitted, except as follows:
 - 1. If proof is submitted to the Resident Engineer that any plant specified is not obtainable, a proposal will be considered for use of nearest equivalent size or variety with an equitable adjustment of contract price.
 - 2. Substantiate and submit proof of plant availability in writing to the Resident Engineer within 10 days after the effective date of Notice to Proceed.

G. Tree Form: Trees shall have a symmetrical form as typical for the species/cultivar and growth form.

1. Central Leader for Single Trunk Trees: Trees shall have a single, relatively straight central leader and tapered trunk, free of co dominant stems and vigorous, upright branches that compete with the central leader. Preferably, the central leader should not have been headed; however, in cases where the original leader has been remove, an upright branch at least $\frac{1}{2}$ the diameter of the original leader just below the pruning point shall be present.
2. Potential Main Branches: Braches shall be evenly distributed radially around and appropriately spaced vertically along the trunk, forming a generally symmetrical crown typical for the species.
3. Headed temporary branches should be distributed around and along the trunk as noted above and shall be no greater than $\frac{3}{8}$ " diameter, and no greater than $\frac{1}{2}$ diameter of the trunk at point of attachment.

H. Tree Trunk

1. Trunk diameter and taper shall be sufficient so that the tree will remain vertical without the support of a nursery stake.
2. Trunk shall be free of wounds (except properly-made pruning cuts), sunburned areas, conks (fungal fruiting-bodies), wood cracks, bleeding areas, signs of boring insects, galls, cankers and/or lesions.
3. Tree trunk diameter at 6" above the soil surface shall be within the diameter range shown for each container size below, except where shown otherwise:

Container	Trunk Diameter in inches	Soil level from Container Top
5 gallon	0.5" to 0.75"	1.25 to 2"
15 gallon	0.75" to 1.0"	1.75 to 2.75"
24" Box	1.5" to 2. 5"	2.25 to 3"

4. Tree trunks shall be undamaged and uncut with all old abrasions and cuts completely callused over. Do not prune plants prior to delivery.

I. Tree Roots

1. Trunk root collar (root crown) and large roots shall be free of circling and/or kinked roots. Contractor may be required to remove soil near the root collar in order to verify that circling and/or kinked roots are not present.
2. The tree shall be well rooted in the container. When the trunk is lifted the trunk and root system shall move as one and the rootball shall remain intact.
3. The top-most roots or root collar shall be within 1" above or below the soil surface. The soil level in the container shall be within the limits shown in above table.

4. The rootball periphery shall be free of large circling and bottom-matted roots.
5. On grafted or budded trees, there shall be no suckers from the root stock.

J. Shrubs

1. Each shrub must stand upright without support.
2. All container shrubs shall be free of girdling roots, defined as those roots greater than 1/8" diameter circling the periphery of the rootball. The top of the rootball shall be free of "Knees" (roots) protruding above the soil, and the bottom shall be free of matted roots.

- K. Measure trees and shrubs with branches in normal position. Height and spread dimensions indicated refer to the main body of the plant, and not from branch tip to tip.

- L. Make substitutions only when a plant (or its alternates as specified) is not obtainable and the Resident Engineer authorizes a change order providing for use of the nearest equivalent obtainable size or variety of plant having the same essential characteristics with an equitable adjustment of the contract price.

2.3 FERTILIZERS

- A. Commercial fertilizer, pelleted or granular form, conform to the requirements of Chapter 7, Article 2, of the Agricultural Code of the State of California for fertilizing materials as follows:

1. Type A:
6% Nitrogen, 20% Phosphorus Acid and 20% Potash, (6-20-20).
2. Type B:
21 gram planting tablets 20% Nitrogen, 10% Phosphoric Acid and 5% Potash (20-10-5) available from Agriform or 10gm BestPacks packets 20% Nitrogen, 10% Phosphoric Acid and 5% Potash (20-10-5) available from Best Fertilizer Co.
3. Type C:
Complete fertilizer 21% Nitrogen, 7% Phosphoric Acid and 14% Potash (21-7-14).
4. If commercial fertilizer having this analysis is not obtainable, other similar commercial fertilizer may be used providing it meets the approval of the Resident Engineer.

- B. Maintenance Fertilizer: Type C

2.4 ORGANIC AMENDMENT FOR IN SITU SOILS (ON-GRADE):

- A. Ground Redwood or Ground Fir Bark with the following properties:

- | | |
|---------------------------|--------------------------|
| 1. <u>Percent Passing</u> | <u>Sieve Designation</u> |
| 100 | 9.51 mm 3/8" |
| 50-60 | 6.35 mm 1/4" |

20-40 4.76 mm No. 4
0-20 2.38 mm No. 8 8 mesh

Redwood Sawdust

Dry bulk density, lbs. per cu. yd., 260-280
Nitrogen stabilized - dry weight basis, min. 0.4%
Salinity (ECe): 4.0 maximum
Organic Content: 90% minimum
Reaction (pH): 4.0 minimum

Ground Fir and/or Pine Bark

Dry bulk density, lbs. per cu. yd., Min. 350
Nitrogen stabilized - dry weight basis, min. 0.5%
Salinity (ECe): 4.0 maximum
Organic Content: 90% minimum
Reaction (pH): 4.0 minimum

- B. Submit sample along with analytical data from an approved laboratory for degree of compliance to the Resident Engineer within two weeks after award of Contract.

2.5 COMPOSTED YARD WASTE AMENDMENT:

- A. The above Ground Redwood or Ground Fir Bark or Ground Pine Bark (ORGANIC AMENDMENT FOR IN SITU SOILS) is the specified organic amendment material required. Acceptance of Composted Yard Waste Amendment in lieu of the above specified ORGANIC AMENDMENT FOR IN SITU SOILS (ON-GRADE) material will be considered if the in situ planting soil salinity and soil structure is favorable for the inclusion of recycled yard waste organic matter, as approved by the Resident Engineer. It is the Contractor's responsibility to secure test samples of both the planting soil and the proposed composted yard waste amendment (2 quart samples) and submit to Soils and Plant Laboratory for evaluation and recommendations. The composted yard waste amendment sample shall be a grab sample from the currently available material that has been tested within the last 30 days and shall include the composter's Compost Technical Data Sheet that includes lab analytical test results and directions for product use along with list of ingredients. The composted yard waste amendment shall be a mixture of feedstock materials including green material consisting of chipped, shredded, or ground vegetation and mixed food waste, or clean processed recycled wood products. Single source, Biosolids (sewage waste) compost will not be acceptable.
- B. Based on the Soils and Plant Laboratory evaluation, the addition of composted yard waste amendment shall not be acceptable if it creates a leaching requirement.
- C. The addition of the compost shall result in a final ECe of the amended soil of less than 4.0 dS/m @ 25 degrees C. as determined in a saturation extract. Use the following table to determine the maximum allowable Ece (dS/m of saturation extract) of compost at desired use rate and allowable Ece increase.

DESIRED USE RATE		MAXIMUM ALLOWABLE Ece INCREASE FROM AMENDMENT		
Cu. Yds. Amendment Per 1000 Sq. Ft. for Incorporation to 6" depth	Volume percentage of amendment	1 dS/m	2 dS/m	3 dS/m
		Maximum Ece of Compost		
1	5	14	28	42
2	11	7	14	21
3	16	5	9.5	14
4	22	3.5	7	10.5
5	27	3	5.5	8.5
6	32	2.5	4.5	7

- Example: Specification calls for 6 cu. Yds. Compost per 1000 sq. ft. for incorporation to 6" depth, and site soil has an Ece of 2.0. In order to avoid exceeding Ece of 4 in final blend, compost Ece shall be less than 4.5 dS/m.

D. Composted Yard Waste Soil Amendment Properties as follows:

1. Gradation:

Percent Passing by weight	Sieve Designation		
90	1/2"		
85-100	9.51 mm	3/8"	
50-80	2.38 mm	No. 8	8 mesh
0-40	500 micron	No. 35	32 mesh
Maximum length 4 inches			

- Organic Content: Minimum 45% based on dry weight and determined by ash method.
- Carbon to nitrogen ratio: Maximum 35:1 if material is claimed to be nitrogen stabilized.
- pH: 5.5 - 8.0 as determined in saturated paste.
- Soluble Salts: See above.
- Moisture Content: 35-60%.
- Physical Contaminants:
 - The compost shall be free of contaminants such as glass, metal and visible plastic per Man Made Inert Removal and Classification: TMECC 02.02, % > 4mm fraction. Combined total less than 1.0.
 - Man Made Inert Removal and Classification: Sharps % > 4mm fraction. (sewing needles, hypodermic needles) Non Detected.
- Pathogens: TMECC 07.01-B Fecal Coliform Bacteria <1000 MPN/gram dry wt. <1000 (Pass)

9. Pathogens: TMECC 07.01-B Salmonella <3 MPN/4grams dry wt. <3 (Pass)
10. Maturity: Physical characteristics suggestive of maturity include:
 - a. Color: Dark brown to black.
 - b. Acceptable Odor: None, soil-like, musty or moldy.
 - c. Unacceptable Odor: Sour, ammonia or putrid.
 - d. Particle Characterization: Identifiable wood pieces are acceptable but the balance of the material shall be soil-like without recognizable grass or leaves.
 - e. TMECC 07.01-A Germination and Vigor, % Relative to Positive Control for Seed Emergence and Seedling Vigor: 80 or above.

E. Submit planting soil and composted yard waste amendment samples along with laboratory report from Soils and Plant Laboratory for degree of compliance as specified above and composter's Compost Technical Data Sheet that includes lab analytical test results and directions for product use along with list of ingredients to the Resident Engineer a minimum of 3 weeks prior to beginning soil prep. The laboratory report shall include recommendations for adjusting fertilizer and amendment quantities. Upon approval of the Laboratory's report by the Resident Engineer, the recommendations in the report shall become a part of the Specifications and the quantities of soil amendment and fertilizer shall be adjusted to conform with the report at no additional cost to the owner.

2.6 IRON SULFATE

A. Type: Dry form.

2.7 PLANT BACKFILL

A. Except for acid loving plants (Azaleas, Rhododendrons, Ferns, Camellias, etc.), use a mixture of 2 parts soil from the hole, and 1 part amendment with iron added at the following rates:

Size	Rate
1 gallon can plants	iron, 1/4 cup
5 gallon can plants	iron, 1/3 cup
15 gallon can plants	iron, 1/2 cup
24" box and larger	iron, 1 cup

1. Mix the iron, amendment and soil thoroughly for use only in the top 8 inches of backfill around plants. For acid loving plants, mixture to be 1/2 soil from the hole and 1/2 amendment only in the top 8 inches.

2.8 MULCH

- A. Organic Mulch: Fir tree or pine tree bark, dark gray or black in color; 3/4-inch to 1-inch size.
- B. Submit samples of organic mulch to the Resident Engineer for approval within two weeks of award of Contract. Resubmit until acceptable to Resident Engineer, at no extra cost.

2.9 TREE SUPPORT POLES

- A. Support Poles for trees up to 36" box size.
- B. Type: Peeled lodge pole pine logs, clean, smooth, new, and sized as follows:
 - 1. Two-inch (2") diameter by eight feet (8') long for trees less than 8' high and 1" caliper.
 - 2. Three-inch (3") diameter by eight to ten feet (8' - 10') long for trees greater than 8' high and 1" caliper.

2.10 TIES

- A. Rubber strap, 24-inch minimum length without sharp edges adjacent to trunk.

2.11 TREE GUYING:

- A. If subgrade does not accept poles sufficiently to stabilize the tree, guy trees per these specifications and plans.
- B. For trees up to 3" caliper, 3/16" galvanized steel cable, with rubber tree collar, 12" minimum long, and secured with cable clamp, and attached to anchor for below-grade location.
- C. For trees 3" to 6" caliper, 1/8" galvanized steel cable with rubber tree collar, 21" minimum long, and secured with cable clamp, 3" take-up eye to eye turnbuckle, and attached to anchor for below-grade location.
- D. For trees in raised planters, provide expansion bolt anchors into concrete planter walls and secure cables to anchor bolts.

2.12 TREE ROOT BARRIER

- A. Root Barrier shall be black injection molded panels of .080" wall thickness in modules 24d" long by 18" deep manufactured with a minimum 50% post consumer recycled polypropylene plastic with added ultraviolet inhibitors, recyclable
- B. Each panel shall have not less than 4 molded integral vertical root deflecting ribs of at least 0.06" thickness protruding 1/2" at 90 degrees from interior of the barrier panel, spaced 6" apart. A double top edge consisting of two parallel, integral, horizontal ribs at the top of the panel of a minimum 0.06" thickness 3/8" wide and 1/4" apart. A minimum of 9 anti-lift tabs consisting of integral horizontal ridges of a minimum 0.06" thickness.
- C. Panels shall have an instant assembly system by sliding one panel into another.

2.13 PLANTING SOIL (TOPSOIL):

- A. Planting soil is defined as screened imported soil. Satisfactory planting soil shall be free of subsoil, clay, lumps, stones, and other objects over 2" in diameter, and without weeds, roots, and other objectionable material.

2.14 IMPORTED PLANTING SOIL (TOPSOIL):

- A. Imported planting soil shall be fertile, friable, natural, productive soil containing a normal amount of humus, and shall be capable of sustaining healthy plant life. Planting soil shall be free of subsoil, heavy or stiff clay, rocks, gravel, brush, roots, weeds, noxious seeds, sticks, trash, and other deleterious substances. Soil shall not be infested with nematodes or with other noxious animal life or toxic substances. Soil shall be obtained from well-drained, arable land, and shall be of an even texture. Soil shall not be taken from areas on which are growing any noxious weeds such as Morning Glory, Sorrel, or Bermuda Grass.
- B. Imported planting soil shall have a pH value of between 6.0 and 7.5, a boron concentration of the saturation extract of less than 1 ppm, salinity of the saturation extract at 25 degrees C. of less than 4.0 millimoles, and a sodium absorption rate (SAR) of less than 8.
- C. The silt and clay content of imported planting soil shall not exceed that of the existing soil it is to be placed over. It shall be a "Sandy Loam" as classified in accordance with USDA Standards with a combined total of between 25% to 40% Clay and Silt. Provide existing site soil sample analysis report for comparison with the imported soil report.
- D. Make the site of the source of supply of planting soil available to the Resident Engineer for observation and approval prior to any hauling or placing of soil. In addition, submit for approval a 1-quart sample of soil, together with a standard soil analysis report by an accredited soils analyst showing chemical analysis stating source, fertility, agricultural suitability and particle size distribution of the soil. Deliver the sample to the Resident Engineer two weeks before starting the contemplated hauling of the soil. Following approval of the sample, provide a one-half cubic yard sample, which shall be stored at the site of work for comparison with subsequent loads of soil. The comparison sample shall be protected by a cover until the furnishing of all soil has been completed and accepted. Should the soil submittal lack certain requirements which can be added to the soil, the Resident Engineer will consider a request by the Contractor to amend the soil as recommended by the Soils Analyst at the Contractor's expense.

2.15 HYDROSEED MIXES

- A. Incorporate the following seed uniformly in hydromulch with tackifier as required at the specified rates per acre. Provide seed of the latest crop, labeled in accordance with the California Food Agricultural Code with the following ingredients per acre:

Erosion Control Hydroseed Mix:
65% Zorro Fescue (*Festuca megalura*)
30% Hykon Clover / Rose Clover (*Trifolium hirtum*)
5% Wildflower Mix
California Poppy (*Eschscholzia californica*)
Lupine (*Lupinus succulentus*)
Tidy Tips (*Layia platyglossa*)
Seed Rate: 60 lbs/acre
Wood Fiber: As specified below, minimum 1,800 lbs/acre
Fertilizer (16-20-0): 450 lbs/acre
Stabilizer: As provided with Hydroseed Mulch with Tackifier specified below, minimum 80 lbs/acre
Native Wildflower Hydroseed Mix:
25#/AC *Bromus carinatus*/California Brome
10#/AC *Hordeum brachyantherum*/Meadow Barley
6#/AC *Vulpia microstachys*/ Three Weeks Fescue
4#/AC *Trifolium wildenovii*/Tomcat Clover
10#/AC Bay Area Native Wildflower LEED - 2011
Seed Rate: 55 lbs/acre
Wood Fiber: As specified below, minimum 1,800 lbs/acre
Fertilizer (16-20-0): 450 lbs/acre

- B. Seeds of Legumes: Inoculated with pure culture of nitrogen-fixing bacteria prepared specifically for legume species in accordance with inoculant manufacturer's instructions.
- C. All seed shall be in conformance with the California State Seed Law of the Department of Agriculture. Each seed bag shall be delivered to the site sealed and clearly marked as to species, purity, percent germination, dealer's guarantee, and dates of test. In addition, the container shall be labeled to clearly reflect the amount of Pure Live Seed (PLS) contained. Prior to seeding at the request of the owner, the contractor shall provide a letter of certification, original Association of Official Seed Analysts (AOSA) seed test results, and calculations of PLS content.
- D. All legume seed shall be pellet-inoculated and provided in Bulletin AXT-280 of the University of California Cooperative Extension, "Pellet Inoculation of Legume Seed." Inoculant sources shall be species specific and shall be applied at a rate of 2 pounds of inoculant per one hundred pounds of seed.
- E. Fiber Mulch with Tackifier: Fibrous, wood cellulose with tackifier containing no growth or germination inhibiting factors and manufactured in such a manner that after addition and agitation in slurry tanks with fertilizer, seed, water and other approved additives, the fibers in the material become uniformly suspended to form a homogeneous slurry; and that when hydraulically sprayed on the ground, the material forms a blotter-like ground cover impregnated uniformly with seed; and which, after application, allows the absorption of moisture and rainfall to percolate to the underlying soil. The fibrous mulch in its air-dry state shall contain not more than 15% by weight of water. The fiber shall have a temporary green dye and shall be accompanied by a certificate of compliance stating that the fiber conforms to these specifications. For slopes 3 to 1 or flatter,

apply at a rate of 3000 lbs. per acre. For slopes greater than 3 to 1, apply at a rate of 4000 lbs. per acre.

F. The Tackifier/Stabilizer: Shall be an organic substance supplied in powder form and shall be psilium-based and packed in clearly marked bags stating the contents of each package. The California Department of Food and Agriculture shall certify the material as an Auxiliary Soil Chemical.

G. Hydroseed fertilizer: Hydroseed fertilizer to be used in the slurry shall be commercial fertilizers conforming to the requirements of the California Food and Agricultural Code; uniform in composition, with a guaranteed chemical analysis of 16% Nitrogen, 20% Phosphoric Acid, and 0% Potash (16-20-0) plus Sulfur (approximately 15%).

2.16 PRE-EMERGENCE WEED KILLER

A. Clean non-staining as recommended by a licensed pest control specialist.

2.17 VINE TIES:

A. For vines that require supports in order to climb, install anchor bolts with clear vinyl coated 3/16" galvanized steel cable, secured and taut with cable clamps, on structure in configuration approved by Resident Engineer. Train vine branches to supports with green nursery tape.

2.18 BIOSWALE PLANTING SOIL BACKFILL MIX:

A. Bioswale backfill mix to receive planting shall be as specified below and as shown in Drawings:

BIOSWALE SPECIFICATION GUIDELINES

(Courtesy of Soil & Plant Laboratory, Inc. Santa Clara, CA)

For the filtration of runoff water before it enters the storm drain system

The mineral component shall be classified as USDA sand or loamy sand and shall conform to the following particle size and characteristics.

US Sieve	Size (mm)	Class	% wt. retained
#10	2.0	Gravel	0-10
#35	2.0-.05	Coarse Sand	20-35
#270	<0.05	Silt & Clay	6-12

Rock 1/2 inch - 1 inch = 0-5% by volume with none > 1 inch
Organic = 0-3% by weight for below 6 inches

2.19 PERCOLATION RATE

A. Must fall in the range of 10 inches per hour Initial Rate and 5 inches Sustained rate as determined by SPL method A06-2.

2.20 CHEMISTRTRY SUITIBILITY CONSIDERATIONS

- A. Salinity: Saturation Extract Conductivity (ECe) Less than 3.0 dS/m @ 25° C.
Sodium: Sodium Adsorption Ratio (SAR) Less than 6.0
Boron: Saturation Extract Concentration Less than 1.0 ppm
Reaction: pH of Saturated Paste: 5.5 - 7.8 without high lime content.
- B. To insure conformance submit ½ gallon sample for analytical packages; A06-2, A05-1 to Soils & Plant Laboratory, Santa Clara, CA.

2.21 PROFILE PREPARATION

- A. NOTE: If organic content of the mineral component is less than 0.6% weight, then it should be blended with *compost in volume proportions of 5% compost to 95% mineral.
- B. After placement the top 6 inches should be blended with *compost. If bulk blended, proportions should be 1 part compost to 4 parts of the above mineral component. If blended in place this would be equivalent to 4 ½ cubic yards per 1000 square feet for blending to 6 inches.
- C. * Compost to comply with Yard Waste Compost specifications on the enclosed form #415.

2.22 YARD WASTE COMPOST -FORM #415 SPECIFICATIONS GUIDELINES

- A. (Courtesy of Soil & Plant Laboratory, Inc. Santa Clara, CA)
- B. Gradation: A minimum of 90% of the material by weight shall pass a 1/2" screen. Material passing the 1/2" screen shall meet the following criteria.

<u>Percent Passing</u>	<u>Sieve Designation</u>
85 - 100	9.51 mm (3/8")
50 - 80	2.38 mm (No. 8)
0 - 40	500 micron (No. 35)

1. Organic content: Minimum 50% based on dry weight and determined by ash method. Minimum 250 lbs. organic matter per yard of compost.
 2. Carbon to nitrogen ratio: Maximum 35:1.
 3. pH: 5.5 - 8.0 as determined in saturated paste.
 4. Soluble salts: Soluble nutrients typically account for most of the salinity levels but sodium should account for less than 25% of the total. To avoid a leaching requirement, the addition of the compost shall result in a final ECe of the amended soil of less than 4.0 dS/m @ 25 degrees C. as determined in a saturation extract.
- C. Use the following table to determine the maximum allowable ECe (dS/m of saturation extract) of compost at the desired use rate.

Desired Use Rate		Salinity (ECe) of On-Site Soil		
Cu. Yds. Amendment per 1000 sq. ft. for incorporation to 6" depth	Volume Percentage of Amendment	3 dS/m	2 dS/m	1 dS/m
		Maximum ECe of Compost		
2	11	7	14	21
3	16	5	9.5	14
4	22	3.5	7	10.5
5	27	3	5.5	8.5

- D. Example: Specification calls for 4 cu. yds. Compost per 1000 sq. ft. to a 6" depth, and site soil has an ECe of 2.0.
- E. In order to avoid exceeding an ECe of 4 in the final blend, compost ECe should be less than 5.5 dS/m.
1. Contaminants: The compost shall be free of contaminants such as glass, metal and visible plastic. Heavy metals, fecal coliform, and Salmonella sp shall not exceed levels outlined in California Integrated Waste Management regulation/
 2. Maturity characteristics:
 - a. Color: dark brown to black
 - b. Odor: Acceptable = none, soil-like, musty or moldy
Unacceptable = sour, ammonia or putrid
 - c. Particle characterization: Identifiable wood pieces are acceptable but the balance of material should be soil-like without recognizable grass or leaves. (3/5/07)

2.23 FILTER FABRIC

1. Needle punched nonwoven geotextile Filter Fabric composed of polypropylene fibers, which are formed into a stable network such that the fibers retain their relative position. Inert to biological degradation and resists naturally encountered chemicals, alkalis, and acids weighing 18 grams per square meter. Meets Aashto M288-06 Class 3 for elongation > 50%.

2.24 PIPE:

- A. Polyvinyl Chloride (PVC) pipe and pipe fittings shall meet extra strength minimum of SDR-35 of the requirements of ASTM Specification D3034.
- B. Perforated and non-perforated corrugated polyethylene pipe, 3- to 10-inch diameter, shall meet the requirements of ASTM D883 and ASTM F412, and shall conform to Section 68 of the Standard Specifications.
 1. Corrugated polyethylene pipe fittings shall comply with all requirements of AASHTO M-252-85I for 3- to 10-inch diameter pipe. Couplings shall be split or snap-on type for perforated pipe and split

couplings with gaskets for non-perforated pipe. Cutting pipe with integral couplings will not be allowed.

2. Corrugated polyethylene pipe and fittings manufactured by Advanced Drainage Systems, Inc., shall be considered the standard to determine compliance to this specification.

C. Inspection Tube Cap

1. Paint cap one coat chocolate-brown color using Flat, exterior grade latex paint as accepted by Resident Engineer.

2.25 PERMEABLE BACKFILL (FILTER ROCK)

- A. Permeable backfill used in subsurface drain installations to be Class 2 permeable material in conformance with Section 68 "Subsurface Drains" of the Caltrans Standard Specifications; gradation to 3/4" maximum size. Submit Sample for approval.

2.26 EROSION CONTROL NETTING

- A. New, with a uniform, open plain-weave, flame-retardant mesh. The mesh shall be [natural brown-tan] [dyed green] and made from unbleached single jute yarn. The yarn shall be of loosely twisted construction and shall not vary in thickness by more than one-half its normal diameter. Furnish jute mesh in rolled strips to meet the following requirements:
 1. Width: 48 inches, with a tolerance of one-inch wider or narrower.
 2. Not less than 78 warp ends per width.
 3. Not less than 41 weft ends per yard.
 4. Weight shall average 1.22 pounds per linear yard, with a tolerance of 5 percent heavier or lighter.

2.27 ANTIDESICCANT

- A. Antidesiccant shall be an emulsion specifically manufactured for agricultural use that will provide a protective film over plant surfaces permeable enough to permit transpiration.

PART 3 - EXECUTION

3.1 FINE GRADING AND SOIL PREPARATION

A. General

1. Soil in all planting areas shall be moist, but not so moist that it sticks to a hand shovel, and loose and friable to a minimum depth of 12 inches with a relative maximum compaction of 85%. Rip and scarify and dry any areas that do not meet this requirement.
2. Prior to excavating for plant pits and bed, verify the location of any underground utilities. Damage to utility lines shall be repaired at the Contractor's expense. Where lawns have been established prior to planting operation, cover the surrounding turf before excavations

are made in a manner that will protect turf areas. Barricade existing trees, shrubbery, and beds that are to be preserved in a manner that will effectively protect them during the project construction

3. No work shall be done when the ground is too wet or in an otherwise unsuitable condition for earthwork and planting. Special conditions may exist that warrants a variance. Submit a written request to the Resident Engineer stating the special conditions and proposal variance.
4. Before proceeding with the work: Carefully inspect all areas and verify all dimensions and quantities. Immediately inform the Resident Engineer of any discrepancy between the drawings and specifications and actual conditions and secure approval to proceed.

B. Lime Treated Soil Removal

1. Any Lime treated soils shall be removed full depth of treated soil from planting areas and replaced with approved planting soil as accepted by Resident Engineer. Contractor shall field measure and record all lime treated areas on As Built Drawings showing both depth and areas.
2. Following removal of lime treated material, scarify subgrade to a minimum depth of 6 inches prior to backfilling.
3. Test subgrade in all planting areas for drainage by flooding with 4 inch depth of water puddle and verify complete absorption of standing water within two hours. If standing water is still present after two hours, provide perforated pipe and drain rock "French Drain" system in bottom of non-draining planters and connect to storm drainage system, as accepted by Resident Engineer.

C. Planting Soil Placement:

1. Inspect planting areas and remove all base rock and other foreign material. Verify placement of planting soil within dripline of trees with Resident Engineer. Except within tree driplines, rip all planting areas in two directions full depth of compacted fill (to a minimum of 12 inches) into undisturbed native soil prior to backfilling. Scarification of any planting area which cannot be accomplished with a tractor shall be accomplished by an alternative method approved by the Resident Engineer to the specified depth to ensure proper percolation/drainage.
2. Prior to placing planting soil secure the Resident Engineers acceptance of the planting areas subgrade condition. Test depth of loose soil with hand shovel in presence of Resident Engineer in several locations as directed. After acceptance of the planting areas subgrade condition, uniformly distribute and spread planting soil backfill over scarified subgrade in planting areas as specified and compact to a maximum of 85% relative compaction.
3. Do not work planting soil in a wet or muddy condition or dump or spread in areas where subgrade is not in proper condition.
4. Water settling, puddling, and jetting of fill and backfill materials as a compaction method is not acceptable.

5. Provide a minimum of [12"] depth in planting areas, or more where shown or specified otherwise.
- D. Planting Soil Placement in Planting Islands and Adjacent to Pavement Areas:
 1. Provide planting soil as a final lift in all planting areas within and adjacent to paved areas and other construction where native site soil has been covered by engineered fill and/or base rock. Remove all engineered fill, base rock and compacted subgrade full depth of compaction and replace with approved planting soil, a minimum lift of [12"]. Unless shown otherwise, finish grade in planting islands shall be crowned with a minimum 2 % pitch to the edges.
- E. All planting areas soil shall be loose and friable prior to planting. Rip any overly compacted and re-compacted planting areas in two directions full depth of compacted soil prior to planting.
- F. Planting operations shall be performed only during periods when beneficial results can be obtained. When excessive moisture or other unsatisfactory conditions prevail, the work shall be stopped until conditions are satisfactory.
- G. Thoroughly wet down the planting areas to settle the soil and confirm irrigation coverage and operation. Allow soil to dry so as to be workable as described herein.
- H. Drag to a smooth, even surface. Grade to form all swales. Pitch grade with uniform slope to catch basins, streets, curb, etc., to ensure uniform surface drainage. Areas requiring grading include adjacent transition areas that shall be uniformly sloped between finish elevations. Slope surface away from walls so water will not stand against walls or buildings. Control surface water to avoid damage to adjoining properties or to finished work on the site. Take required remedial measures to prevent erosion of freshly graded areas and until such time as permanent drainage and erosion control features have been installed. Refer to Erosion Control Netting below for treatment of slopes 3:1 and steeper.
- I. Finish Grade: Hold finish grade and/or mulch surface in planting areas 1/2-inch below adjacent pavement surfaces, tops of curbs, manholes, etc. The subgrade of the mulch in mulched planting areas shall be a minus 2 inches for a distance of 12 to 18 inch from the edge of pavement. The remainder of the planting area shall be graded to receive the required 3 inch layer of mulch.
- J. In Situ Soil Preparation:
 1. Spread organic amendment, iron and Type A fertilizer evenly over installed and rough graded topsoil in all planting areas including ground cover and shrub areas at the following rates:
 - a. Organic Amendment: 6 cubic yards per 1,000 square feet
 - b. Fertilizer: Type A (6-20-20) at 20 lbs. per 1,000 square feet.
 - c. Iron Sulfate: 10 lbs. per 1,000 square feet

2. Rototill above additives into soil 6 to 8 inches deep. Keep iron sulfate off pavement and other surfaces to prevent rust staining. Correct all rust damage to work.

3. Planting soil shall have a pH range of 6.5 to 7.5.

- K. After the rototill work, float areas to a smooth, uniform grade as indicated on the drawings. Slope all planting areas to drain. Roll, scarify, rake and level as necessary to obtain true, even planting surfaces. Remove rocks, sticks and debris 2 inches or larger in shrub and ground cover areas. Secure approval of the grade by the Resident Engineer before any planting.

3.2 BIOSWALE PLANTING SOIL BACKFILL MIX

- A. Install the above specified bioswale backfill mix as shown in Drawings after approval of the drainage material installation.

3.3 HYDROSEED

- A. The contractor shall proceed with work during a period of August 15 through October 15, or between January 15 and February 15 which are optimal for application. Refer to 1.11 PLANT ESTABLISHMENT PERIOD for performance requirements.

3.4 EROSION CONTROL NETTING

- A. Verify finished grades and provide Jute Mesh and single grind Redwood bark mulch on all slopes 3:1 and steeper as accepted by the Resident Engineer. Install jute mesh loosely up and down the slope in accordance with manufacturer's specifications and as follows. Fit the soil surface contour and hold in place with 12-inch long, 11-gauge (minimum) steel wire staples driven vertically into the soil at 18- to 24-inch spacing. Jute mesh strips shall overlap along all edges at least 6 inches. Ends of side strips shall be buried into the soil at least 6 inches. Drive staples along edges to securely anchor mesh to ground.

3.5 ALUMINUM EDGING

- A. Install in continuous strips as indicated and in accordance with manufacturer's recommendations with stakes spaced 48 inches on center maximum and at all joints.

3.6 TREE AND SHRUB PLANTING

- A. Mark tree and shrub locations on site using stakes, gypsum or similar approved means and secure location approval by the Resident Engineer before plant holes are dug. Review location of plants in relationship to irrigation heads and adjust location(s) that interfere with the function of the spray heads as accepted by the Resident Engineer prior to planting.
- B. Test drainage of plant pits by filling with water (minimum 6"). The retention of water in planting beds and plant pits for more than two (2) hours shall be brought to the attention of the Resident Engineer. If rock, underground construction work, tree roots, poor drainage, or other

obstructions are encountered in the excavation of plant pits, alternate locations may be selected by Resident Engineer.

- C. Break and loosen the sides and bottom of the pit to ensure root penetration and water test hole for drainage as required above.
- D. Backfill plant holes with mix as specified, free from rocks, clods or lumpy material. Backfill native soil free of soil amendments under rootball and foot tamp to prevent settlement. Backfill remainder of the hole with soil mix and place plant tablets or packets (Type B fertilizer) 3 inches below finish grade and 1/2-inch from roots at the following rates:

<u>Size</u>	<u>Rate</u>
1 gallon can plant	1 tablet or packet
5 gallon can plant	3 tablets or packet
15 gallon can plant	6 tablets or packet
24-inch box plant	6 tablets or packet
36-inch box plant	8 tablets or packet

- E. Carefully remove and set plants without damaging the rootball. Superficially cut edge roots vertically on three sides. Remove bottom of plant boxes before planting. Remove sides of boxes after positioning the plant and partially backfilling.
- F. Set plants in backfill with top of the rootball 2 inches above finished grade. Backfill remainder of hole and soak thoroughly by jetting with a hose and pipe section. Water backfill until saturated the full depth of the hole.
- G. Build 6" high watering basin berms around trees and shrubs to drain through rootball.
- H. Stake and/or guy trees as detailed and noted herein. Drive stake(s) until solid (at least 12" beyond bottom of rootball) and remove excess stake protruding above top tree tie to prevent rubbing against branches. Avoid driving stakes through rootball. If subgrade does not accept stakes to a stable degree, delete stakes and guy the trees as specified herein and as detailed. Locate tree ties to avoid contact with tree branches. Locate top tie at tree flex point.
- I. Where tree guying is required, Guy Trees using 3 cables with below grade anchors and rubber collars secured with cable clamps.
- J. Remove any soil from top of plant rootballs and secure Resident Engineer's approval of rootball height prior to mulching.
- K. After approval of rootball height, install mulch as required below.
- L. Trees damaged during installation, including broken branches, shall be brought to the attention of the Resident Engineer. Contractor shall replace damaged tree as determined by the Resident Engineer. If replacement is not necessary, Contractor shall prune damaged branches as directed by the Resident Engineer and under the direct supervision of a foreman certified by Western Chapter of International Arboriculture Society (WCIAS) and in accordance with WCias standards. ^(Add#01)

3.7 EXISTING TREES (Add#01)

- A. Where new planting is shown within the drip line of existing trees, the Contractor shall proceed with care and caution. Perform a thorough investigation of the area with a Certified Arborist and the Resident Engineer to determine where excavation for new plants is possible, without impacting or damaging tree roots.
- B. Excavation within the drip line shall be done by hand only, with no exceptions unless approved or directed by the Arborist and Resident Engineer.
- C. The contractor shall coordinate with the Irrigation installation and the requirements of 328400 Planting Irrigation to determine and adjust plant locations.

3.8 GROUND COVER PLANTING

- A. Plant in neat, straight, parallel and staggered rows as indicated on plan. Plant first row one-half required ground cover spacing behind adjacent curbs, structures, or other plant bed limits. Plant ground cover to edge of water basins of adjacent trees and shrubs.

3.9 MULCH

- A. Except where rock mulch is required, mulch all tree, shrub and ground cover areas with organic mulch to a 3-inch depth, except adjacent to walkways where soil grade is 2 inches below top of pavement, mulch shall be 2 inches deep, and 2-inches deep where planting ground cover plants from flats. Hold bark mulch away from base (trunk) of plant 4" or as directed by the Resident Engineer. Individual trees and/or shrubs planted in non-irrigated areas shall, at minimum, receive bark mulch over their watering basin and berm. No mulch is required around trees in bioswales or bioretention basins.
- B. Install rock mulch to a minimum 3-inch depth where shown.

3.10 ROOT BARRIER

- A. Install in linear fashion along and adjacent to the edges of the planting area as detailed or, if not shown, in accordance with manufacturer's recommendations. Set top of barrier approximately ½-inch above finished soil surface to allow concealment with mulch, as accepted by Resident Engineer.

3.11 PRE-EMERGENCE WEED KILLER

- A. Apply pre-emergence weed killer in all areas to receive ground cover planting. Work shall be done under the supervision of a person licensed by the State of California as a pest control applicator and holding a qualified applicator license or a Qualified Applicator Certificate. Obtain approval of the finish grades prior to applying weed killer and coordinate planting and watering with the pest control specialist prior to planting. Take care to keep weed killer off areas to be seeded.

3.12 WATERING

- A. Water trees, shrubs and ground cover immediately after planting. Apply water to plants as often and in sufficient amount as conditions may require to keep the plants in a healthy vigorous growing condition until completion of the Contract. Do supplemental hand watering of trees and shrubs during the first 3 weeks of plant establishment.

3.13 RESTORATION AND CLEAN-UP

- A. Where existing or new turf areas have been damaged or scarred during planting and construction operations, restore disturbed area to their original condition. Keep at least one paved pedestrian access route and one paved vehicular access route to each building clean at all times. In areas where planting work have been completed, clear the area of all debris, spoil piles, and containers. Clear all other paved areas when work in adjacent areas is completed. Remove all debris, rubbish and excess material from the station.

3.14 ENVIRONMENTAL PROTECTION

- A. All work and Contractor operations shall comply with the requirements of Section 01 57 19, TEMPORARY ENVIRONMENTAL CONTROLS.

3.15 CONSTRUCTION WASTE MANAGEMENT

- A. General: Comply with Contractor's Waste Management Plan and Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.
- B. To the greatest extent possible, separate reusable and recyclable products from contaminated waste and debris in accordance with the Contractor's Waste Management Plan. Place recyclable and reusable products in designated containers and protect from moisture and contamination.

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(Add#01) 18 SEP 2013, Addendum No. 1

(Add#02) 07 OCT 2013, Addendum No. 2