SECTION 23 52 33.20
HEAT RECOVERY STEAM GENERATOR (HRSG)

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies packaged heat recovery steam generator (HRSG) with trim (accessories), natural gas duct burner, fuel trains, main and diverter vent stacks, silencer on diverter vent stack, expansion joints, controls, instrumentation, flue gas economizer, ladders, walkways, platforms and/or stairs, and diverter assembly. All references to “boiler” in the specifications and Drawings are interchangeable with the term “heat recovery steam generator” or “HRSG” as specified in this section as it pertains to the Cogen installation.

1.2 RELATED WORK:

A. Section 09 91 00, PAINTING.

B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.

C. Section 23 05 51, NOISE and VIBRATION CONTROL FOR BOILER PLANT.

D. Section 23 21 11, BOILER PLANT PIPING SYSTEMS: Valves for HRSG trim, non-return stop-check valve, piping for fuel and feedwater trains.

E. Section 23 51 00, BREECHINGS, CHIMNEYS, and STACKS: HRSG outlet damper systems, breechings, stacks, flue gas recirculation (FGR) ductwork.

F. Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT: Burner controls, combustion control system, HRSG water level control, pressure gages, thermometers.

G. Section 23 08 11, DEMONSTRATIONS and TESTS FOR BOILER PLANT.

H. Section 23 08 00 – COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.

I. Section 23 50 10, TURBINE/GENERATOR PACKAGE.

1.3 QUALITY ASSURANCE:

A. The turbine/generator package manufacturer shall be solely responsible for providing the HRSG, diverter burner and accessories necessary to provide a fully functional cogeneration plant.

B. Coordinate all new and existing equipment and conditions. This includes, but is not limited to: HRSG, HRSG trim, burner, fuel trains, gas pressure regulators and available gas pressure, burner control system, combustion control system, economizer, diverter, breeching and stacks and access platforms.

B. Provide written certification that the entire assembly has been coordinated to achieve the required performance and to provide the required features.

C. The model and size of the proposed burner shall have been previously applied to at least three HRSGs that are similar in size, proportion, and arrangement to the proposed HRSG. In each of the three installations, burner performance shall have conformed to requirements listed in Part 2, BURNER and FUEL TRAINS. Provide list of these installations, and name, address and telephone number of person familiar with each project who will serve as a reference source.

D. 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.

1.4 SUBMITTALS:

A. Before executing any work, submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. 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, emissions and arrangement of refractory and insulation.
5. Amount of heating surface, combustion volume.
6. Weight of HRSG and burner assembly, empty and flooded.
7. Design pressures and temperatures.
8. Loading diagram of support frame. Evidence that HRSG support requirements have been coordinated with foundation design.
9. Recommended anchorage of HRSG support frame to foundation.
10. Furnace viewport construction, locations.
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 HRSG.

C. 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 HRSG.

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 HRSG and highest and lowest permissible water lines of HRSG.
8. Set pressure and capacity of safety valves.

D. Duct Burner and Fuel Trains:

1. Catalog data and drawings showing construction of burner parts and assembly of complete system.
2. Drawings, with dimensions, showing burner overall size and mounting on the HRSG.
3. Catalog data and outline drawings of forced draft fan, flue gas recirculation ductwork (if provided), dampers, motors and sound attenuators on fan intake or discharge.
4. Drawings showing assembly of throat refractory into furnace refractory wall.
5. Type and temperature rating of throat refractory.
6. Drawings and catalog data on all equipment in igniter (pilot) train, main fuel trains, atomizing media train. Include data on pressure and temperature ratings, flow vs. pressure drop, performance characteristics, and inspection agency approvals. Complete data on oil atomization air compressor systems with sound attenuators.
7. ASTM number and schedule numbers on all piping.
8. Type and pressure ratings of pipe fittings.
9. Burner flow and pressure data:
   a. Main burner fuel and atomizing media pressures 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 and LP gas) at outlet of burner-mounted pressure regulators.
10. Full load efficiency and power factor of all motors.
11. Predicted sound level at maximum firing rate.
12. Weight of burner assembly.
13. Drawings showing location and arrangement of drive units and jackshaft system (if provided) for controlling fuel and air flow.

14. Weight of burner assembly.

E. Burner Management (Flame Safeguard) Control System: Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT.

F. Flue Gas Economizer:

1. Drawings showing arrangement and dimensions of unit and all accessories.
2. Design and construction of unit and accessories including soot blowers, safety relief valve.
3. Weight of entire unit, empty and flooded.
4. Pressure and temperature limitations of unit and accessories.
5. Performance data on safety relief valve.
6. Drawing showing tube arrangement, clearance for tube removal (rectangular units) and soot blower nozzle locations. Written recommendations of soot blower manufacturer on number of elements and locations of nozzles for this economizer design and size.
7. Manufacturers operating recommendations for mounting and support requirements for economizer (weight-flooded).

G. HRSG and Burner Predicted Performance Data, for Each Fuel, Site Altitude:

1. At Maximum Required Output With and Without Economizer (If Applicable) In Service, at 15 Percent Excess Air: Fuel and steam flow, HRSG flue gas outlet temperature, economizer flue gas outlet temperature, steam quality, HRSG efficiency, windbox and furnace pressures, predicted HRSG radiation and unaccounted losses, feedwater and flue gas pressure losses in the economizer (if provided).
2. At Low Fire, 25%, 50% and 75% of Maximum Firing Rate: Percent excess air, carbon monoxide (CO) ppm and NOx ppm.

H. ASME “P” Forms, Manufacturer’s Data Report, on HRSG and economizer construction.

I. Pretest Data - HRSG, Burner, Controls: As required by Part 3.

J. Final Test Report - HRSG, Burner, Controls: As required by Part 3.

K. 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 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

1.5 PROJECT CONDITIONS:

A. Fuels to be Fired, Main Burner: Natural gas.

B. Igniter (Pilot) Fuels: Natural Gas.

C. Natural Gas: Gas analysis report included at the end of this section indicates gas quality available at this site. Pressure provided to the

inlet of the HRSG-mounted regulators will be 15 psi as maintained by the main gas regulator station.

1.6 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):

A106/A106M-08.....Standard Specification for Seamless Carbon Steel Pipe for High Temperature Service.

A178/178M-02(2007).....Standard Specification for Electric-Resistance-Welded Carbon Steel and Carbon-Manganese Steel Boiler and Superheater Tubes

A269-10.....Standard Specification for Seamless and Austenitic Welded Stainless Steel Tubing for General Service

C612-10.....Standard Specification for Mineral Fiber Block and Board Thermal Insulation

D396-09a.....Standard Specification for Fuel Oils

C. American Society of Mechanical Engineers (ASME):

Boiler and Pressure Vessel Code - 2007 Edition with Amendments.

Section I.....Power Boilers

Section II.....Material

Section VII.....Recommended Rules for Care of Power Boilers

Section IX.....Welding and Brazing Qualifications

Performance Test Code (PTC):

PTC 4-2008.....Fired Steam Generators

Code for Pressure Piping:

B31.1-2007.....Power Piping

D. National Fire Protection Association (NFPA):

70-2008.....National Electric Code

85-2007.....Boiler and Combustion Systems Hazards Code

E. National Board of Boiler and Pressure Vessel Inspectors (NBPVI):

NB-232007.....National Board Inspection Code

F. Fluid Controls Institute (FCI):

70-2-2006.....Control Valve Seat Leakage

G. Department of Health and Human Services, Food and Drug Administration (FDA):

CFR 21, 173.310,.....Boiler Water Additives Permitted in Plants Where Steam Contacts Food

H. Environmental Protection Agency (EPA):

CFR 40, PART 60, Appendix A, Method 9, Visual Determination of the Opacity of Emissions from Stationary Sources

PART 2 - PRODUCTS

2.1 HEAT RECOVERY STEAM GENERATOR

A. Factory-assembled, packaged water tube, industrial-class, high pressure steam HRSG. Designed for natural gas and fuel oil firing.

B. Service: Designed to continuously receive feedwater at 100 °C (212 °F) and generate steam at pressures and quantities shown.

C. Performance:

1. Steam output quantity, refer to drawings.
2. Steam output quality, 99 percent minimum at all steam flow rates. Based on water quality in HRSG of 3500-ppm maximum total solids, 15-ppm maximum suspended solids, 700-ppm maximum alkalinity.
3. Minimum Efficiency at Required Maximum Output:
   a. Natural Gas Fuel ~~(~~37.3 MJ/cubic meter~~)~~ (1000 Btu/cubic foot): 78 percent at 15 percent excess air or 80 percent at 5 percent excess air.

D. HRSG Construction and Design Requirements:

1. Superheater: A superheater shall be provided to provide steam at the specified design pressure and temperature.
2. Boiler:
   a. The heat recovery boiler shall have 36 I.D. steam drum, with each drum head incorporating a 12″ x 16″ elliptical manway. Each manway shall be provided with an insulation-retaining ring so that the drums can be externally insulated and lagged in the field.
   b. The boiler shall be designed with unheated downcomers to provide maximum thermal syphon natural circulation. The downcomers must be completely external to the insulated casing of the boiler so that no hot gas is in contact with the downcomers. The downcomers shall be insulated with heavy duty blanket insulation and lagged.
   c. The boiler shall be provided with a spare gasket for each elliptical manway. A 15″ x 18″ access door shall be provided in the boiler sidewall for inspection and maintenance purposes.
   d. The boiler tubes shall be in accordance with ASME Code requirements.
   e. The casing insulation system shall be designed for an average surface temperature of 150°F based on a wind velocity of two

feet per second 100° ambient temperature. The casing shall be seal welded, gas tight, and internally insulated.

f. The boiler casing shall be at least 10 ga. Thickness constructed of carbon steel with reinforcement adequate for 10" wg; gas side design pressure.

g. The external surface of the boiler shall be cleaned in accordance with SSPC-SP 3 (power tool cleaning) and provided with one coat of shop primer paint.

h. The boiler shall have, but not be limited to, at least the following nozzles:
   1) Steam
   2) Feedwater
   3) Safety Relief Valves
   4) Vent
   5) Intermittent blowdown
   6) Continuous blowdown
   7) Water column
   8) Level control
   9) Level gauge
   10) Chemical feed
   11) Steam gauge
   12) Manway

i. The steam drum internals shall include, but not be limited to the following items:
   1) Piping for feedwater, chemical feed, and continuous blowdown. Each set of piping shall be supported to prevent possible vibration and fatigue. The internal piping shall be properly drilled to provide the correct distribution and collection of water and chemicals within the drum.
   2) The steam purifier shall be provided to assure the specified steam purity. The unit shall be designed so that it can be installed and replaced through drum end manways.
   3) The internal girth baffle shall be provided to separate the water in the drum from the vapor/ water mixture entering from the risers. The baffle system shall be constructed so that it can be replaced through drum end manways.

j. The boiler shall be designed for high and low alarm levels and low water shutdown levels.

k. The boiler shall be provided with lifting lugs as required to facilitate loading and unloading.

K. Factory Inspection and Tests:

1. Pressure Vessel Inspection and Certification: Inspect and certify the completed HRSG assembly in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section I. Submit four copies of completed ASME Form P-3 for each HRSG.

L. Finish: Provide surface preparation, heat resistant prime and finish coats using standard color of HRSG manufacturer as specified in Section 09 91 00, PAINTING.

2.2 HRSG TRIM (ACCESSORIES):

A. Conform to ASME Boiler and Pressure Vessel Code, Section I. Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT, for operation of water level and steam pressure controls.

B. Steam Safety Valves:

1. Provide two or three on each HRSG. Capacities certified by National Board of Boiler and Pressure Vessel Inspectors (NB).
2. Type: Angle pattern, flanged or threaded inlet, flanged or threaded side outlet, lifting lever, bronze or cast iron bodies, stainless steel trim, dual control rings. Valves with bronze bodies shall have EPDM O-ring seat seals. Valves with cast iron bodies shall have lapped seats.
3. Settings and Adjustments: Factory set, sealed, and stamped on nameplate. Set pressures as shown. Lowest set pressure shall not exceed normal operating pressure by more than 210 kPa (30 psi). Provide 30 kPa (5 psi) difference in setting between each of the valves.

C. Steam Pressure Gage:

1. Construction:
   a. Case: Surface-mounting, bottom or back connection, threaded ring, blowout disc in rear.
   b. Dial: 200 mm (8 inch) minimum diameter, non-corrosive, black markings on white background.
   c. Measuring Element: Bourdon tube designed for steam service.
   d. Movement: Stainless steel, rotary.
   e. Pointer: Micrometer adjustable, black color.
   f. Window: Laminated safety glass, or plastic.
2. Accuracy: Full span, 1/2 percent.
3. Range: 0-2000 kPa, 0-300 psi.
4. Installation: Stop valve, steel piping, valved blowdown, siphon, union at gage, valved connection for inspector's gage. Mount gage on

sheet metal panel affixed to front of HRSG. Use spacers between panel and gage to permit operation of blow-out disc.

D. Water Column with Water Level Indicator:
   1. Type: Conductivity probe type water level sensing, tilted prismatic gage glass with illumination, 1725 kPa (250 psi) steam minimum design.
   2. Conductivity Probes: Stainless steel with virgin Teflon insulation, AC power. High water alarm, low water alarm, primary low water cutoff, grounding probe. Low water alarm point higher than low water cutoffs. High and low alarms operate bell and warning lamp on HRSG control panel but do not cause a burner shutdown.
   3. Gage Glass - Prismatic: Single or double (offset) tilted prismatic tempered borosilicate reflex units of sufficient length to include all low water cutoff points and high water alarm point without discontinuity. Provide gage illuminator, mounted vertically, designed to direct light at gage only. Locate in front of gage. Do not block view of gage from personnel standing 1800 mm (6 feet) in front of burner. Provide chain-operated 1/4 turn gage valves. Extend chains to within 1800 mm (6 feet) of the floor.

E. Auxiliary Low Water Cutoff:
   1. Type: Float chamber with float-actuated sealed snap switch. Water piping connections to the steam drum shall be independent from other devices such as the water column.
   2. Construction:
      a. UL listed.
      b. Float chamber shall have drain connection.
      c. Packless construction with pivot and bearing point remote from high temperature areas.
      d. Design for 1725 kPa (250 psi) steam.

F. Low Water Cutoff Shunt Switches: Provide two separate non-latching pushbutton controls, one to short-circuit probe-type primary low water cutoff and the second to short-circuit the auxiliary low water cutoff when each is blown down. Locate pushbuttons within reach of drain valves for cutoffs.

G. High Steam Pressure Cutouts:
   1. Provide two units with different set points. Unit with lowest set point shall be automatic reset; unit with highest set point shall be manual reset.

2. Type: Bellows actuated sealed snap-acting or mercury switch with adjustable set point and adjustable differential pressure (automatic reset unit).
3. Construction:
   a. UL listed.
   b. Design for 1375 kPa (200 psi) minimum emergency pressure.
   c. Switch position indicator visible without removing cover.
   d. Set pressure range: To 110 percent of required set pressure.
   e. Provide set point indicators with graduated scales for set point and differential pressure that are visible without removing cover.
4. Mounting: Pipe directly to HRSG steam drum or to water column. There shall be no valves between cutouts and steam drum. Provide siphons at each switch to protect bellows from high temperature.
5. Set Points:
   a. Automatic Reset Unit: Refer to HRSG schedule shown on the drawings.
   b. Manual Reset Unit: 35 kPa (5 psi) higher than automatic reset cutout but below safety valve set pressure. Subtractive differential not to exceed 70 kPa (10 psi).

H. Feedwater Control Valve:
1. Type: Single-seated, cage guided, balanced valve plug, or characterized rotary valve, designed for throttling service. Equal-percent valve flow characteristic. Electric actuator with positioner.
2. Performance: Refer to schedules on drawings for pressure, temperature and flow requirements. If not scheduled, flow capacity shall be 125% of maximum HRSG steam flow with a maximum pressure drop of 35 kPa (5 psi). Maximum seat leakage at shut-off shall not exceed 0.01% of maximum valve capacity (FCI 70-2, Class IV).
3. Construction – Plug Type:
   a. Body Type: Cast iron or bronze, flanged for 65 mm (2-1/2 inch) pipe size and larger, threaded for 50 mm (2 inch) pipe size and under, rated for 1725 kPa, 138 °C (250 psi, 280 °F) minimum.
   b. Plug, Cage, Seat Ring: Replaceable, hardened stainless steel.
4. Construction – Rotary Type:
   a. Three-piece body, cast steel or bronze, flanged for 65 mm (2-1/2 inch) pipe size and larger, threaded for 50 mm (2 inch) pipe size and under, rated for 2000 kPa (300 psi) 138 °C (280 °F) minimum.
   b. 316 SS ball and stem, Polyfil seat, TFE coated SS seal.
5. Valve Sound Levels: Conform to Section 23 05 51, NOISE and VIBRATION CONTROL FOR BOILER PLANT.

6. Actuators and Controllers: Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT.

2.3 DUCT BURNER AND FUEL TRAINS:

A. Duct Burner System:

1. Provide a natural gas fired, duct burner system to increase the turbine exhaust gas temperature to provide the specified steam flow and pressure. The duct burner system shall be complete with a burner frame and elements, fuel piping skid, scanner blower skid and a Burner Management System (BMS) with a flame safety system designed in accordance with NFPA 85.
2. The duct burner frame shall be constructed of a minimum of 3/16” carbon steel plate. Provide mating flanges for installing the duct burner into the HRSG ductwork. Manufacturer shall coordinate the fit-up of the mating flanges with the HRSG.
3. The duct burner shall be internally insulated with mineral wool or ceramic fiber insulation covered with stainless steel lagging suitable for the maximum operating temperatures and thermal expansion.
4. Fuel gas manifold in the turbine exhaust gas flow shall be seamless stainless steel pipe. Burner castings in contact with the gas flame shall be 309 or 310 stainless steel or equal. Burner elements shall be secured to the burner frame in a manner that allows for sufficient thermal expansion and prevents the elements from sagging or vibrating.
5. Natural Gas Duct Burner and Fuel System:
   a. The duct burner shall produce a stable flame over a 10:1 turndown range. There shall be no objectionable pulsating noise or vibration of the flame to and from the burner face.
   b. The duct burner shall be designed to operate efficiently at turbine exhaust gas flow rates, oxygen levels and temperature ranges as specified by the gas turbine manufacturer. The duct burner shall be designed to distribute the fuel gas evenly across the duct with properly sized fuel manifold. Exhaust gas flow distribution device (if required) shall be sized to maintain a pressure drop of less than 1.5" W.C. through both this device and duct burner.
   c. The duct burner shall be pre-assembled as much as practical for shipping to minimize field erection time. Where multiple burner elements are used, distribution headers with pressure gauges shall be provided for the fuel gas, pilot gas and scanner cooling air.

The headers shall be mounted on the burner assembly to minimize field erection time.

c. The gas pilot shall be provided as indicated in NFPA 85. The design of the pilot shall be stable under all turbine exhaust firing conditions. In case of pilot light-off failure, the safety shutoff valve on both the main and the pilot line shall be proven closed with a visual indication displayed on a local HMI screen (ref: Section H).

d. Burner ignition source shall be spark ignited gas pilots per NFPA, Class III interruptible design. Pilot heads shall be made of 304 or 309 stainless steel. Each burner element shall have one pilot and ignition transformer. The transformers shall be pre-wired to the pilots and located in a NEMA 4 enclosure on the duct burner assembly. Pilots shall have a removable electrode to allow maintenance during turbine operation.

6. The main and pilot gas train shall be designed as indicated in NFPA 85. All fuel gas piping shall be mounted on a freestanding pipe rack skid with all piping trains mounted and instruments wired to the BMS controller. All solenoid or motor operated valves and all limit devices shall be mounted on the piping skid. All components shall be configured for easy maintenance access with gauges visible from the front side of skid. All wiring shall be run in conduit. All field terminations shall be wired to numbered terminal blocks located in junction boxes in accordance with NFPA 70 (NEC).

1. The main and pilot gas piping system shall be designed for use with pipeline quality natural gas supplied at 30 PSIG regulated pressure and will include at minimum:

Main Fuel Train

Two (2)	3-1/2″ burner pressure gauges with isolation valve
One (1)	Leak test cock valve
One (1)	Low fuel gas pressure switch
One (1)	High fuel gas pressure switch
Two (2)	Electric or Pneumatic operated shut-off valves
One (1)	Electric or Pneumatic operated vent valve
One (1)	Flow control valve
One (1)	Manual shut-off valve
One (1)	Flexible hose to burner front header

Pilot Fuel Train

Two (2)	Manual shut-off valve
One (1)	Pilot gas pressure regulator
Two (2)	Electrically operated shut-off valves
One (1)	Electrically operated vent valve
One (1)	2-1/2″ Pilot gas pressure gauge with shut-off cock
One (1)	“Y” type strainer
One (1)	Flexible hose

7. Provide two (2) scanner blowers, each sized for 100% flow, including cooling air to the observation ports. The scanner blowers shall be mounted on a separate skid. The starters for the scanner blowers will be provided by the others along with the motor control center (MCC). Provide controls to automatically start the second scanner blower in the event the operating scanner blower fails. Blowers shall be complete with inlet air filter silencers. All wiring and conduits shall be in accordance with NFPA 70 (NEC).
8. Factory Inspection and Tests
   a. An Inspection and Test Plan (ITP) shall be provided to describe the Quality Assurance and Quality Control Program requirements for the HRSG package. The ITP shall define quality requirements for purchased and manufactured material from receiving inspection to the final package inspection. The ITP shall list the primary controlling and verifying documents, codes and standards used to define the quality requirements and identified inspection points.
   b. All testing operations shall be conducted under the direct control of the Manufacturer’s Quality Assurance Activity. This Activity shall ensure compliance with the specified test limits and procedures.
   c. All electrical panels and software including the BMS shall be shop-tested before shipment.

2.4 BURNER MANAGEMENT CONTROL (FLAME SAFEGUARD) SYSTEM AND ACCESSORIES:

A. Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.
B. Control Panel: Controls shall be mounted in free standing NEMA 4 enclosure. There shall be no power wiring in this enclosure.
C. Factory Testing: Install controls on HRSG and burner at factory and test operation of all devices.

2.5 FLUE GAS ECONOMIZER:

A. Heat exchangers to transfer heat from HRSG flue gases to HRSG feedwater.

B. Type: Rectangular configuration, replaceable finned tubes, up flow flue gas, parallel flow water, insulated casing with removable panels allowing access to all tubes for cleaning and replacement. Arrange tube to permit lane-type soot blowing.

C. Performance: Refer to schedules shown on the drawings. Coordinate input flue gas temperatures with data from HRSG manufacturer.

D. Construction:

1. Comply with ASME Boiler and Pressure Vessel Code, Section I. Design unit to permit operation with no water in the tubes at the temperature listed below.
2. Design Pressure:
   a. Water tubes, 2050 kPa (300 psi) minimum.
   b. Inner casing, 2.5 kPa (10 inches water column) minimum.
3. Design temperature 370 °C (700 °F) minimum.
4. Tubes: ASTM A269 Type 316 stainless steel tubing. Helical-wound non-serrated Type 316 fins continuously welded to tubes. Headers of Type 316 seamless carbon steel tubing, Schedule 40 minimum. 2050 kPa (300 psi) flanged piping connections. Gravity drainage. Return bend areas shall be exposed to the bulk temperature of the flue gas. Headers shall be external to the casing. Fin density shall not exceed 157 fins per meter (48 fins per foot). Maximum fin height 13 mm (0.5 inches).
5. Casing: Inner and outer casing with insulation between. 80 mm (3 inch) angle flanges on flue gas inlet and outlet for attachment of breeching and stack.
   a. Inner Casing, 3.5 mm (10 gage) thick Type 316 stainless steel, all welded. Stainless steel angles for breeching attachment to casing. Entire casing system must be gas tight.
   b. Insulation: Mineral fiber, ASTM C612, 50 mm (2 inches) thick.
   c. Outer Casing: Galvanized or painted steel, 0.4 mm (27 gage) thick.
   d. Access and Inspection Openings: Insulated, 400 mm (16 inches) square minimum.
6. Design to permit field replacement of tubes without removing unit from stack. Provide bolted access doors for tube replacement.
7. Provide all supporting structure to install the economizer.

E. Accessories:

1. Safety Relief Valve: Valve designed for steam and water service, ASME - National Board certified, selected by economizer manufacturer in

accordance with ASME Code requirements. Set pressure 1900 kPa (275 psi) gage.

2. Access ladders, platforms and stairs: Provide access to all control valves, sensors and isolation valves per the VA boiler plant standards. Platforms can be supported off the floor or HRSG if permitted by the manufacturer.
3. Inlet and Outlet Transitions: Designed and furnished by economizer manufacturer.

F. Factory Test and Inspections: Inspect the completed economizer assembly in accordance with the ASME Boiler and Pressure Vessel Code, Section I. Certify the inspection and submit four copies of the completed ASME Form P-3 for each economizer.

2.6 SPARE PARTS

A. 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. Complete set of filter elements and gaskets for each gas filter for each HRSG.

B. HRSG, Burner, Trim, Feedwater Control Valve:
1. Drum handhole gaskets, three complete sets for each HRSG.
2. One clear lens and one tinted lens for each furnace and burner observation port on each HRSG.
3. Sufficient glass inserts and gaskets to re-equip all water level gage glasses on one HRSG.
4. One set of drive belts for each belt-driven apparatus on each HRSG.
5. If cast refractory plug is utilized for furnace access, provide sufficient refractory material to rebuild one plug for each HRSG.
6. 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 and STEAM GENERATION.

B. HRSG, 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 HRSG Water Column, Gage Glass, Low Water Cutoffs, Water Level Alarms:

1. Refer to Articles, BOILER and BOILER TRIM. After individual drain valves, combine all drains into one pipe with a sight flow indicator, gate valve and check valve. Pipe to HRSG 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. HRSG Drum Level Transmitter for Feedwater Regulator System:
1. Provide three-valve isolation and equalizing system rated for 1375 kPa (200 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 HRSG insulation.

3.2 CLEANING AND PROTECTION FROM CORROSION

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.

B. HRSG Cleaning:
1. Upon completion of installation, the initial firing of the burner shall be performed to boil out, under supervision of HRSG manufacturer, all internal surfaces with chemical solution recommended by HRSG manufacturer, to remove all mill scale, corrosion products and other foreign material. Following boil out, HRSG shall be washed and flushed until water leaving the HRSG is clear. Inspect internal surfaces for cleanliness. Then, drain and refill HRSG with softened and treated water or place HRSG 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 HRSG after the operational tests are completed.

C. Protection from Corrosion:
1. Protect the HRSGs from fireside and waterside corrosion at all times.
2. Dry Storage: When the HRSGs are not filled with water, protect the watersides and firesides 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 HRSGs, they are not fired for equipment adjustment or testing for more than two weeks, the HRSGs shall be protected with a wet storage method recommended either by the HRSG manufacturer or the ASME Code, Section VII. If

HRSGs are not fired for equipment adjustment and testing for more than one month, drain the HRSGs and place in dry storage.

4. Chemical Treatment: The quality of the water in the HRSGs 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 HRSG storage, operating, standby and test conditions. Furnish monthly reports, by the water treatment organization, to the PM/COTR. The Contractor shall provide all chemicals, labor and professional services until the HRSGs 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 HRSGs, economizers, burners, controls, instruments, and accessories comply with requirements specified. Refer to Section 23 08 11, DEMONSTRATIONS and TESTS FOR BOILER PLANT for general requirements. 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 and Economizer After Delivery, Rigging, Placement: After setting HRSG on foundation and placing economizer on supports, and prior to making any connections to HRSG 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 HRSG casing. The Contractor shall conduct these tests at no cost to the Government.

C. Hydrostatic Tests:

1. HRSG, Economizer (if provided): 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 HRSG 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, BOILER PLANT PIPING SYSTEMS.

b. Test may be conducted concurrently with HRSG 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. HRSG Steam Safety Valves:

1. Test each safety valve set pressure and blowdown pressure with HRSG steam pressure. Perform accumulation test to verify that safety valves have sufficient capacity to relieve full HRSG output at maximum firing rate of burner. Tests shall be performed with HRSG 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 HRSG 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 HRSG.
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. Burner Management Control (Flame Safeguard) System:

1. Demonstrate set points and operation of all control, interlock, monitoring and indicating functions. Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT.
2. Prior to scheduling final test, submit certification that all control, indicating and interlock devices have been pretested (Refer to Section 23 08 11, DEMONSTRATIONS and TESTS FOR BOILER PLANT.
3. Conduct final test immediately prior to HRSG-burner tests.
4. Experienced personnel representing the manufacturer of the system shall conduct the tests.

F. Performance Testing of HRSG, Burner, Economizer, Combustion Control, HRSG Plant Instrumentation, Computer Workstation (if provided):

1. Perform tests on each HRSG on all main burner fuels.
2. If required by local emissions authorities, provide the services of a testing firm to determine the NOx and carbon monoxide at HRSG loads

as required by the emissions authorities. Test firm shall be acceptable to emissions authorities.

3. Test No. P-1:
   a. Operate HRSG on natural gas fuel, with economizer in service, and record data for at least six evenly spaced steam outputs between low fire start and 100 percent of full steam output, and in the same sequence back to low fire. Demonstrate performance required by paragraphs under the Article, BURNER AND FUEL TRAINS and ECONOMIZER in Part 2 and by HRSG and economizer equipment list shown on the drawings.
   b. Demonstrate proper operation of combustion controls, draft controls (if provided), feedwater level controls, instrumentation and computer workstation programming (if provided). Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT.
   c. When flue gas oxygen trim is provided, conduct tests with trim control on manual at the zero trim (null) position. Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT.
4. Test No. P-2:
   a. Check current draw of forced draft fan motor at pre-purge and at 100 percent of maximum HRSG load with combustion air control at maximum position.
   b. Current draw shall not exceed full load current stamped on the motor nameplates.
   c. This test may be combined with Test No. P-1.
5. Test No. P-3: Operate HRSG on natural gas fuel, flue gas oxygen trim in service on automatic control, and record data at a minimum of 6 evenly spaced steam output points between low fire start and full steam output and in the same sequence back to low fire. Demonstrate oxygen trim control performance required by Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT.
6. Test No. P-4: Operate HRSG on natural gas fuel, flue gas oxygen trim in service on automatic control, and record data at the following load points: Low fire start, 13, 20, 40, 60, 80, 100, 80, 60, 40, 20 and 13 percent of full steam output. Demonstrate oxygen trim control performance required by Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT.
7. Test Methods:
   a. Utilize permanent instrumentation systems for data. All instrumentation systems and computer workstation (if provided) shall be operational and in calibration.

b. Provide portable thermocouple pyrometer furnished and retained by the Contractor to measure stack temperature as a verification of permanent stack temperature instrumentation.
c. Use portable electronic flue gas analyzer furnished by Contractor to determine constituents of flue gas and stack temperature. Analyzer shall be capable of measuring oxygen in percent with accuracy of plus or minus 0.5 percent and carbon monoxide in parts per million (ppm) with accuracy of plus or minus 5 percent of reading (Range 0-1000 ppm). Obtain oxygen and carbon monoxide readings at each test point. Instrument shall have been calibrated with certified test gases within three months prior to use and immediately after cell replacement.
d. In Test Nos. P-1, 2 and 4 P, retain HRSG at each load point for a time period sufficient to permit stabilization of flue gas temperature and other parameters.
e. Steam loads for test may be furnished by the VA Medical Center hospital systems, by operation of the steam silencer vent system, or by a combination of the above. If variable hospital loads interfere with the testing, conduct tests at night or on weekends when the loads are more stable.
f. Provide dry bulb and wet bulb thermometers furnished and retained by Contractor for checking combustion air.
g. Smoke testing shall be by visual observation of the stack and by smoke density monitor (permanent instrument - if provided). If smoke density monitor is not provided, utilize Bacharach Model 21-7006 Smoke Test Kit. If there is disagreement with the results of these tests, provide qualified observation person and tests in compliance with EPA Reference Method 9 (CFR 40, Part 60, Appendix A).
h. 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.

8. Pretesting:
a. Perform pretest at the final stage of the burner fine-tuning process.
b. Prior to scheduling final test, submit evidence of pretest. Evidence shall consist of data sheet signed and dated by personnel

representing burner manufacturer, combustion controls manufacturer, burner controls manufacturer.

c. Pretest data sheets shall list the following data for each fuel and each screw on the fuel flow valve characterization cam starting at the minimum position, proceeding to the maximum position and returning to the minimum position.
   1) Fuel valve screw number or actuator position.
   2) Steam flow rate (at minimum, 50 percent, maximum firing position only).
   3) Steam pressure: At HRSG drum, and at header (at minimum, 50 percent, maximum firing position only).
   4) Fuel Pressures: At burner and also upstream of fuel flow control valve.
   5) Fuel temperature (heated oil only).
   6) Fuel flow rate.
   7) HRSG feed pressure, upstream of feedwater regulator (at minimum, 50 percent and maximum firing positions only).
   8) HRSG feed temperature (at minimum, 50 percent, maximum firing positions only).
   9) Stack temperature: HRSG outlet, economizer outlet.
   10) Flue gas oxygen and carbon monoxide (utilize instrument which has been calibrated with certified test gases).
   11) Flue gas NOx (if limit specified).
   12) Percent excess air.
   13) Opacity of flue gas.
   14) Submaster position.
   15) Flame shape: Note and describe any flame contact with refractory or heating surface.
   16) Combustion air temperature-dry bulb and wet bulb.
   17) Barometric pressure (one reading).

d. Calibrate all pressure gages prior to the pretest.

G. Capacity - Efficiency Test of HRSG and Burner:
   1. Perform test on one of each size HRSG in the project, selected by RE, on all main burner fuels.
   2. Test No. E-1: Test HRSG on each fuel, with no water in economizer (if provided), at full load. Demonstrate performance required by paragraphs under the Article, BOILER in Part 2 and by HRSG equipment list shown on the drawings.

3. Test Methods:
   a. Conform to ASME Performance Test Code PTC 4.1. Use abbreviated input-output and heat balance methods. Utilize ASME Test Forms PTC 4.1-a, 4.1-b.
   b. Test Meters and Instruments:
      1) Feedwater Flow Meter: Vortex or turbine-type, totalizing in increments of 10 gallons or less, pressure rating exceeding feed pump no flow shut-off pressure, temperature rating exceeding normal feedwater temperature, calibrated immediately prior to test by independent laboratory. Calibrate at three points, ten percent above, ten percent below, and at the required flow rate at high fire. Furnish calibration data. Remove meter from the line and deliver to RE after tests are accepted.
      2) Natural Gas Flow Meter: Utilize permanent meter serving HRSG plant.
      3) Steam Calorimeter (for measuring steam quality): Throttling, U-path, temporary instrument, furnished and retained by Contractor, with thermometer that has been calibrated immediately prior to test. Provide one spare calibrated thermometer.
      4) Portable electronic flue gas analyzer as specified for the performance testing.
      5) Thermocouple Pyrometer (for measuring flue gas temperature): Temporary instrument furnished and retained by Contractor, 100 - 400 °C (200 - 800 °F) range, automatic ambient temperature compensation.
      6) Thermometers: Utilize contractor-furnished and retained temporary thermometers and permanent thermometers to measure fuel and air temperatures. All must be calibrated immediately prior to test. Furnish calibration data.
      7) Pressure Gages: Utilize permanent gages. Calibrate each gage immediately prior to test. Furnish calibration data.
      8) Plant Instruments and Computer Work Station (if provided): Must be calibrated, programmed and in proper operation.
   c. Fuel Analyses: The Government will furnish analysis of natural gas. The Contractor must obtain an ultimate type analysis of fuel oil prior to the final HRSG tests. Fuel oil analysis must include heating value, specific gravity, viscosity and percent carbon,

hydrogen, sulfur, ash, oxygen, and nitrogen. Test by independent laboratory.

d. Duration of each test will be four hours after all systems and measured parameters have stabilized.

e. Water quality in the HRSG shall be checked immediately prior to the start of the tests. Solids and alkalinity must be adjusted prior to the test to conform to limits listed in Paragraph, BOILER in Part 2.

4. Pretesting: None required.

H. Internal Inspection of Pressure Parts and Furnace:

1. After all operational tests are satisfactorily completed, a Government retained licensed HRSG inspector will 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 HRSG 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 HRSG and burner performance.

5. After the HRSG inspector has approved the HRSG, all handholes and furnace access openings shall be closed with new gaskets.

6. Hard carbonaceous deposits in the furnace are evidence of flame impingement. Within one year after acceptance of the HRSG for Government operation, the Government will inspect the furnace for the carbonaceous deposits. If deposits are present, the Contractor shall remove them. If tubes or refractory are damaged, the Contractor shall replace them to achieve a like new condition. The Contractor shall make corrections to burners to eliminate the conditions that have caused the problems and shall provide complete retest of HRSG and burner performance.

I. 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.

3.4 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.

3.5 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 – COMMISSIONING OF HVAC SYSTEMS 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 23 08 00 – COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.6 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for four hours to instruct each VA personnel responsible in the operation and maintenance of units.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00 – COMMISSIONING OF HVAC SYSTEMS.

- - - E N D - - -

Gas Analysis Report

Analysis id: 19140201

Test Number: 393336

Source Information

Operator Waco City Of

Source Beverly Hills
County Mclennan
State Texas
Freq Daily

Field Data

Date Sampled from 10/13/2012 to 11/06/2012

Static Pressure (psia)	0
Diff Pressure (inches)	0
Flowing Temp (deg. f.)	72
Water Vapor (lbs/mmcf)	0
Hydrogen Sulfide (ppm)	0
Sampled by	PRUITT
Field BTU @ 14.65D	1002
Field Rel Den (R)	0.87

Analysis Results

Constituent	MOL %	Gal/MCF
Helium	0.00	
Carbon Dioxide	1.58	
Oxygen	0.00	
Nitrogen	1.10	
Methane	94.90	
Ethane	2.14	0.57
Propane	0.19	0.05
Isobutane	0.03	0.01
N-Butane	0.03	0.01
Isopentane	0.01	0.00
N-Pentane	0.01	0.00
Hexanes+	0.01	0.00
Hydrogen Sulfide	0.00	
Totals	100.00	0.64

Laboratory Data

Calculated BTU @ 14.65 Dry	1003.386
Calculated BTU @ 14.65 Saturated	985.828
Relative Density(real)	0.5884
Total Inerts	
Interchange Factor	1292
Date Reported	11/15/2012

Composite Contract Quality Requirements

	Minimum	Maximum
BTU	950	1100
Relative Density		0
Interchange	0	0
Water Vapor(lbl/mmcf)		7
Carbon Dioxide(%)		2
Oxygen(%)		0.05
Nitrogen(%)		
CO2+N2		
Total Inerts(%)		4
Hydrogen Sulfide(gr/ccf)		0.25
Hydrocarbon Dew Pt(F)		40

Remarks

Approved by DC