UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

SECTION 23 72 00.00 10

ENERGY RECOVERY SYSTEMS

01/08

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USACE / NAVFAC / AFCEC / NASA | **UFGS-23 72 00.00 10 (January 2008)**

Preparing Activity: USACE | **Superseding UFGS-23 72 00.00 10 (October 2007)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021

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SECTION 23 72 00.00 10

ENERGY RECOVERY SYSTEMS
01/08

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NOTE: This guide specification covers the requirements for energy recovery systems for power plant installations where a steady source of waste heat is available.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

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PART 1 GENERAL

1.1 REFERENCES

****

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature

to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

****

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

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B31.1	(2020) Power Piping
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC I	(2017) BPVC Section I-Rules for Construction of Power Boilers
ASME BPVC SEC IV	(2017) BPVC Section IV-Rules for Construction of Heating Boilers
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME PTC 19.3 TW	(2016) Thermowells Performance Test Codes

ASTM INTERNATIONAL (ASTM)

ASTM D1066	(2018; E 2018) Standard Practice for Sampling Steam
ASTM D2186	(2005; R 2009) Deposit-Forming Impurities in Steam

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2018) Motors and Generators

1.2 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item,

if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation

SD-03 Product Data

Calculations
Welding Procedures and Qualifications
Spare Parts
Posted Instructions
Performance Tests; G[, [_____]]

SD-06 Test Reports

Tests

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G[, [_____]]

1.3 WELDING PROCEDURES AND QUALIFICATIONS

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NOTE: If the need exists for more stringent requirements for weldments, delete the first bracketed statement.

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[Submit a copy of qualified procedures and a list of names and identification symbols of qualified welders and welding operators. Piping shall be welded in accordance with qualified procedures using performance qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer, may be accepted as permitted by ASME B31.1. Contracting Officer shall be notified 24 hours in advance of tests and the tests shall be performed at the work site if practicable. The welder or welding operator shall apply his assigned symbol near each weld he makes as a permanent record. Structural members shall be welded in accordance with Section 05 05 23.16 STRUCTURAL WELDING.] [Welding and nondestructive testing procedures are specified in Section 40 05 13.96 WELDING PROCESS PIPING.]

1.4 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, humidity and temperature variation, dirt and dust, or other contaminants.

1.5 EXTRA MATERIALS

****

NOTE: If fire-tube boilers are specified, delete paragraph "Tube Cleaner;" if water-tube boilers are specified, delete paragraph "Tube Brush." If the boiler design utilizes bent tubes, both paragraphs "Tube Cleaner" and "Tube Brush" should be deleted.

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Furnish all special tools necessary for the operation and maintenance of boilers, pumps, fans, and other equipment. Furnish small hand tools with a suitable cabinet, mounted where directed.

1.5.1 Tube Cleaner

Tube cleaner shall be the water-driven type with three rotary cutters and rotary wire brush, complete with the necessary length of armored water hose, valves, and other appurtenances necessary for operation. Tube cleaner and rotary brush shall be provided for each size of water tube in the boiler, with one extra set of cutters for each size cleaner. Necessary valves and fittings shall be provided to permit quick connection of the raw water supply hose to one boiler feed pump for operation of the cleaner.

1.5.2 Tube Brush

Provide tube brush, with steel bristles and jointed handle of sufficient length to clean full length of fire tubes.

1.5.3 Smoke Pipe Cleaner

Provide smoke pipe cleaner to clean the breeching and smoke connections. Cleaner shall have jointed handle long enough to clean breeching and smoke connections without dismantling the system.

1.5.4 Special Wrenches

Provide special wrenches as required for opening boiler manholes, handholes, and cleanouts.

1.5.5 Spare Parts

Submit spare parts data for each different item of equipment specified, after approval of the detail drawings and not later than [_____] months before the date of beneficial occupancy. Include in the data a complete list of spare parts and supplies with current unit prices and source of supply.

1.6 OPERATION AND MAINTENANCE MANUALS

****

NOTE: The designer should require the Contractor to prepare (in addition to providing O&M manuals for each piece of equipment) O&M manuals for the completed work which consists of diverse equipment integrated into a system not covered by instructions from a single manufacturer; in that case retain the first bracketed statement. Remove the first bracketed statement when the manufacturer's instructions are sufficient to operate and maintain the completed work.

****

The manuals will be approved by [the Contracting Officer] [_____] before acceptance of the installed system. Submit [6] [_____] complete copies of operation manual for energy recovery system outlining the step-by-step procedures required for system startup, operation, and shutdown. Include in the manuals the manufacturer's name, model number, service manual, parts list, and a brief description of all equipment items and their basic operating features. Submit [6] [_____] copies of maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide shall be provided. Include in the manuals piping layout, equipment layout, and simplified wiring and control diagrams of the system as installed.

PART 2 PRODUCTS

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NOTE: In order to comply with Executive Order 13423 and Public Law 109-58 (Energy Policy Act of 2005), designs must achieve energy consumption levels that are at least 30 percent below the level required by ASHRAE 90.1 - 2004. In accordance with P.L. 109-58 (Energy Policy Act of 2005), Executive Order 13423, and Federal Acquisition Regulation (FAR) 23.203 Energy-efficient Products shall meet or exceed the performance criteria for ENERGY STAR®-qualified or FEMP-designated products as long as these requirements are nonproprietary. The FEMP and ENERGY STAR product requirements are available on the web at www.eere.energy.gov/femp/procurement and www.energystar.gov/products. Where ENERGY STAR or FEMP products are not applicable, energy consuming products and systems shall meet or exceed the

requirements of ASHRAE 90.1.
****

2.1 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.1.2 Nameplates

Each major item of equipment shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

2.1.3 Prevention of Rust

Unless otherwise specified, surfaces of ferrous metal subject to corrosion shall be factory prime-painted with a rust-inhibiting coating and subsequently factory finish-painted in accordance with the manufacturer's standard practice. Heat recovery equipment exposed to high temperature when in service shall be prime and finish painted with the manufacturer's standard heat resistant paint to a minimum thickness of 0.025 mm 1 mil.

2.1.4 Equipment Guards and Access

Fully enclose or guard belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts located where personnel contact is possible. High temperature equipment and piping located within personnel contact or where a potential fire hazard exists shall be properly guarded or covered with insulation of a type specified. Provide items such as catwalks, operating platforms, ladders, and guardrails where shown and construct them in accordance with Section [08 31 00 ACCESS DOORS AND PANELS][05 51 33 METAL LADDERS].

2.2 HEAT RECOVERY EQUIPMENT

****
NOTE: Heat recovery equipment is closely associated with the prime mover and it will frequently be more advantageous to specify this equipment in the same section in which the prime mover is specified. The designer must insure that drawings defining the interrelationship between all components and design data such as flows, pressures, temperatures, and heat transfer rate are included.

Specify 2, 3, 4, or 8 degrees C 3, 5, 8, or 15 degrees F for the maximum temperature differential for coolant in and out of engine. Differential selected must be in accordance with engine manufacturer's recommendations. The 2 degree C 3 degree F) range is for conventional ebullient cooling where the heat of evaporation is used to

remove the rejected heat from the engine. A 8 degrees C 15 degree F differential across the engine is desirable for all other systems but may be limited by engine manufacturer's recommendations.
****

A heat recovery system shall be an integrated design package compatible with the prime mover [cooling] [and] [exhaust] system in accordance with the drawings and data sheets. The heat recovery system shall be a [diesel engine exhaust waste heat boiler only to generate [saturated steam at [_____] Pa psig pressure] [hot water at [_____] degrees C degrees F and [_____] Pa psig pressure].] [diesel engine [jacket water cooling and heat reclaim system] [and] [lube oil cooling and heat reclaim facilities].] [diesel engine ebullient cooling system combining jacket water heat reclaim and exhaust waste heat boiler to generate up to 105 kPa 15 psig steam.] [gas turbine exhaust heat reclaim unit to generate [steam at [_____] Pa psig] [hot water at [_____] degrees C degrees F and [_____] Pa psig pressure].]

2.2.1 Diesel Engine Cooling

2.2.1.1 Antifreeze

[For ebullient cooling, the cooling system shall be suitable for a combination of water and an azeotropic antifreeze compatible with the equipment (methoxy propanol) as a cooling medium, hereafter called the coolant.] [For cooling systems where steam is not required, an ethylene glycol permanent type antifreeze shall be utilized. Size of cooling system shall be based upon the use of an antifreeze solution which will protect the system down to minus 45 degrees C minus 50 degrees F.] Antifreeze for cooling the lube oil and auxiliaries shall be a permanent type suitable for use with water, or the antifreeze solution specified above may be used and shall be connected to a separate section of the waste heat condenser from the engine coolant. Valve trim and materials shall be compatible for use with the antifreeze solution. Operation of the cooling system shall be fully automatic while the prime mover is running.

2.2.1.2 Water Jacket Temperature

For diesel engine ebullient cooling, jacket water temperature shall be not lower than 110 degrees C 230 degrees F, nor higher than 120 degrees C 250 degrees F in the steam separator at all loads with a maximum differential of [_____] degrees C degrees F for coolant in and out of the engine.

2.2.1.3 Construction

Where cooling system design is part of prime mover installation, components other than the wasteheat condenser and condensate receiver or pump units may be mounted on the engine skid extension. For any antifreeze cooling system, a PVC makeup tank with an electric motor-driven pump unit shall be provided as indicated. Pump shall be manifolded to allow using it as a mixing unit by shunting the flow back to the tank. System fill shall be [manual] [automatic] with feed into the piping system steel expansion tank connection line as indicated.

2.2.2 Electrical Equipment

Electric motor-driven equipment specified shall be provided complete with

motors and necessary motor control devices. Motors and motor control devices shall conform to the applicable requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM including requirements for hazardous area locations. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1.

2.2.2.1 Motor Ratings

Motors shall be suitable for the voltage and frequency provided. Motors 373 watt 1/2 horsepower and larger shall be three-phase, unless otherwise indicated. Ratings shall be adequate for the duty imposed, but shall not be less than indicated.

2.2.2.2 Motor Controls

Where a motor controller is not shown in a motor control center on the electrical drawings, a motor controller shall be provided. Where required, motor controllers shall be provided complete with properly sized thermal overload protection and other equipment at the specified capacity including an allowable service factor, and other appurtenances necessary for the motor control specified. Manual or automatic control and protective or signal devices required for operation specified and any wiring required to such devices, not shown on the electrical drawings, shall be provided. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function.

2.2.3 Heat Recovery Silencer for Diesel Engine

****

NOTE: The degree of silencing will match the environmental requirement. In a retrofit installation, the unit should match the original silencer installation. As a general guide the attenuation will be approximately as follows:

Type of Silencer	Attenuation in dB	Measured at Octave Band Frequency (Hz)
Industrial	25	250
Semi-Residential	30	250
Residential, Critical Area	35	250
Quiet Residential	37.5	250

Indicate pressure required. For most low-pressure installations this will be 345 kPa 50 psig.

****

Each combination boiler silencer or supplementary silencer shall reduce the generated sound spectrum to standard commercial level permitted for [industrial] [semi-residential] [residential, critical] area. Exhaust gas boiler shall be a combination boiler silencer or a boiler with a supplementary silencer to meet the noise limits, and heat recovery unit shall be constructed in accordance with ASME BPVC SEC VIII D1 for [_____] Pa psig steam working pressure. The boiler shall be designed for maximum

efficient heat recovery under any load condition up to 110 percent of full load with an exit exhaust gas temperature not less than 165 degrees C 330 degrees F. Each boiler shall be designed for continuous wet operation or for periods of dry operation without interruption of the diesel engine operation when located and connected as indicated. Provisions shall be made for expansion and contraction to prevent overstressed conditions in the pressure vessel during continuous wet or dry operation. Gas side pressure drop through the boiler shall not exceed the recommendations of the engine manufacturer. Each boiler shall be provided with standard boiler trim including, but not limited to, pressure gauge, water gauge with try cocks, water level control, ASME-rated safety relief valve, surface blowoff valve, bottom blowdown valves, and bottom dump valves. The shell shall be insulated as required by the paragraph "INSULATION" and the insulation shall be covered by lagging.

2.2.4 Heat Recovery Section for Gas Turbine

The unit shall consist of a [fire tube] [water tube or water wall] exhaust boiler equipped with an exhaust gas bypass. Unit shall be specifically designed for the specified installation and shall be a complete package with thermal insulation, controls, accessories, and base. The insulation shall be in accordance with the paragraph "INSULATION." If heat recovery section does not meet the turbine exhaust sound levels specified, it shall be supplied with supplementary exhaust silencer to meet specification requirements for both on-stream and bypass conditions.

2.2.5 Steam Separator Unit

The unit shall be a combination flash tank and steam separator unit of sufficient size for the engine cooling and waste heat recovery system when engine is operated at 110 percent load in an ambient temperature of [40] [_____] degrees C [105] [_____] degrees F at [_____] m feet altitude. The unit shall be complete with low-water alarm switch, low-level cutout switch (set at a level lower than the low-water alarm switch), pressure gauge, safety valve, gauge glass and cocks, vent valve, water-level control, high-water-level alarm, condensate-motor control, and blowdown connection. Controls shall be so positioned that coolant level shall be visible in gauge glass at all times. The vessel shall be constructed and certified in accordance with the ASME requirements and shall be hydrostatically tested conforming to ASME requirements. Steam at 105 kPa 15 psig from this separator shall be used for [space heating] [and] [absorption cooling] [_____]. The unit shall be insulated as required by paragraph "INSULATION."

2.2.6 Condensate Pumps and Receiver

Condensate unit shall have duplex pumps and receiver and shall be skid-mounted. Each pump shall be capable of full capacity at 120 percent full steam rate when all of the heat is wasted under 110 percent engine load in an ambient temperature of [40] [_____] degrees C [105] [_____] degrees F. An alternator shall be provided for automatically switching the pumps under response from the liquid level control of the steam generator units each time an ON-OFF cycle is completed. Pumps shall be electric motor-driven type with stainless steel shafts and bronze impellers for operation with condensate at 95 degrees C 200 degrees F. Means shall be provided to control pump operation to maintain condensate level between high and low visible levels indicated on the glass gauge of the receiver. The receiver shall be sized to hold at least enough condensate for 15 minutes of operation without raw water makeup and shall

be complete with skid mounting, gauge glass, float-type makeup water valve with emergency manual valve, air vent, high-and low-level controlled pump switch, low-level alarm, and drain connection. Air vent shall be suitable for use with coolant selected.

2.2.7 Load Control Condenser

Each condenser unit shall have a capacity to dissipate the heat rejected by the engine and its components at 110 percent full-rated load under temperature of [_____] degrees C degrees F and at [_____] m feet elevation from above sea level. The maximum coolant temperatures leaving the engine shall not be in excess of that recommended by the engine manufacturer; however, temperature differential shall not be greater than [_____] degrees C degrees F for coolant in and out of the engine.

2.2.7.1 Air-Cooled Condenser

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NOTE: Designer will select proper speed, based on air requirements. The larger units will generally require the slowest speed motor but the type of fan drive must also be considered. The fan speed and pitch of the blades are determined from manufacturer's rating data.

****

Main core unit shall be suitable for condensing the vapor generated during engine operation from zero to 110 percent of full load when there is no utilization of the steam for useful purposes. A secondary core shall be used for cooling the auxiliary system coolant. The condenser shall be the [vertical] [horizontal] air discharge type with round tubes. Fins and tubes shall be constructed of nonferrous materials; headers shall be of carbon steel and of the plug type. Fins shall be firmly bonded to tubes; tanks and supporting framework shall be constructed of steel; and fan shall be adjustable-pitch type constructed of aluminum. Inlet and outlet coolant connections shall be on one side. A drain cock shall be installed at the low point of each core. A welded structural frame shall be provided for entire unit, drilled and arranged for mounting on a concrete base, and designed to withstand winds up to [80] [_____] km/hour [50] [_____] mph. [Hail screens shall be provided in areas where hails storms are prevalent.] Reliefs shall be provided to protect against excessive pressures and temperatures developed in the system.

a. The condenser shall be complete with motor-driven fan or fans and with face dampers controlled by the condensate temperature. [Two fans per bay shall be provided.] Excessive subcooling of the condensate by overexposure to the air stream shall be avoided. Freeze protection for all modes of operation shall be provided. Fan tip speed shall not exceed 60 meters/second 12,000 feet/minute.

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NOTE: Where motor starters for mechanical equipment are provided in motor control centers, delete the reference to motor starters.

****

b. The fan motor shall be direct-connected or belt-connected to the fan and shall have sealed bearings. The motor shall be three-phase, squirrel cage induction type, [208] [460] volts at 60 Hz, synchronous

speed not to exceed [1,200] [1,800] rpm. Motor size shall be such that seasonal adjustments of the fan blade pitch are not necessary to prevent motor overloads when ambient air temperature drops to lowest value or rises to highest value specified for the prime mover operating conditions. A 60 Hz, across-the-line, enclosed type, magnetic motor starter having thermal overload protection in each ungrounded phase shall be provided. If the condenser fan motor is large enough to cause a transient voltage dip of 20 percent or more during starting inrush, a reduced-voltage type magnetic motor starter shall be used. Connections shall be such that the fan motor shall start automatically as its respective engines are started.

c. The distance between condenser and engine shall be [[_____] m feet] [as shown]. Unit shall be furnished complete with a matched float and thermostatic trap installation. Air flow shall be from the fan motor [upward] [downward] [inward] [outward] through the condenser. Furnish 300 mm twelve-inch lengths of flexible hose or pipe for all inlet and outlet pipe connections. A valved vent for release of noncondensible gases shall be provided. Condenser shall be sized by the engine manufacturer for this application. Auxiliary system coolant temperature shall not exceed 80 degrees C 180 degrees F, with a maximum differential of 8 degrees C 15 degrees F. Temperature for the system shall be maintained by regulating the steam pressure.

2.2.7.2 Water-Cooled Condenser

Unit shall be a shell-and-tube type rated for 30 degrees C 85 degrees F entering water and 40 degrees C 105 degrees F leaving water. Unit shall be furnished complete with a matched float and thermostatic trap installation as well as a subcooler unit to reduce flashing of condensate. A valved vent for release of noncondensible gases shall be provided.

2.2.8 Pressure-Operated Control Valve

The control valve shall be the butterfly type with maximum 60 percent full open operating position for good control characteristics. Nominal rating shall be with 7 kPa 1 psig pressure drop at 60 percent of full open position. For use as a back pressure valve when there is no auxiliary fired boiler, metal-to-metal seats which do not provide 100 percent shutoff to condenser shall be provided. For use with an auxiliary fired boiler, high temperature butyl or silicone rubber or EPDM seats for bubble-tight shutoff to the condenser shall be provided. Valve operator shall be [electric proportional operator with pressure control mounted internally] [pneumatic with controller with proportional band, reset and filter regulator mounted on operator]. Valve shall open on loss of air supply pressure.

2.2.9 Auxiliary Boiler for Supplemental Firing

****

NOTE: Delete this paragraph if auxiliary fired boiler is not required. Auxiliary boiler is required when a constant source of heat must be maintained during maintenance or overhaul of prime movers or to supplement heating requirements during peak demands which are beyond the capacity of the heat recovery installation.

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Boiler and related equipment shall be as specified in Section 23 52 30.00 10 HEAT RECOVERY BOILERS .

2.2.10 Forced Circulation Pump

Where an engine-driven pump is not provided for jacket water circulation, a separate electric motor-driven pump interlocked with engine operation shall be provided as required by the engine manufacturer.

2.2.11 Heat Exchangers

Heat exchangers shall be provided as shown. Heat exchangers shall be of the shell-and-tube design, either U-tube type or helical coil type. Other types of construction are not acceptable unless prior written approval is received. Heat exchangers shall be designed, fabricated, tested, and stamped in accordance with ASME BPVC SEC VIII D1.

a. Materials of construction shall be suitable for the intended service except that no cast material shall be used. The manufacturer's drawing submittal shall indicate the grade of material that has been used, giving the full ASME specification number designation for each component. U-tube materials shall be furnished as light drawn temper; helical coils shall be furnished fully annealed. The materials of construction on the shell side [casing] shall be carbon steel. The tube side materials shall be 90-10 Copper-Nickel for the tubes, tubesheets, and channel bonnets for U-tube designs. Tubing and headers for the helical coil designs shall be 90-10 Copper-Nickel.

b. Tube-to-tube sheet connections and tube-to-header connections for helical coils shall be either rolled or welded for the condensate cooler and lube oil cooler, and shall be welded for lube oil preheater.

2.2.11.1 Lube Oil Cooling

Lube oil cooling and heat reclamation exchangers shall be furnished as part of the engine. The designs shall provide for the oil to be on the outside of the tubes and the cooling water on the inside. A thermal sensing unit shall be provided in the oil outlet piping where it can sense the mixed average temperature of the oil leaving the cooler and actuate the control valve on the cooling water flow to prevent overcooling the lube oil.

2.2.11.2 Fuel Oil Preheating

If fuel oil preheating is required, this heat exchanger shall be provided as part of the boiler package. The designs shall provide for the oil to be on the outside of the tubes and the steam or high temperature water on the inside. A thermal sensing unit shall be provided in the oil outlet piping where it can sense the mixed average temperature of the oil leaving the preheater and actuate the control valve on the high temperature hot water/steam to ensure that oil temperature is in the proper range for the prime mover.

2.2.11.3 Condensate Heat Exchanger

High pressure condensate heat exchanger shall provide heating of domestic or boiler feedwater while reducing the condensate temperature to minimize flashing in the condensate surge tank. The designs shall provide for the

condensate to be on the outside of the tubes and the cooling water (domestic or boiler feedwater) to be on the inside.

2.2.12 High Temperature Water Heat Recovery Systems

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NOTE: Delete this paragraph if high temperature water heat recovery is not utilized.
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Where high temperature water is utilized as a heat recovery system medium, the system shall be provided with proper expansion tank, dump tank, pressurization system, circulation pumps, makeup water facilities, controls, unit heaters, and piping as specified in Section 23 50 52.00 10 CENTRAL HIGH TEMPERATURE WATER (HTW) GENERATING PLANT AND AUXILIARIES.

2.2.13 Pressure Gauges

Gauges shall be heavy-duty industrial type conforming to ASME B40.100, style as required, suitable for pressure or vacuum specified, with minimum 152 mm 6 inch diameter dial, except as otherwise specified. Pressure gauges shall be installed on each boiler, on the low-pressure side of each pressure reducing valve, on the discharge side of each pump, and where shown or where required for proper operation. Gauges shall be readily accessible and easily read from the operating floor. Gauges shall be equipped with integral or separate siphons and shall be connected by brass pipe and fittings with shutoff cocks. Where pressure-reducing valves are used, gauges shall be placed close to the pressure-reducing assembly, both downstream and upstream, but connected approximately 3 m 10 feet therefrom. Operating ranges of the gauges shall be as follows:

Gauges	Operating Pressure, kPapsig	Pressure Range, kPapsig
Boiler	690-860100-125	0-13800-200
Medium-Pressure Steam	34550	0-6900-100
Low-Pressure Steam	14-352-5	0-2100-30
Boiler Feed Pump	10342-5	0-13800-200
Other Pumps	140-34520-50	0-6900-100

2.2.14 Thermometers

Thermometers shall conform to ASME PTC 19.3 TW, Type I, Class 3, with wells. Mercury shall not be used in thermometers. Temperature ranges shall be suitable for the intended use. Thermometers shall be installed in the feedwater pipeline between the feedwater heater and boiler feed pump in the main condensate return line before entering the surge tank, and elsewhere as indicated or specified. Thermometers shall have straight or angle stems as required and shall be easily read from the operating floor.

2.3 WATER TREATMENT EQUIPMENT

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NOTE: The proper condition of feedwater and boiler water is of major importance in assuring long life and minimum maintenance of any heat recovery system. Due to varying conditions in different locations, it is impossible to set forth specific control standards. If water treatment is covered in another section, the requirements should be reviewed for compatibility with the requirements of waste heat recovery systems. A study should be made as follows:

a. Internal Treatment: Conventional internal water treatment should be used along with regular boiler blowdown. Water treatment should consist of alkalinity adjustments and chemical additions for the removal of dissolved oxygen and treatment of residual hard-scale-forming materials. Treatment may also be required for sludge dispersal and to prevent foaming.

The following values can be used as a guide:

pH	**10.5 - 11.2**
02	**0 ppm**
PO4	**20-40 ppm**
TDS	**3500 ppm, max**

b. External Treatment: Makeup water must be treated to remove calcium, magnesium, and total iron. Special attention should be given to water which contains suspended solids, a high residual of iron and sodium chloride, and dissolved oxygen.

c. Condensate Return Line Corrosion: Corrosion in the return line will allow harmful iron oxide to enter the boiler system where it can adhere to the internal surfaces and reduce the heat transfer. It is recommended that steps be taken to protect the condensate return system from the corrosive effects of oxygen and carbon dioxide.

For additional information concerning control of internal chemical conditions, refer to ASME Boiler and Pressure Vessel Code, Section VII (Recommended Rules for Care of Power Boilers), Subsection C7.

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Water treatment equipment is required and shall be as specified in Section 23 25 00 CHEMICAL TREATMENT OF WATER FOR MECHANICAL SYSTEMS.

2.4 INSULATION

Apply insulation in sufficient thickness to limit the surface temperature of the lagging to not more than [50] [65] degrees C [120] [150] degrees F when in still air at site maximum dry bulb temperature. Submit Heat transfer calculations to the Contracting Officer to substantiate insulation material and thickness selection. Provide insulation with waterproof lagging when installed outdoors. Comply with EPA requirements in accordance with Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

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NOTE: All pertinent piping and related equipment supports are to be designed and indicated in accordance with UFC 3-301-01 for seismic design.

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Install equipment in accordance with manufacturer's instructions and recommendation. All pieces of equipment shall be bolted in place on foundations unless they are skid-mounted on the prime mover base skid. Submit detail drawings consisting of a complete list of equipment and material, including manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, drawings, and installation instructions. Include in the drawings complete piping and wiring drawings, schematic diagrams, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Also show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances required for maintenance and operation. Flexible connectors shall be used to connect any piping to the prime mover. Piping for interconnecting various components of the heat recovery equipment shall conform to the requirements of ASME B31.1. Submit calculations, manufacturer's design data and structural computations for walls, roof, foundations, and other features for specialty type of construction, with design data for lateral forces that may be encountered due to wind loads and seismic zone forces.

3.3 CLEANING OF BOILERS AND PIPING

3.3.1 Boiler Cleaning

After the hydrostatic tests have been made and before starting the operating tests, the boiler shall be thoroughly and effectively cleaned of foreign materials, including mill scale, grease, and oil deposits. The Contractor may use the following described procedure or may submit his own standard procedure for review and approval by the Contracting Officer. Wherever possible, surfaces in contact with water shall be wire-brushed to remove loose material before filling the boiler with a solution containing:

caustic soda	11 kg24 pounds
sodium nitrate	4 kg8 pounds
disodium phosphate, anhydrous	11 kg24 pounds
approved wetting agent, 3785 L1000 gallons water	230 g1/2 pound

Chemicals shall be thoroughly dissolved in the water before being placed in the boilers. The boiler shall then be operated at 210 to 345 kPa 30 to 50 psig and minimum rating for 24 to 48 hours, exhausting the steam to atmosphere. After the boiling period, the boiler shall be allowed to cool before being drained and thoroughly flushed out. Piping shall be cleaned by operating the boilers for a period of approximately 48 hours, wasting the condensate.

3.3.2 Boiler Water Conditioning

Provide chemical treatment and blowdown of boiler water during periods of boiler operation to prevent scale and corrosion in boilers and in steam and return distribution systems from initial startup of the system, through the testing period, and to final acceptance by the Government. Chemicals used and method of treatment shall be approved by the Contracting Officer.

3.4 POSTED INSTRUCTIONS

Submit framed instructions under glass or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system, to be posted where directed. Submit proposed diagrams, instructions, and other sheets, prior to posting, as specified. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above for the wiring and control diagrams, and posted beside the diagrams. Post the framed instructions before acceptance testing of the systems.

3.5 FIELD TRAINING

Provide a field training course for designated operating staff members. Training shall be provided for a total of [_____] hours of normal working time and shall start after the system is functionally complete, but prior to final acceptance tests. Field training shall cover all of the items contained in the approved operation and maintenance instructions.

3.6 TESTS

Following installation, each boiler shall be tested hydrostatically and proved tight under a gauge pressure of 1.5 times the working pressure specified and in accordance with applicable ASME requirements. Following the installation of piping and heat recovery equipment, but before the application of any insulation, hydrostatic tests shall be made and the system proved tight under gauge pressures of 1.5 times the working pressure specified, but not less than the following:

Low-pressure lines	275 kPa40 psi
Medium-pressure lines	415 kPa60 psi
High-pressure-steam lines	1035 kPa150 psi
Boiler feed lines	1550 kPa225 psi

The boilers and the piping shall be inspected by a boiler inspector qualified as required by ASME BPVC SEC VIII D1, ASME BPVC SEC I, or ASME BPVC SEC IV, as applicable. A certificate of approval shall be supplied for each boiler. Submit test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Indicate in each test report the final position of controls.

3.7 EFFICIENCY AND OPERATING TESTS

Upon completion, and before acceptance of the work, the heat recovery plant shall be subjected to such operating tests as may be required to demonstrate satisfactory functional operation. Each operating test shall be conducted at such times as the Contracting Officer may direct. Water meter used in the test shall be suitable for hot water. Provide instruments, test equipment, and test personnel required to properly conduct all tests; the necessary fuel, water, and electricity will be furnished by the [Government] [_____]. The boiler operating tests shall, as a minimum, be conducted continuously at the following capacities for the following time:

Test Percentage of Operating Capacity		
Testing Time	Water Wall or Water Tube Boilers	Firebox Boilers
First 2 hours	50	50
Next 2 hours	75	75
Next 6 hours	100	100*
Next 2 hours	110	--

a. Firebox boiler shall not be operated above 100 percent of capacity.

b. The general performance tests on the heating plant shall be conducted by an experienced test engineer and will be observed by the Contracting Officer. Submit a proposed performance test procedure, 30 days prior to the proposed test date. Include in the procedure a complete description of the proposed test with calibration curves or test results furnished by an independent testing laboratory of each instrument, meter, gauge, and thermometer to be used in the tests. Do not start the test until the procedure has been approved. A test report including logs, heat balance calculations, tabulated results, and conclusions shall be delivered to the Contracting Officer as

stated in the paragraph "PERFORMANCE TEST REPORTS." [An analysis of the fuel being burned on the test shall be submitted to the Contracting Officer.]

c. Test of capacity of water treatment equipment and quality of the effluent shall meet the requirements specified. Tests for ion-exchange units shall cover at least two complete regenerations and capacity runs. Tests for hot process or other precipitation type softeners shall be conducted continuously for a period of at least 48 hours, with samples taken at 2-hour intervals.

d. Tests for steam quality in accordance with ASTM D1066 shall be conducted under the operating conditions specified.

e. Quality of steam used for air conditioning equipment shall be tested in accordance with the conductivity method in ASTM D2186 with the conductivity of the steam corrected for carbon dioxide and ammonia content not to exceed 4.0 microsiemens 4.0 micromhos at 18 degrees C 65 degrees F.

3.8 RETESTING

If any deficiencies are revealed during test, such deficiencies shall be corrected and the tests reconducted at no additional costs to the Government.

3.9 FIELD PAINTING

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NOTE: Where identification of piping is required by the using service, this paragraph will be amplified to include appropriate requirements, either directly or by reference to a separate section.

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Ferrous metal surfaces not specified to be coated at the factory shall be cleaned, prepared, and painted as specified in Section 09 90 00 PAINTS AND COATINGS. Exposed pipe covering shall be painted as specified in Section 09 90 00 PAINTS AND COATINGS. Aluminum lagging over insulation shall not be painted.

-- End of Section --