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USACE / NAVFAC / AFCEC **UFGS-23 72 00 (May 2024)**

Preparing Activity: USACE **Superseding**
UFGS-23 72 00.00 10 (January 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2025
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DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

SECTION 23 72 00

ENERGY RECOVERY SYSTEMS

05/24

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SECTION 23 72 00

ENERGY RECOVERY SYSTEMS
05/24

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NOTE: This guide specification covers the requirements for energy recovery systems for power plant installations and boilers where a steady source of waste heat is available. This specification also covers air-to-air energy recovery for HVAC systems.

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

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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.

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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	(2024) Power Piping
ASME B40.100	(2022) 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 B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM D1066	(2018; E 2018) Standard Practice for Sampling Steam
ASTM D2186	(2005; R 2009) Deposit-Forming Impurities in Steam
ASTM E84	(2023) Standard Test Method for Surface Burning Characteristics of Building Materials

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2021) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2024) Standard for the Installation of Air Conditioning and Ventilating Systems

UL SOLUTIONS (UL)

UL 723	(2020) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials
UL 900	(2015; Reprint Aug 2022) UL Standard for SafetyStandard for Air Filter Units
UL 1812	(2013; Reprint Apr 2024) UL Standard for Safety Ducted Heat Recovery Ventilators
UL 1995	(2015; Reprint Aug 2022) UL Standard for Safety Heating and Cooling Equipment

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 and Air Force 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.

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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. Submittals not having a "G" or "S" classification are 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-01 Preconstruction Submittals

Welding Procedures And Qualifications

SD-02 Shop Drawings

Installation

SD-03 Product Data

Spare Parts

Posted Instructions

Performance Tests; G, [_____]

Water Treatment Equipment

Fixed Plate Heat Exchangers

Energy Recovery Wheel

Engine Jacket Heat Recovery Equipment

Engine Heat Recovery Silencer

Gas Turbine Heat Recovery Section

Steam Separator Unit

Load Control Condenser

Auxiliary Boiler

Heat Exchangers

SD-05 Design Data

Calculations

SD-06 Test Reports

Tests

Performance Test Procedure; G, [_____]

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G, [_____]

Training; 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. Weld piping in accordance with qualified procedures using performance qualified welders and welding operators. Furnish qualified procedures and welders 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. Notify Contracting Officer 24 hours in advance of tests and perform tests at the work site if practicable. The welder or welding operator must apply his assigned symbol near each weld he makes as a permanent record. Weld structural members 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

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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

Provide 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. Provide tube cleaner and rotary brush for each size of water tube in the boiler, with one extra set of cutters for each size cleaner. Provide necessary valves and fittings 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. Provide cleaner with a 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

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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.

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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 provide troubleshooting guide. Include in the manuals contact information for repairs, point of contact information for customer support, piping layout, equipment layout, and simplified wiring and control diagrams of the system as installed.

PART 2 PRODUCTS

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. Provide equipment supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.1.2 Nameplates

For each major item of equipment, secure a plate to the item of equipment containing the manufacturer's name, address, type or style, model or serial number, and catalog number.

2.1.3 Prevention of Rust

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

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NOTE: For equipment to be installed outdoors, adequate protection must be specified. Manufacturers must submit evidence that unit specimen has passed the specified salt spray fog test. A 125 hour test will be specified in a noncorrosive environment, and a 500 hour test will be specified in a corrosive environment.

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[Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, must be factory finished with the manufacturer's standard finish, except that items located outside of buildings must have weather resistant finishes that will withstand [125][500] hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen must show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 3 mm1/8 inch on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used it must be coated with a zinc-rich coating conforming to ASTM D520, Type I.]

2.1.4 Equipment Guards and Access

Fully enclose or guard belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts. Guard or cover high temperature equipment and piping with insulation of a type specified by the manufacturer. 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].

2.1.5 Electrical Equipment

Provide electric motor-driven equipment specified complete with motors and necessary motor control devices. Provide motors and motor control devices conforming to the applicable requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM including requirements for hazardous area locations. Provide premium efficiency integral size motors in accordance with NEMA MG 1.

2.1.5.1 Motor Ratings

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

2.1.5.2 Motor Controls

Where a motor controller is not shown in a motor control center on the electrical drawings, provide a motor controller. Where required, provide motor controllers 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. Provide 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. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function.

2.1.6 Condensate Pumps and Receivers

Furnish condensate unit with duplex pumps and receiver and skid-mount. Provide pump that is 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. Provide an alternator 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. Provide electric motor-driven pumps with stainless steel shafts and bronze impellers for operation with condensate at 95 degrees C 200 degrees F. Control pump operation to maintain condensate level between high and low visible levels indicated on the glass gauge of the receiver. Provide receiver sized to hold at least enough condensate for 15 minutes of operation without raw water makeup and 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. Provide air vent suitable for use with coolant selected.

2.1.7 Pressure Gauges

Provide heavy-duty industrial type gauges 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. Install pressure gauges 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. Provide gauges that are readily accessible and easily read from the operating floor. Equip gauges with integral or separate siphons and connect by brass pipe and fittings with shutoff cocks. Where pressure-reducing valves are used, place gauges close to the pressure-reducing assembly, both downstream and upstream, but connect approximately 3 m 10 feet therefrom. Provide operating ranges of the gauges 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

Gauges	Operating Pressure, kPapsig	Pressure Range, kPapsig
Boiler Feed Pump	10342-5	0-13800-200
Other Pumps	140-34520-50	0-6900-100

2.1.8 Thermometers

Furnish thermometers conforming to ASME PTC 19.3 TW, Type I, Class 3, with wells. Do not use Mercury in thermometers. Temperature ranges must be suitable for the intended use. Install thermometers 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 must have straight or angle stems as required and must be easily read from the operating floor.

2.2 EXHAUST HEAT ENERGY RECOVERY EQUIPMENT

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NOTE: Exhaust heat energy recovery equipment is closely associated with the boiler or prime mover and it will frequently be more advantageous to specify this equipment in the same section in which the boiler or 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.

Heat Recovery Steam Generators (HRSG) for Gas Turbines are not included in this specification. Gas Turbines may have duct burners to increase efficiency. Duct burners raise the exhaust gas to a much higher temperature than found in boilers and engines. Boiler exhaust is typically below 800 deg F and engine exhaust below 1250 deg F. Gas turbine exhaust downstream of duct burners can raise exhaust gas up to 2600 deg F. HRSG's for gas turbines must be integrated into the gas turbine assembly to meet unique requirements and is not included in these generic specifications. The Designer will need to specify this equipment as required for each project.

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.

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Provide a heat recovery system that is an integrated design package compatible with the prime mover [cooling] [and] [exhaust] system in accordance with the drawings and data sheets. Provide 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 Boiler Economizer

[Unit performance requirements are shown in the equipment schedules on the drawings.]

2.2.1.1 Rectangular Tube Recovery Unit

Provide a rectangular tube recovery (RTR) unit in the exhaust duct of the boiler. RTR must have heat transfer design manufactured and tested in accordance with Section VIII, Division 1 of the ASME Boiler and Pressure Code, and stamped for a minimum 250 [_____] psig design pressure. RTR must include stainless steel, internal flue gas bypass diverter to provide full emergency bypass requiring no additional ductwork for controlling. RTR unit must have removable, gas-tight inspection doors providing complete access to the entire heating surface for inspection, tube removal, and cleaning. RTR must be capable of draining completely when mounted in vertical or horizontal position. Liquid inlet and outlet pipe connections greater than 2 inch NPT must be flanged. Liquid header manifolds must also contain connections for venting, draining and safety relief valves as required. Tube to tube or tube to header joint welds must not be in contact with the exhaust stream to minimize potential vessel failure.

Water side design pressure must be 250 [_____] psig at 350 [_____] deg F and 375 [_____] psig test pressure. Unit must be designed for [_____] deg F flue gas inlet temperature with a design pressure of 3 [_____] in. water column. Tube and fin design must be [SA178GrA ERW x 1.0 in OD x 0.083 in wall thickness with carbon steel 0.030 in fin thickness x 0.50 hgt nickel brazed or welded to the tube][TP316L x 1.0 in OD x 0.065 in wall thickness with aluminum 0.020 fin thickness x 0.50 in hgt Al-Fuse bonded to the tube][TP316L x 1.0 in OD x 0.065 in wall thickness with 304 stainless steel 0.020 fin thickness x 0.50 hgt nickel brazed or welded to the tube][_____].

2.2.1.2 Fin Coil Recovery Unit

Provide a fin coil recovery (FCR) unit in the exhaust duct of the boiler. FCR must have heat transfer design manufactured and tested in accordance with Section VIII, Division 1 of the ASME Boiler and Pressure Code, and stamped for a minimum 250 [_____] psig design pressure. FCR must include stainless steel, internal flue gas bypass diverter to provide full emergency bypass requiring no additional ductwork for controlling. RTR must have removable, gas-tight inspection doors providing complete access to the entire heating surface for inspection, tube removal, and/or cleaning. RTR must be capable of draining completely when mounted in vertical or horizontal position. Liquid inlet and outlet pipe connections greater than 2" NPT must be flanged. Liquid header manifolds must also contain connections for venting, draining and/or safety relief valves as

required. Tube to tube or tube to header joint welds must not be in contact with the exhaust stream to minimize potential vessel failure.

Water side design pressure must be 250 [_____] psig at 350 [_____] deg F and 375 [_____] psig test pressure. Unit must be designed for [_____] deg F flue gas inlet temperature with a design pressure of 3 [_____] in. water column. Tube and fin design must be [SA178GrA ERW x 1.0 in OD x 0.083 in wall thickness with carbon steel 0.030 in fin thickness x 0.50 hgt nickel brazed or welded to the tube][TP316L x 1.0 in OD x 0.065 in wall thickness with aluminum 0.020 fin thickness x 0.50 in hgt Al-Fuse bonded to the tube][TP316L x 1.0 in OD x 0.065 in wall thickness with 304 stainless steel 0.020 fin thickness x 0.50 hgt nickel brazed or welded to the tube][_____].

2.2.1.3 Condensing Economizer Unit

Provide a [single][two] stage condensing economizer unit in the exhaust duct of the boiler. Unit must have heat transfer design manufactured and tested in accordance with Section VIII, Division 1 of the ASME Boiler and Pressure Code, and stamped for a minimum 250 [_____] psig design pressure. Unit must include stainless steel, internal flue gas manual bypass assembly requiring no additional ductwork for bypassing. Unit must have removable, gas-tight inspection door providing complete access to the entire heating surface for inspection and cleaning. Unit must have stainless steel condensate drain assembly. Unit must have stainless steel interior and exterior construction, 2 inch thick minimum factory insulation, exhaust stack flanged connections, and removable finned tubes.

Water side design pressure must be 250 [_____] psig at 350 [_____] deg F and 375 [_____] psig test pressure. Unit must be designed for [_____] deg F flue gas inlet temperature with a design pressure of 3 [_____] in. water column.

2.2.2 [Boiler][Engine] Exhaust Steam Generator

Exhaust Steam Generator (ESG) must be manufactured and tested in accordance with the requirements of Section 1 of the ASME Boiler and Pressure Vessel Code and stamped at 150 [_____] psig to the appropriate Section. The operating pressure must be [_____] psig. The ESG must operate in a fully automatic mode under fluctuating steam loads and exhaust volumes. The ESG must be pre-piped, pre-wired and mounted on a structural steel base requiring no field assembly. The ESG must include finned tube heating surface, modulating full port exhaust bypass, steam flash drum assembly, and integral circulating pump to circulate water from the heat transfer section back to the steam flash drum assembly. All water, air and blowdown connections must have a common manifold assembly for ease of piping installation.

Explosion proof heat exchanger surface must be nickel [brazed][welded] fin to tube. Finned tubing must be designed in multiple sections for ease of replacement. The heat exchanger section must contain a main inspection door for removal, cleaning, and inspection. The reinforced enclosure must contain [304 stainless steel][_____] baffles with 4 inch [_____] minimum thickness thermal insulation. The enclosure must be designed to operate with exhaust temperatures entering at 1250 [_____] deg F maximum, have a gas tight seal, and have a continuously welded 10 [_____] gauge carbon steel exterior. ESG must be designed for a exhaust side design pressure of 10 [_____] inches water column. ESG must be primed or painted with high temperature metallic paint.

2.2.2.1 Modulating Bypass

ESG modulating bypass assembly must be constructed of [plate steel][stainless steel] and exhaust connections must be 150 lb [_____] design SA105 exhaust flanges. Bypass assembly must be bolted to the heat exchanger section. Bypass must be controlled by a modulating positioning actuator and steam pressure dial control for controlling the volume of waste heat exhaust gas dependent on steam pressure. The reinforced damper assembly must be constructed of 304 stainless steel and designed for tight seal during full bypass. Damper shaft must contain high temperature bearings and packing glands to seal exhaust leakage. In the event of an air pressure or electrical failure to the ESG, the modulating bypass assembly must contain an alarm fail safe operating mode whereby the damper assembly must automatically move to the full exhaust bypass position.

2.2.2.2 Steam Flash Drum

ESG steam flash drum assembly must contain internal baffles and dry pipes for dry steam output and 1 inch [_____] thick thermal insulation with carbon steel exterior. ESG must include circulating pump to maintain high water flow turbulence for minimum fouling, main flash drum blowdown valving assembly, continuous surface blowdown valve, and water level control blowdown valve all manifolded into a single blowdown connection. Safety controls must include low and high water cutout, excess steam pressure cutout, and low air pressure cutouts where required for pneumatic exhaust bypass actuator. ESG must have water level control system with boiler feedwater on and off auxiliary switch and red line water level sight glass with drain cock. ESG must include all required gauges for steam, feedwater, pump cooling water and air indication. ESG must include ASME and National Board stamped steam safety relief valve. All interconnecting piping linkages and valving must be factory installed. Control panel must be NEMA 12 construction and accept a single main power connection with disconnect, starter, power and run indicating lights, fill indicating light, low and high water alarm indicating lights, and ow air and excess steam pressure lights.

2.3 Engine Jacket Heat Recovery Equipment

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NOTE: Jacket 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.
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2.3.1 Engine Cooling

2.3.1.1 Antifreeze

[For ebullient cooling where steam is required, provide a cooling system 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, utilize an ethylene glycol permanent type antifreeze. Base size of cooling system upon the use of an antifreeze solution which will protect the system down to minus 45 degrees C minus 50 degrees F.] Provide a permanent type antifreeze for cooling the lube oil and auxiliaries suitable for use with water, or use the antifreeze solution specified above and connect to a separate section of the waste heat condenser from the engine coolant. Provide valve trim and materials that are compatible for use with the antifreeze solution. Operation of the cooling system must be fully automatic while the prime mover is running.

2.3.1.2 Water Jacket Temperature

For diesel engine ebullient cooling, provide jacket water temperature no 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.

2.3.1.3 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, provide a PVC makeup tank with an electric motor-driven pump unit as indicated. Manifold pump to allow using it as a mixing unit by shunting the flow back to the tank. System fill must be [manual] [automatic] with feed into the piping system steel expansion tank connection line as indicated.

[Construction for Ebullient steam generator from engine jacket water must be as follows. The Exhaust Cooling Steam Generator (ECSG) must be designed to produce low pressure steam (15 psig and under) from engine jacket water using natural circulation. Steam flash tank must be ASME stamped and built in accordance with ASME Section VII Div 1, shipped as a packaged unit, include continuous water level feed control with low water cutoff, auxiliary low water cutoff, excess steam pressure switch, gauge glass assembly, surface and man blowdown assembly, vent valve, ASME steam safety valve, steam pressure gauge and wall or floor mounting provisions. Connections must include 150 psig steam outlet, 150 psig water/steam inlet, blowdown, an boiler feedwater. ECSG must be pre-piped and wired for single point power connection.]

2.3.2 Forced Circulation Pump

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

2.3.3 Lube Oil Cooling

Provide lube oil cooling and heat reclamation exchangers as part of the engine. The designs must provide for the oil to be on the outside of the tubes and the cooling water on the inside. Provide a thermal sensing unit 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.

2.4 ENGINE HEAT RECOVERY SILENCER

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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:

Grade of Silencer	Electric Generating Systems Association (EGSA) Rating	dBA Reduction Range
Commercial	1	10-15
Residential	3	20-25
Hospital	7	40-45

****

For each Heat Recovery silencer or supplementary silencer, reduce the generated sound spectrum to EGSA Rating and dBA reduction range specified here. Silencer EGA Rating must be [_____] with a dBA reduction range of [_____]. Provide Heat Recovery silence that is a combination boiler silencer or a boiler with a supplementary silencer in accordance with ASME BPVC SEC VIII D1 for [_____] Pa psig steam working pressure. Design the boiler 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. Design each boiler for continuous wet operation (flue gas condenstation exists) or for periods of dry operation (flue gas condensation does not exist) without interruption of the diesel engine operation when located and connected as indicated. Make provisions 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 exceeding the recommendations of the engine manufacturer is not permitted. Provide each boiler 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. Insulate the shell as required by the paragraph "INSULATION" and cover the insulation by lagging.

2.5 GAS TURBINE HEAT RECOVERY SECTION

Provide unit consisting of a [fire tube] [water tube or water wall] exhaust boiler equipped with an exhaust gas bypass. Design unit for the specified installation and provide a complete package with thermal

insulation, controls, accessories, and base. The insulation must be in accordance with the paragraph "INSULATION." If heat recovery section does not meet the turbine exhaust sound levels specified, supply a supplementary exhaust silencer to meet specification requirements for both on-stream and bypass conditions.

2.6 STEAM SEPARATOR UNIT

Provide unit consisting of 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 must 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. Position controls so that coolant level is visible in gauge glass at all times. Construct and certify the vessel in accordance with the ASME requirements and hydrostatically test conforming to ASME requirements. Use steam at 105 kPa 15 psig from this separator for [space heating][and][absorption cooling][_____]. Insulate the unit as required by paragraph "INSULATION."

2.7 LOAD CONTROL CONDENSER

Provide condenser unit with 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 must not be in excess of that recommended by the engine manufacturer; however, temperature differential must not be greater than [_____] degrees C degrees F for coolant in and out of the engine.

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.

****

Provide main core unit 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. Use a secondary core for cooling the auxiliary system coolant. The condenser must be the [vertical] [horizontal] air discharge type with round tubes. Construct fins and tubes of nonferrous materials; provide carbon steel headers of the plug type. Firmly bond fins to tubes; construct tanks and supporting framework of steel; and construct adjustable-pitch fan of aluminum. Make inlet and outlet coolant connections on one side. Install a drain cock at the low point of each core. Provide a welded structural frame for entire unit, drilld and arrange for mounting on a concrete base, and design to withstand winds up to [80] [_____] km/hour [50] [_____] mph. [Provide hail screens in areas where hails storms are prevalent.] Provide reliefs to protect against excessive pressures and temperatures developed in the system.

a. Furnish condenser complete with motor-driven fan or fans and with face dampers controlled by the condensate temperature. [Provide two fans per bay.] Avoid excessive subcooling of the condensate by overexposure to the air stream. Provide freeze protection for all modes of operation. Do not exceed fan tip speed of 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. Direct-connect or belt connect rhe fan motor to the fan and seal bearings. Provide motor that is three-phase, squirrel cage induction type, [208] [460] volts at 60 Hz, synchronous speed not to exceed [1,200] [1,800] rpm. Provide motor size 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. Provide a 60 Hz, across-the-line, enclosed type, magnetic motor starter having thermal overload protection in each ungrounded phase. If the condenser fan motor is large enough to cause a transient voltage dip of 20 percent or more during starting inrush, use a reduced-voltage type magnetic motor starter. Make connections such that the fan motor will start automatically as its respective engines are started.

c. The distance between condenser and engine must be [[_____] m feet] [as shown]. Furnish complete unit with a matched float and thermostatic trap installation. Provide air flow 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. Provide a valved vent for release of noncondensible gases. Provide condenser sized by the engine manufacturer for this application. Auxiliary system coolant temperature must not exceed 80 degrees C 180 degrees F, with a maximum differential of 8 degrees C 15 degrees F. Maintain temperature for the system by regulating the steam pressure.

2.7.2 Water-Cooled Condenser

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

2.7.2.1 Pressure-Operated Control Valve

Provide butterfly control valve with maximum 60 percent full open operating position for good control characteristics. Nominal rating must be 7 kPa 1 psig with pressure drop at 60 percent of full open position. For use as a back pressure valve when there is no auxiliary fired boiler, provide metal-to-metal seats which do not provide 100 percent shutoff to condenser. For use with an auxiliary fired boiler, provide high temperature butyl or silicone rubber or EPDM seats for bubble-tight shutoff to the condenser. Provide valve operator that is [electric

proportional operator with pressure control mounted internally] [pneumatic with controller with proportional band, reset and filter regulator mounted on operator]. Valve must open on loss of air supply pressure.

2.8 AUXILIARY BOILER FOR SUPPLEMENTAL FIRING

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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.

****

Provide boiler and related equipment in accordance with Section 23 52 30.00 10 HEAT RECOVERY BOILERS.

2.9 HEAT EXCHANGERS

Provide heat exchangers as shown on drawings. Provide heat exchangers that are the [shell-and-tube design, either U-tube type or helical coil type][plate frame type]. Other types of construction are not acceptable unless prior written approval is received. Design, fabricate, test, and stamp heat exchangers in accordance with ASME BPVC SEC VIII D1.

a. Provide construction materials suitable for the intended service except do not use cast material. The manufacturer's drawing submittal must indicate the grade of material that has been used, giving the full ASME specification number designation for each component.[Provide U-tube materials as light drawn temper; provide fully annealed helical coils. Provide carbon construction materials on the shell side [casing]. Provide tube side materials that are 90-10 Copper-Nickel for the tubes, tubesheets, and channel bonnets for U-tube designs. Provide tubing and headers for the helical coil designsthat are 90-10 Copper-Nickel.]

[b. Provide either rolled or welded tube-to-tube sheet connections and tube-to-header connections for helical coils for the condensate cooler and lube oil cooler, and welded for lube oil preheater.]

2.9.1 Fuel Oil Preheating Heat Exchanger

If fuel oil preheating is required, provide this heat exchanger as part of the boiler package. The designs must provide for the oil to be on the outside of the tubes and the steam or high temperature water on the inside. Provide a thermal sensing unit 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.

2.9.2 Condensate Heat Exchanger

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

2.10 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, provide system 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.

2.11 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.

****

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

2.12 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.

2.13 AIR-TO-AIR ENERGY RECOVERY DEVICES

2.13.1 Fixed Plate Heat Exchangers

The enthalpy plate energy exchanger must transfer both sensible and latent energy between outgoing and incoming air streams in a cross or counter flow arrangement. The enthalpy plate exchanger media must be coated with hydrophilic resin. The hydrophilic resin will allow the exchange of water by direct vapor transfer using molecular transport without the need of condensation. The plate exchanger will be constructed of alternate layers of corrugated spacer and liner material coated with a hydrophilic resin. The enthalpy plate must transfer both sensible and latent energy. Frame supporting enthalpy matrix must be constructed of G90 galvanized material with end caps constructed of 18 gauge, minimum, galvanized plates. The enthalpy plate exchanger must be operable at temperatures between -40 degree C and 60 degree C-40 degree F and 140 degree F.

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NOTE: Fixed plate heat exchanger below is for sensible only energy recovery where no humidity transfer is wanted such as Natatoriums and Kitchens.

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[The enthalpy plate energy exchanger must transfer sensible energy between outgoing and incoming air streams in a cross or counterflow arrangement. The enthalpy plate must be [epoxy coated] corrugated aluminum, flat plate laminar designs are unacceptable. Exchanger must withstand a maximum pressure differential of [7] [_____] inches wg. Plate corners must be sealed with silicone free polymer sealant and rated for air temperatures up to [190] [_____] deg F. Leakage must not exceed [0.1] [_____]% percent of rated airflow at 1.6 in wc differential pressure. Exchanger casing must be constructed of extruded aluminum corner profiles and aluzinc steel or aluminum endplate framing.]

2.13.1.1 Performance

The enthalpy plate exchanger must bear the AHRI 1060 Certified Product Seal. Sensible, latent and total effectiveness along with supply and exhaust air pressure drop, Exhaust Air Transfer Ratio (EATR) and Outside Air Correction Factor (OACF) rating must be clearly documented with performance tests conducted in accordance with ASHRAE Standard 84 and per the official AHRI laboratory. Exchangers that do not bear the AHRI 1060 certified seal are unacceptable. The enthalpy plate exchanger must withstand pressure differentials of at least 5 inch w.g. The enthalpy plate exchanger must be a UL Recognized Component and bear the UL Certification Mark as an indication of meeting UL 723 testing requirements when tested by a UL Laboratory also following UL 1995 procedures. The exchanger must have a flame spread of less than 25 and a smoke developed of less than 50 when rated in accordance with ASTM E84. Exchangers only tested in accordance with UL 723 will not be acceptable. The membrane must not promote the growth of mold or bacteria and must have successfully passed ASTM-G21 testing.

2.13.2 Energy Recovery Wheel

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NOTE: Energy Recovery Wheel specified below applies to wheel sections integrated into equipment such as standalone heat recovery ventilators, air handling systems, and packaged direct expansion units.

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The energy recovery cassette must incorporate a rotary wheel in an insulated cassette frame complete with removable energy transfer media, seals, drive motor, and drive belt. Energy recovery wheel performance will be AHRI 1060 certified and bear the AHRI certified label. Components that are independently tested or "rated in accordance with" will not be acceptable. Certified components must be listed as active in the AHRI Directory (www.ahridirectory.org). The energy recovery cassette must be an Underwriters Laboratory (UL) recognized component for fire and electrical safety and bear the UL symbol. Recognized components are to be listed in the UL directory (http://database.ul.com). The energy recovery cassette must be in accordance with NFPA 90A by virtue of UL 1812 and UL 900 fire test for determination of flammability and smoke density.

2.13.2.1 Cassette Construction

Cassette frame and structural components must be constructed of G90 galvanized steel for corrosion resistance. Wheel structure must consist of a welded hub, spoke and continuous rolled rim assembly of stainless steel, and must be self-supporting without energy transfer segments present. Wheel bearings must be permanently sealed and selected for a minimum 30 year L-10 life of 400,000 hours. Bearings requiring external grease fittings or periodic maintenance are not acceptable. Wheels 30 inch in diameter and greater must be provided with removable energy transfer segments to facilitate maintenance and cleaning. All diameter and perimeter seals must be provided as part of the cassette assembly and must be factory set. Seals must be non-contact type oriented in a labyrinth style configuration. Diameter seals must be fully adjustable and easily accessible. Perimeter seals must be permanently mounted to the wheel rim and not require adjustment. The wheel drive motor must be an Underwriters Laboratory Recognized Component, be mounted in the cassette frame and supplied with a service connector or junction box. Three phase

motors must be suitable for use in both standard and inverter rated applications. Wheels 50 inch and smaller must use a urethane stretch belt for wheel rim drive without the need for external tensioners. Wheels 60 inch and larger must use a urethane non-stretch belt with integral cord and constant tensioner. Wheel drive system must not require periodic adjustment.[Provide double wall G90 galvanized steel construction to encapsulate all exposed insulation within the cassette frame.]

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NOTE: For corrosive environments, select options below.
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[Corrosion protection must consist of powder coating on all exposed metals and inclusion of stainless steel bearings. The powder coating must have a minimum thickness of 2.0 mils and be rated for a 1,000 hour salt spray.]

2.13.2.2 Energy Transfer Media

Energy transfer media must be constructed of a durable synthetic lightweight polymer. Media must be wound continuously with one flat and one structural layer in an ideal parallel plate geometry. Airflow across heat exchanger surface must remain laminar. Energy transfer media must be suitable for use in corrosive, marine or coastal environments without the need for additional coatings.[Sensible only energy transfer media must be constructed in the same fashion as the enthalpy transfer media with the exception of the desiccant coating process required for enthalpy wheels.][Desiccant must be either silica gel or molecular sieve and be permanently bonded to the energy transfer media without the use of binders or adhesives, which may degrade desiccant performance. Desiccants not permanently bonded are not acceptable due to potential delamination or erosion of the desiccant from the energy transfer media. Desiccant must be non-migrating and must not dissolve or deliquesce in the presence of water or high humidity. Energy transfer media must be capable of repeated washings without significant degradation of the desiccant bond.] Energy recovery segments are to be cleanable outside of the cabinet with detergent or alkaline coil cleaner and water. Energy transfer segments must be capable of submersion in a cleaning solution. Submersion must be capable of restoring [latent]performance within AHRI certified performance limits.

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.
****

Install equipment in accordance with manufacturer's instructions and recommendation. Bolt all pieces of equipment 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. Use flexible connectors to connect any piping to the prime mover. Provide piping for interconnecting various components of the heat recovery equipment conforming 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, thoroughly and effectively clean the boiler of foreign materials, including mill scale, grease, and oil deposits in accordance with Section 23 52 30.00 10 HEAT RECOVERY BOILERS.

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 must 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. Prepare 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 in typed form, frame as specified above for the wiring and control diagrams, and post 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 must be provided for a total of [_____] hours of normal working time and must start after the system is functionally complete, but prior to final acceptance tests. Cover all of the items contained in the approved operation and maintenance instructions.

3.6 TESTS

Following installation, test each boiler hydrostatically and prove that the system is 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, perform hydrostatic tests and prove that the system is tight under gauge pressures of 1.5 times the working pressure specified, but no 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 must 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. Supply a certificate of approval 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 HEAT RECOVERY PLANT EFFICIENCY AND OPERATING TESTS

Upon completion, and before acceptance of the work, subject the heat recovery plant to such operating tests as may be required to demonstrate satisfactory functional operation. Conduct each operating test at such times as directed by the Contracting Officer. Use water meter in the test that is 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] [_____]. Conduct boiler operating tests, as a minimum, 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. Do not operate firebox boiler above 100 percent of capacity.

b. Conduct general performance tests on the heating plant by an experienced test engineer and tests 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. Deliver test report including logs, heat balance calculations, tabulated results, heat recovery efficiencies, and conclusions to the Contracting Officer as stated in the paragraph "TESTS."[Submit an analysis of the fuel being burned on the test to the Contracting Officer.]

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

d. Conduct tests for steam quality in accordance with ASTM D1066 under the operating conditions specified.

e. Test quality of steam used for air conditioning equipment 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 ENERGY RECOVERY WHEEL INSPECTION AND TESTING

Verify that the wheel is rotating in the direction of the rotation arrow located on cassette frame and is not damaged. Visually inspect belt, ensure belt is tracking near the center of the rim and is not flipped or twisted. Check for excessive noise such as scraping, brushing, or banging. Measure and verify running amps do not exceed nameplate Full Load Amperes (FLA). Measure and record entering and leaving air dry bulb and wet bulb temperatures, airflow and pressure drop across wheel; then determine sensible heat, latent and total effectiveness for those conditions. Airflow and pressure drop must be within plus or minus five percent of specified values. Show access and removal procedure to clearly show how wheel is to be cleaned.

3.9 FIXED PLATE HEAT EXCHANGER INSPECTION AND TESTING

Inspect heat exchanger plate for damage and show access procedure to show how plate is to be cleaned. Measure and record entering and leaving air dry bulb and wet bulb temperatures, airflow and pressure drop across heat exchanger; then determine sensible heat, latent and total effectiveness for those conditions. Airflow and pressure drop must be within plus or minus five percent of specified values.

3.10 RETESTING

If any deficiencies are revealed during test, correct such deficiencies and reconduct the tests at no additional costs to the Government.

3.11 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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Clean, prepare, and paint ferrous metal surfaces not specified to be coated at the factory as specified in Section 09 90 00 PAINTS AND COATINGS. Paint exposed pipe covering as specified in Section 09 90 00 PAINTS AND COATINGS. Do not paint aluminum lagging over insulation.

-- End of Section --