

**Department of Public Safety
Alaska Bureau of Investigation (ABI) Boiler Upgrades Project
Project # 12-133434F
Evolution Model EVS Hot Water Boiler Specifications and Controls**

Boiler Specification

PART 1 GENERAL

1.1 SUMMARY

- A. This section includes vertical copper fin-tube non-condensing hot water boiler(s) for indoor space-heating application.

1.2 REFERENCES

- A. Underwriters Laboratories
 - 1. UL 795: Commercial-Industrial Gas Heating Equipment
- B. American Society of Mechanical Engineers
 - 1. ASME Section IV: Boiler and Pressure Vessel Code - Heating Boilers
 - 2. ASME CSD-1: Controls and Safety Devices for Automatically Fired Boilers
- C. American Society of Heating, Refrigeration and Air Conditioning Engineers
 - 1. ASHRAE: Standard 90.1 Energy Standard for Buildings
- D. American National Standards Institute
 - 1. ANSI Z21.13: Gas Fired Low Pressure Steam and Hot Water Boilers
- E. Hydronics Institute, Division of Air Conditioning, Heating and Refrigeration Institute:
 - 1. BTS-2000: Testing Standard to Determine Efficiency of Commercial Space Heating Boilers
- F. National Fire Protection Association
 - 1. NFPA 54: National Fuel Gas Code (ANSI Z223.1)
- G. State of Alaska and Municipality of Anchorage Codes and Standards
 - 1. Comply with all State and Local codes and standards

1.3 SUBMITTALS

- A. In accordance with Contract Documents. Minimum product data to include:
 - 1. Capacities, accessories and options included with boiler.
 - 2. General layout, dimensions, size and location of all required field connections.
 - 3. Electrical characteristics - provide wiring diagrams that are specific to this project.
 - 4. Weight and mounting loads.
 - 5. Manufacturer's installation and start-up instructions.
 - 6. Equipment Operation & Maintenance Manuals and control device cut-sheets.

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1.4 QUALITY ASSURANCE

- A. Use an adequate number of skilled workers, trained and experienced in the necessary crafts, and who are completely familiar with the specified requirements, pertinent contract documents, and methods needed for proper performance of the work described therein.
- B. Provide the services of a manufacturer's factory-authorized representative to inspect and verify proper installation of this equipment, and to provide equipment start-up and operator training.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. In accordance with Contract Documents.
- B. Accept equipment and accessories in Factory shipping packaging. Inspect for damage. Keep boiler in a vertical position from time of delivery to final installation.
- C. While stored, all equipment must be protected from external elements such as inclement weather, job site construction activity, etc. Protect equipment from damage by leaving packaging in place until installation.

1.6 WARRANTY

- A. The boiler shall come with the warranties stated below. Warranty period shall be one (1) year from date of start-up or eighteen (18) months from date of shipment, whichever comes first.
 - 1. Heat exchanger: 5-year limited warranty, and a 20-year warranty against thermal shock.
 - 2. Burner: 10-year limited warranty.
 - 3. All other parts: 1-year limited warranty.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Thermal Solutions Boiler, Evolution Model EVS [1500, 2000S]. Refer to the Equipment Schedule in the Contract Documents for specific design and performance criteria.
- B. **Department of Public Safety has specified this equipment as part of our program for standardizing equipment, maintenance, and our repair parts inventory in facilities statewide. This equipment is specified for our operational needs and substitutions will not be accepted.**

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2.2 GENERAL REQUIREMENTS

A. Boiler

1. The boiler shall be a factory-packaged unit, complete with jacket, gas manifold, burner and controls mounted and wired, as specified in this Section. The boiler shall be factory assembled and fire tested. Boiler connections shall be limited to the water supply & return, relief valve and boiler drains, fuel input, electrical power, exhaust vent and air inlet (as specified/shown in contract documents).
2. The boiler shall be constructed in conformance to ASME Section IV and UL 795. The boiler shall bear the ASME "H" stamp and be National Board Listed for 160 psi working pressure and 250°F. The gas train and safety controls shall conform to requirements of UL 795 and ASME CSD-1.
3. The complete boiler shall be factory fire tested by the manufacturer and a copy of the fire-test report shall be supplied with the boiler.
4. The boiler heat exchanger shall be constructed in accordance with Section IV of the ASME code with straight copper tubes having extruded, integral fins. Fin spacing shall be at least seven (7) fins per inch. Each copper tube shall have a minimum wall thickness of .072". All tubes shall be rolled securely into the headers (top and bottom). There shall be no bolts, gaskets, "O-Rings", welding or brazing used in the header construction. Removable access plugs shall be included in the design of the heat exchanger to allow for access (cleaning and inspection) and replacement of each individual tube. The heat exchanger shall encompass the entire burner and be enclosed in stainless steel inner shells. Stainless steel "V" Baffles shall be used between each tube to provide uniform heat distribution of the flue gases across the entire heat exchanger. The heat exchanger shall be of sufficient size and design to ensure effective, non-limiting control of the water flow rate and velocity through each tube at all load levels. The heating surface of the heat exchanger shall be no less than 6.5 ft² per boiler horsepower.
5. The boiler shall be contained in a minimum 16-gauge negative pressure steel jacket protected with a powder-coated finish. The boiler control panel shall be non-pressurized allowing boiler operation with any jacket panels removed. Hinge-less front and rear access panels shall be provided for easy access to the operating controls and to eliminate electrical code "swing radius" clearance issues.
6. The operating sound level for the boiler shall not exceed 50 dBA.
7. Electrical input to the boiler shall be 208v/3ph. The manufacturer will mount the control transformer and fuses inside the boiler control panel. Single-point electrical hook-up for each boiler shall be provided. Separate power wiring and control wiring is not acceptable. A dedicated disconnect shall be provided for each boiler located on west wall closest to the boilers.

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B. Combustion System

1. **The burner shall be a radiant non-corroding ceramic burner, with no moving parts.** Double-meshed screen, fiber-metal mats, aluminized or stainless steel construction of the burner will not be accepted. The burner shall fire in a full 360-degree pattern providing uniform heat transfer across the entire heat exchanger. A viewing port shall be provided for visual observation of burner performance. **Burner shall require no maintenance, inspection or service.**
2. Burner operation shall provide infinite Modulation with minimum 3:1 turn down utilizing a Variable Frequency Drive and air-fuel ratio control gas valve for dependable, repeatable modulation and precise combustion control. The boiler will be equipped with a non-sparking blower manufactured with a cast-aluminum housing. Dampers, linkages or a single-speed fan are not acceptable.
3. An interrupted-type mixed fuel/air pilot system with electric spark-to-pilot ignition shall be used. The pilot system shall use a UV scanner to prove pilot prior to energizing the main gas valves. **Hot surface ignition systems and flame rods are not acceptable.**
4. The entire ignition and firing control sequence shall be monitored by a UL approved commercial-type microprocessor based integrated flame safeguard burner control with first out fault annunciation and operating sequence and diagnostic indicator lights. The burner control shall incorporate both pre-purge and post-purge timing functions. In the event of ignition pilot and/or main flame failure a burner "lockout" will occur requiring a manual reset of the burner control. It shall also recognize the Proof of Closure switches on the gas valves (if DB&B w/POC).
5. The combustion air blower shall be equipped with a replaceable combustion air filter, 99% efficient to one micron to protect the burner from contamination. A delta-P type pressure switch shall be provided to alert the boiler operator of a dirty filter condition. Air inlet dampers and vacuum relief dampers are not required for proper operation. A combustion airflow switch shall be provided.
6. The gas train shall be UL/FM/CSD-1 compliant and capable of accepting up to 5 psi Natural Gas. Additional step-down regulators are not allowed. The gas train shall consist of a pilot gas pressure regulator, high and low gas pressure switches (each with manual reset), automatic main and redundant gas valve - Motorized automatic main and redundant gas valve and a normally open vent valve in between (if DB&B) - Motorized automatic main and redundant gas valve w/ Proof of Closure contacts and a normally open vent valve in between (if DB&B w/POC), leak test valves downstream of each gas valve, a manual shut off valve upstream of burner and downstream of last gas valve. The main gas valve shall perform the functions of safety shutoff, constant pressure regulation and air-fuel ratio control.

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C. Operating Control

1. The boiler shall be equipped with an onboard microprocessor based Electronic Control Module (ECM) featuring a 2-line, 16-character LCD display and user-friendly menu selections. All safety, operating and ignition controls shall be integrated in the ECM. The ECM shall include a diagnostic menu that provides an alarm history of the last ten (10) alarm messages and a low boiler inlet water temperature alarm history. The ECM shall have a user-friendly menu that allows easy selection of desired operating temperature, upper and lower temperature set-point limits, burner on/off thresholds PID control loop characteristics and local or remote operating modes. The ECM shall have an outdoor temperature reset function to allow the boiler operating temperature to vary based on outdoor air temperature. The ECM shall be capable of accepting a 0-10 vdc remote signal for changing temperature set-points and/or remote modulation control. Operating variables such as boiler inlet & outlet water temp, remote system temp, outdoor air temp, firing rate set-point, modulating percent and mixing valve demand percent are accessible on the display. The display shall also automatically present boiler sequence messages, alarms, and hold and lockout messages. Design features of the ECM shall include multi-level password security, outdoor temperature reset and DHW prioritization. The ECM shall provide for control of a dedicated boiler pump, up to two system pumps and a mixing valve to insure proper inlet water temperature to the boiler. The EMC shall be capable of providing peer-to-peer communication and lead/lag sequencing control (with auto rotation) of up to eight (8) boilers using standard RJ11 phone cables. The ECM shall also be capable of communicating with a BAS/BMS using Modbus [Use TSCG for BACnet, LonWorks, Johnson Controls Metasys N2] communication protocol. The type of DDC system used by DPS at this facility will be given at time of boiler order to ensure proper communication between systems.

D. Water Trim

1. Water trim devices including an ASME rated pressure relief valve set at 125 psig, combination water pressure and temperature gage (furnish graduated pressure gauge scale from 1-1/2 to 3 times of pressure relief valve setting) and water flow switch to prevent burner operation during low water flow conditions shall be provided in the boiler outlet piping. An adjustable high limit temperature controller with manual reset to prevent water temperature from exceeding a safe system temperature and an Auxiliary Low Water Cutoff to provide redundant low water protection shall both be provided.

E. Vent & Intake Air Connections

1. The boiler shall be designed to accommodate sealed, direct, or conventional venting options. The flue duct shall be AL 29-4C, positive pressure type vent material. Single wall vent is acceptable where allowed by local code.

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2. Barometric dampers are to be used only on multiple boiler installations where the individual vents are combined into a common vent.
3. When used for sealed combustion, air intake piping can be PVC or galvanized smoke pipe that is sealed and pressure tight. Pipe must be at least the same size as the air inlet connection on the boiler.
4. Intake dampers and vacuum relief dampers are not required for sealed combustion/direct venting. Vacuum relief dampers can violate the intent of sealed combustion/direct vent applications.

2.3 PERFORMANCE

- A. Boiler efficiency shall be as stated in the Equipment Schedule of the Contract Documents.
- B. The burner shall emit no more than 9 ppm NO_x and 50 ppm CO (corrected to 3% O₂) at all firing rates.
- C. Provide services of a manufacturer's authorized representative to perform combustion test including boiler firing rate, gas flow rate, heat input, burner manifold gas pressure, percent carbon monoxide, percent oxygen, percent excess air, flue gas temperature at outlet, ambient temperature, net stack temperature, percent stack loss, percent combustion efficiency, and heat output. Perform test at minimum, mid-range, and high fire.

PART 3 EXECUTION

3.1 INSTALLATION

- A. In accordance with Contract Documents and boiler manufacturer's printed instructions.
- B. Flush and clean the boiler upon completion of installation in accordance with manufacturer's start-up instructions. The boiler must be isolated when any cleaning or testing of system piping is being performed.
- C. Install skid plumb and level, to plus or minus 1/16 inch over base.
- D. Maintain manufacturer's recommended clearances around and over equipment, and as required by local Code.
- E. Arrange all electrical conduit, piping, exhaust vent, and air intake with clearances for burner removal and service of all equipment.
- F. Connect exhaust vent to boiler vent connection.
- G. If shown in Contract Drawings, connect full sized air inlet vent to flanged connector on boiler.

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- H. Connect fuel piping in accordance with NFPA 54. Pipe size to be the same, or greater, than the gas train inlet connection.
- I. Use full size (minimum) pipe/tubing on all gas vent connections.
- J. Connect water piping, full size, to supply and return connections.
- K. Install all piping accessories per the details on the contract drawings.
- L. Install discharge piping from relief valves (open termination for viewing) and all drains to nearest floor drain.
- M. Provide necessary water treatment to satisfy manufacturer's specified water quality limits.

END OF SECTION

Controls For
Multiple Thermal Solution Copper Finned Tube
Hot Water Boilers

2.4 Boiler Control System

A Scope of Supply

Supply a Boiler Control System to provide safety interlocks and water temperature control. The control system shall be fully integrated into the burner control cabinet and incorporate single and multiple boiler control logic, inputs, outputs and communication interfaces. The control system shall coordinate the operation of up to eight (8) fully modulating hot water boilers and boiler pumps. The control system shall simply control boiler modulation and on/off outputs based on the boiler water supply temperature and an operator-adjusted setpoint. However, using parameter menu selections, the control system shall allow the boiler to respond to remote system water temperature and outside air temperatures with Domestic Hot Water Priority (DHWP) and Warm Weather Shut Down (WWSD) or Energy Management System (EMS) firing rate demand, remote setpoint or remote start/stop commands. In the event a selected sensor fails, the control system shall automatically change to a control mode that will allow continued safe automatic operation of the boiler.

B Boiler Control

Using PID (proportional-integral-derivative) based control; the remote system water temperature shall be compared with a setpoint to establish a target boiler firing rate. If the secondary loop GPM is greater than the primary loop GPM, firing rate is increased in response to secondary loop temperature decreases. When the remote system temperature is near the boiler high limit temperature, the boiler supply sensor shall limit the maximum boiler supply temperature to prevent boiler High Limit Trips. Alternately, using parameter menu selections, the control system shall allow the boiler to respond to directly to boiler supply temperature and setpoint to establish a target boiler firing rate while remote system water temperature is used for display purposes only. Each boiler's fuel flow control valve

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shall be mechanically linked to the air flow control device to assure an air rich fuel/air ratio. All the logic required to ensure that pre-purge, post-purge, light-off, and burner modulate cycles are automated shall be provided.

C Hot Water Temperature Setpoint

When the controller is in the local control mode, the control system shall establish the setpoint based on outside air temperature and a reset function curve or be manually adjusted by the operator. When enabled, the setpoint shall be adjusted above a preset minimum setpoint upon sensing a domestic hot water demand contact input. When in remote mode, the control system shall accept a Modbus or 4-20mA dc remote setpoint or firing rate demand signal from an external Energy Management System (EMS).

D Multiple Boiler Sequence

Multiple boilers shall be modulated in "Unison" (all at the same firing rate). The control system shall utilize both water temperature and boiler firing rate percent to start and stop the boilers and shall minimize the total number of boilers in operation. The control system shall start and stop boilers when the water temperature is outside the adjustable temperature limit for longer than the adjustable time delay. In order to minimize temperature deviations, the control system shall start and stop the next boiler when the "lead" boiler is at an adjustable firing rate limit for longer than the adjustable time delay. The control system shall monitor both boiler lockout and limit circuits to automatically skip over those boilers that are powered down for maintenance, tripped or otherwise will not start. When rotation is enabled the lead boiler shall automatically rotate every 1 to 168 hours. The boiler shall be run at low fire for warm-up for a preset low fire hold time. When enabled, warm weather shut down control logic shall prevent boiler operation.

E User Interface

A panel front-mounted English language, two line, sixteen character LCD message display shall be provided to display numeric data, startup and shutdown sequence status, alarm, system diagnostic, first-out messages and boiler historical information. Historical information shall include the last ten lockout and alarm conditions, number of boiler cycles, boiler hours and last ten low boiler inlet temperature events. When boiler inlet water temperature is below a minimum setpoint a low temperature events shall be stored with time, date; "lowest temperature for event" and duration below setpoint data. A panel mounted red alarm light shall annunciate alarm messages. Alarm conditions requiring a manual reset shall be annunciated by a flashing red light. At a minimum, the boiler system shall display the following:

1. Numeric Display with Engineering Units:
 - a. Boiler Supply Water Temperature
 - b. Boiler Return Water Temperature
 - c. Remote System Temperature (when required by contract drawings)
 - d. Outside Air Temperature (when required by contract drawings)
 - e. Firing Rate %
 - f. Boiler Temperature Setpoint
 - g. Mixing Valve Position % (when required by contract drawings)
 - h. Lead Boiler Position
 - i. Boiler Cycles

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- j. Boiler Operating Hours
 - 2. Status, Startup And Shutdown Sequence English language Messages:
 - a. Boiler Disabled
 - b. Warm Weather Shutdown
 - c. Lockout
 - d. Pump Purge
 - e. Limit Hold
 - f. Purge / Pilot Ignition
 - g. Low Fire / Pilot Ignition
 - h. Main Burner Ignition
 - i. Low Fire Hold
 - j. Boiler Running
 - k. Fan Post Purge
 - l. Pump Cooldown
 - m. Standby
 - 3. Alarm, System Diagnostic, First-Out English language Messages: (numeric code numbers shall not be acceptable):
 - a. Low Water Level (when required by contract drawings)
 - b. Off Switch
 - c. Low Water Flow (when required by contract drawings)
 - d. Fuel Limit (low or high gas pressure switch)
 - e. High Boiler Supply Temperature Limit
 - f. Low Boiler Return Temperature
 - g. Low Air Flow
 - h. Flame Safeguard Internal Fault
 - i. Supply Temperature Sensor Fault
 - j. Return Temperature Sensor Fault
 - k. Outside Air Temperature Sensor Fault
 - l. Remote System Temperature Sensor Fault
 - m. Remote Input Signal Fault
 - n. Modbus Communication Fault
 - o. Memory Fault
- F Flame Safeguard (FSG)
An industrial duty microprocessor-based FSG shall provide: safety interlocks, flame monitoring protection and timed sequences. Sequences shall include forced draft fan start and stop, furnace purge, burner light-off and shutdown and post-purge. Control components shall be fully integrated for automatic sequencing of light-off and shutdown.
- G Boiler Pump Sequence
Include primary water pump control to allow boiler warm-up to the return water temperature before the boiler start; continue water flow for an adjustable cool down period after the boiler has stopped; and ensure water is always moving past the remote system temperature sensor even after the last boiler has been stopped. The pump shall immediately stop if any trips occur during pre-purge, pilot, or main flame trial for ignition.

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- H System and Standby System Pump (when required by contract drawings)
System pump shall be energized based upon an input from the system, unless when turned off by the Warm Weather Shutdown feature. A Standby System pump, if applicable, shall be energized based on an input signal indicating the primary system pump is not operating.
- I Flue Gas Condensate Protection
Include alarms and control logic to help prevent corrosion in the boiler due to sustained flue gas condensation. These features become increasingly important as we add energy savings modulation and outdoor air reset functions. Provide a 4-20mA_{dc}, three-way mixing valve control output based on PID control, measured boiler inlet temperature and minimum inlet temperature setpoint and measured boiler inlet and outlet temperature difference and differential setpoint. If the boiler inlet water temperature drops below setpoint or the differential temperature is excessive the valve shall open to allow hot boiler outlet water to blend with cold inlet water temperature. The valve repositions toward 0% recirculation after inlet water temperature increases above setpoint. Low boiler inlet water temperature shall be alarmed using an alarm message, indicating light and an alarm contact output. Excessively low boiler inlet temperature events shall be stored with boiler historical data.
- J Mixing Valve (when required by contract drawings)
In order to prevent low inlet water temperature, provide an electric actuated three-way mixing valve with a 4-20 mA_{dc} input control signal and slow (1 minute) travel time for each boiler. If the boiler inlet water temperature is below 130° F (adjustable) or when boiler differential temperature is above 40° F (adjustable), the valve shall slowly jog closed causing boiler outlet water to blend with the inlet water. When the inlet water temperature and differential temperature return to an acceptable range, the boiler outlet valve shall slowly jog open.
- K Combustion Air Damper and Vent Inducer (when required by contract drawings)
PART 2 The boiler control system shall have the capability of energizing the combustion air damper and vent inducer upon call for heat.
- L Communication
Include an RS485 Modbus slave or peer-to-peer communications data highway on each boiler control system. When peer-to-peer communication is enabled the data highway shall allow the connected boilers to exchange signals as required to provide coordinated fully modulating lead/lag functions. It shall not be required to wire individual control signals between boilers. When Modbus communication is enabled the data highway shall allow individual boiler limits, lockout, boiler and system temperatures and firing rate status to be readable and water setpoint, boiler firing rate, and start/stop command to be readable and writable. Provide all equipment capabilities specified in this paragraph, even if a connecting SCADA (Supervisory Control And Data Acquisition system, typically a desktop personal computer) system or Energy Management System (EMS) is not included in this project.
- M Quality Assurance
The boiler control system shall be supplied as part of a factory-assembled and tested burner control cabinet.