**CBEX Firetube Hot Water Boiler**

**Sample Specification**

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# PART 1 – GENERAL

1. SUMMARY

1.1. Section includes horizontal, packaged, factory fabricated and assembled fire-tube boilers, trim, and accessories for generating hot water (100-1200HP, 30 & 125 PSIG).

1. REFERENCE STANDARDS

2.1. ASME BPVC-IV Boiler and Pressure Vessel Code, Section IV-Rules for Construction of Heating Boilers.

2.2. NFPA 54- National Fuel Gas Code

2.3. NFPA 58- Liquefied Petroleum Gas Code

2.4. NFPA 70- National Electric Code

2.5. CSD-1- Boiler burner and gas train shall have compliance.

2.6. NBIC- Boiler installation shall comply with all National Board Inspection Code requirements

2.7. UL Compliance- Test boilers for compliance with cUus certification and be cULus labeled as a packaged boiler & burner. Boilers shall be listed and labeled and include label affixed to the equipment.

3. QUALITY ASSURANCE

3.1. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum of twenty-five years of documented experience.

3.2. Provide authorized factory representatives to conduct initial boiler installation review and start-up. Manufacturer is responsible for burner adjustment and testing.

4. ACTION SUBMITTALS

4.1. Product Data: For each type of product, include the following:

4.1.1 Shop Drawings: For boilers, boiler trim, and accessories. Include product description, model number, dimensions, clearances, weights, components and options.

4.1.2 Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

4.1.3 Include diagrams for power, signal, and control wiring.

* + - 1. Schematic wiring diagram of boiler control system of the ladder-type showing all components, interlocks, etc. Schematic wiring diagram shall clearly identify factory wiring and field wiring by others.
      2. Detail wiring for power, signal, and control systems

5. INFORMATIONAL SUBMITTALS

5.1. Source quality-control test reports.

5.2. Field quality-control test reports.

5.3. Seismic calculations.

5.4. Fuel to water predicted efficiency data report.

5.5 Predicted exhaust stack emission data report.

5.6. The boiler, burner and other associated mechanical and electrical equipment have been properly coordinated and integrated to provide a complete and operable boiler package.

6. CLOSEOUT SUBMITTALS

6.1. Operation and Maintenance Data: Operation and maintenance manuals shall contain dimension and wiring drawings, product data, operating instructions, cleaning procedures, maintenance and repair data, complete parts list, etc.

6.2. ASME Stamp Certification and Report: Submit a copy of the inspection report and documentation of hydrostatic testing.

6.3. Spare parts List: Recommended spare parts list with quantities for each.

6.4. Manufacturer’s data reports.

6.5. The specified factory tests have been satisfactorily performed.

6.6. cULus Certification in the form of an affixed label to the equipment.

6.7. Start-up reports proving satisfactory performance.

7. DELIVERY, STORAGE, AND HANDLING

7.1. Ship boilers from the factory free of water. Drain water to remove all water before shipping.

7.2 Cover and protect flue, electrical controls, and piping connections before shipping. Protect and seal with removable temporary durable plastic to prevent damage during shipment, storage, and installation. Provide double bagging of the boiler as an option.

8. WARRANTY

8.1. All equipment shall be guaranteed against defects in materials and/or workmanship for a period of 12 months from date of start-up, or 18 months from date of shipment; whichever comes first. Warranty shall include parts and labor.

8.2. Extended warranty on pressure vessel and refractory available upon request.

# PART 2 – PRODUCTS

1. PERFORMANCE REQUIREMENTS
   1. Fuel-to-water efficiency indicated shall be based on the following:
      1. ASME Power Test Code, PTC 4.1 Heat Loss Method
      2. Test Operating Conditions:
         1. Ambient Temperature: 80 degrees F.
         2. Ambient Relative Humidity: 30%.
         3. Percent Excess Air in Exhaust Flue Gas: 30% at low fire, 15% at mid to high fire, firing Natural Gas.
         4. Fuel Heating Value: 1,000 to 1,090 BTU/Cubic Ft
   2. Gas-Fired Boiler Emissions: Not to exceed allowable ambient air quality standards in governing jurisdiction and indicated values.
      1. Carbon monoxide:
         1. 50 parts per million at any point from 100 percent to 50 percent firing rate.
         2. 100 parts per million at any point below 50 percent firing rate.
      2. Nitrogen compounds: 60 or 30 parts per million (dry volume basis and corrected to 3 percent oxygen) at any point from 100 percent to low fire. Provide lower NOx emission rates as an option.
      3. Hydrocarbon and Volatile Organic Compounds: 20 parts per million (dry volume basis and corrected to 3 percent oxygen) at any point from 100 percent to low fire.
      4. Particulate Matter: 0.01 lb/MMBtu.
   3. Oil-Fired Boiler Emissions: Not to exceed allowable ambient air quality standards in governing jurisdiction and indicated values.
      1. Carbon monoxide:
         1. 50 parts per million at any point from 100 percent to 50 percent firing rate.
         2. 100 parts per million at any point below 50 percent firing rate.
      2. Nitrogen compounds: 120 or 90 parts per million (dry volume basis and corrected to 3 percent oxygen) at any point from 100 percent to low fire. Note: Lower NOx emission rates are available.
      3. Hydrocarbon and Volatile Organic Compounds: 30 parts per million (dry volume basis and corrected to 3 percent oxygen) at any point from 100 percent to low fire.
      4. Particulate Matter: 0.015 lb/MMBtu.
      5. Smoke: Not visible and not to exceed No. 1 on the Bacharach smoke scale.
   4. Multiple Boiler Operation: Equip individual boilers in multiple boiler applications with integral controls and a single stand-alone Master Control Panel to control each boiler. To provide multiple boiler operation for optimum system performance and energy efficiency, the following options shall be available:
      1. Equalize runtime of boilers in service.
      2. Operate multiple boilers hot to minimize disruption of service in the event of single boiler failure.
      3. Configure controls so any boiler can be taken out of service with power disconnected and not impact multiple boiler operation.
   5. Steam Quality: 99.5 percent dry.
   6. Operation Following Loss of Normal Power:
      1. Loss of power shall require a manual reset of the control.
2. HORIZONTAL FIRE-TUBE BOILERS
   1. Acceptable Manufacturers:
      1. Cleaver-Brooks
      2. Hurst Boiler Inc
      3. Johnston Boiler Co.
      4. Superior Boiler Works, Inc.
   2. Pressure Vessel: Dry-back or Water-back design with the following:
      1. Two (2) passes.
      2. Minimum Heat-Exchanger Surface: provide sufficient square feet of heating surface per rated boiler horsepower to guarantee rated boiler capacity.
      3. Provisions for lifting boiler in-place.
   3. Base:
      1. Factory-mounted pressure vessel and other boiler components on steel saddles or supports that are fastened securely to a structural steel base, which shall be constructed to make a complete self-supported unit requiring only a flat level surface for support.
      2. Base included with attachments if required to secure boiler to structure.
      3. Manufacturer's standard provisions for lifting shall be sufficient to carry total weight of fully assembled boiler with a safety factor of 1.2.
   4. Shell:
      1. Horizontal, cylindrical, steel pressure vessel.
      2. Manholes and Handholes:
         1. Manhole for waterside inspection and access.
         2. Handholes at front and rear of boiler for waterside inspections.
      3. Hot Water Boilers:
         1. Connections for water outlet including dip tube, water inlet, air vent and level controls.
         2. Connections for safety relief valve(s), drain and exhaust stack.
   5. Furnace:
      1. Welded cylindrical steel chamber that is welded to steel tube sheets.
      2. Arranged to provide uniform heat distribution under all firing conditions with no flame impingement on any refractory-covered or dry-backed surface.
      3. Surrounded by water without interfering with natural circulation of water within shell.
      4. Positioned from shell to inhibit unequal thermal stresses during operation.
   6. Fire Tubes:
      1. Steel, seamless or resistance welded with extended tube heat transfer surface area.
      2. Fitted in sized holes in tube sheets and rolled, beaded or welded in place.
      3. Removable from one end of boiler on waterback boilers and on both ends on dryback boilers.
      4. Provided without spinners, turbulators, and other inserted devices.
   7. Flue:
      1. Flanged connection located along top centerline and near the front of the boiler. The exhaust gas flue connection shall be capable of supporting a field-installed flue stack with a weight of:
         1. 100 hp: 1000 pounds
         2. 125- 1200 hp: 2000 pounds
      2. Equip boiler flue with bimetal thermometer in a stainless-steel thermowell and nominal 5-inch diameter face having a graduated scale and range of approximately 1.5 times the outlet temperature. Mount thermometer in a visible location to indicate flue-gas temperature.
   8. Front and Rear Doors:
      1. The front smokebox doors shall be hinged and davited, sealed with super-wool insulation and fastened tightly using locking lugs on steel studs.
      2. Designed so tube sheets and flues are fully accessible for inspection or cleaning when doors are open without the need to disconnect burner, blower, and fuel piping.
      3. Include observation ports in doors at both ends of boiler for inspection of flame conditions.
      4. Door insulation and refractory shall be accessible for inspection and maintenance.
      5. Reinforce doors of dryback boilers to limit deflection due to thermal stresses and burner combustion pulsations to prevent progressive cracking and loosening of refractory.
   9. Insulation:
      1. Minimum 2-inch-thick, mineral-fiber insulation surrounding the boiler shell and secured in place to prevent sagging or displacement.
      2. Insulation of sufficient density or attached with reinforcement to prevent permanent deformation of protective jacket when subjected to an impact force and forces associated with service personnel walking, kneeling, and laying on boiler while performing service.
   10. Jacket: Sheet metal, with factory-applied protective finish.
       1. Nominal Thickness: Not less than 0.048 in.
       2. Consisting of multiple removable painted sections attached with corrosion-resistant screw-fasteners to facilitate removal and replacement multiple times.
3. BURNER
   1. Light Oil or Gas-Fired:
      1. Furnish Cleaver Brooks Integral burner. The burner shall be completely assembled, wired and factory tested. The complete Burner System shall be listed by Underwriters Laboratories and, if Low NOx is required, have individual UL labels on the major Low NOx system components, i.e. FGR (Flue Gas Recirculation) shutoff valve assembly, FGR metering valve, and panel, proving the total system to be certified.
      2. A supplier shall not be allowed to furnish a standard UL approved Non-FGR Burner and “field mount” the Low NOx FGR parts, in an effort to circumvent the intent of Underwriters Laboratories for a total Low NOx FGR system approval.
      3. Systems which use a separate FGR fan assembly to force FGR into the burner and/or combustion chamber during normal burner “run” shall not be acceptable.
   2. Burner type - The burner shall be mounted at the front of the boiler and shall be a combination of the low pressure air atomizing type for oil and multi-port type for gas. The burner shall be approved for operation with either CS12-48 Commercial No. 2 oil or natural gas.
   3. Gas Pilot - The gas pilot shall be a premix type with automatic electric ignition. An electronic detector shall monitor the pilot so that the primary fuel valve cannot open until pilot flame has been established. The pilot train shall include one manual shut-off valve, solenoid valve, pressure regulator and one plugged leakage test connection.
   4. Oil Burner
      1. Oil Pump - An oil pump with a capacity of approximately 1.5 to 2 times the maximum burning rate shall be included. The motor-driven pump set shall be provided as factory mounted, with an option to ship loose.
      2. Oil Burner Piping - Fuel oil piping on the unit shall include oil pressure regulating devices, oil metering controls, low oil pressure switch, two (2) motorized oil valves, and pressure gauges all integrally mounted on the unit.
      3. Low pressure air atomizing - Separate air compressor module shall be provided as factory mounted, with an option to ship loose, with burner mounted low-atomizing air pressure switch.
      4. Burner Turndown - Turndown range shall be:
         1. 4:1 when firing No. 2 oil for capacities 100hp thru 200hp
         2. 8:1 when firing No. 2 oil for capacities 250hp thru 1200hp
   5. Gas Burner
      1. Gas Burner Piping - Gas burner piping on all units shall include a primary gas shutoff valve, motor operated with proof of closure switch and plugged leakage test connection. The main gas valve shall be wired to close automatically in the event of power failure, flame failure, low water or any safety shutdown condition. A lubricating plug cock shall be provided as a means for a tightness check of the primary shutoff valve. An additional plug cock shall be furnished at entrance to gas train. High and low gas pressure switches shall be provided. A second motorized safety shutoff valve with plugged leakage test connection shall be provided. A vent valve shall be located between the safety shutoff valves, if necessary.
         1. 100-300 hp. High and low gas pressure switches shall be provided. A second motorized safety shutoff valve, plus an additional plugged leakage test connection shall be provided. Shall comply with ASME CSD-1.
         2. 350-1200 hp. High and low gas pressure switches shall be provided. A second motorized safety shutoff valve, plus an additional plugged leakage test connection shall be provided. A valve proving switch shall be located between the safety shutoff valves. Shall comply with NFPA 85.
      2. Burner Turndown - Turndown range shall be:
         1. 4:1 when firing natural gas for capacities 100hp thru 200hp
         2. 10:1 when firing natural gas for capacities 250hp thru 1200hp.
4. BLOWER
   1. Air for combustion shall be supplied by a forced draft blower incorporated into the burner design to eliminate vibration and reduce noise level.
   2. The impeller shall be fabricated or cast aluminum with radial blade, carefully balanced, and directly connected to the blower motor shaft. Shaft grounding ring shall be supplied on motors greater than 75hp.
   3. Blower and drive assembly shall be controlled through boiler's integral controls in response boiler manufacturer's prescribed sequence of operation that is coordinated with burner and fuel train to achieve performance indicated.
      1. Where indicated or required to achieve performance, provide blower with unit-mounted variable frequency controller to vary blower speed in response to prescribed control set point and changes in operating conditions.
      2. Variable-speed fan operation shall be checked for resonant frequencies and adjusted to provide no resonant frequencies throughout entire operating range.
5. HOT WATER BOILER TRIM
   1. Safety Relief Valve:
      1. Size and Capacity: As required for equipment according to the most recent edition of the ASME Boiler and Pressure Vessel Code.
      2. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
   2. Pressure Gauge: Nominal 6-inch diameter face with graduated scale and siphon, with isolation valve to indicate pressure vessel pressure.
   3. Temperature Gauge: Nominal 6-inch diameter face with graduated scale and siphon, with isolation valve to indicate hot water temperature.
   4. Drain valve: Provide drain valve and an option for factory mounting.
   5. Blend pump when required, shipped loose and an option for factory mounting.
   6. Provide Sample Cooler as an option: Furnished for field installation, with needle valve for each connection. Constructed of Type 316 stainless steel.

5.11.1. Provide option for factory installation of sample cooler.

1. CONTROLS
   1. Boiler operating controls shall include the following devices and features:
      1. Control transformer with fuse protection. Provide transformer with 20 percent spare capacity.
   2. Temperature Control for Hot Water Boilers:
      1. Operating Limit Control: Factory wired and mounted to control boiler to maintain boiler at constant temperature (auto reset).
      2. High Limit Cutoff: Factory wired and mounted to stop burner if operating conditions rise above normal operating set point (manual reset).
      3. Firing Rate Control: Factory wired and mounted used to change the burner-firing rate to adjust to water temperature requirements.
   3. Water-Level Control for Hot Water Boilers:
      1. Low Water Cutoff: A low water cutoff control (manual reset) shall be mounted on the top centerline of the boiler wired into the burner control circuit, to prevent burner operation if boiler water falls below a safe level.
   4. Boiler Emergency Shutdown: Interlock with field-installed boiler emergency shutdown switch to shut down boiler when activated.
      1. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for emergency conditions.
   5. Burner Flame Safeguard Controls:
      1. Factory equipped with flame safeguard control and infrared flame scanner.
      2. Microprocessor-based, solid-state control having sequence and flame-on visual indication and fault code indications of flame safeguard trip functions.
      3. Control shall include dynamic self-check logic.
      4. Control shall have a fixed operating sequence incapable of being manually altered that includes start, prepurge, pilot and main fuel ignition run, and postpurge cycles.
      5. Control shall be non-recycle type for maximum safety that shall shut down the burner and indicate, as a minimum, the following trip functions:
         1. Pilot and main flame failure.
         2. High- and low-fire proving switch faults.
         3. Running interlocks open.
         4. False flame signal and fuel valve open.
      6. Control shall include a run/test switch to allow interruptions to sequence just after prepurge and during pilot ignition trial, and run cycles for adjustments to firing rate motor, damper linkages, and pilot flame for minimum turndown tests.
   6. Combustion-Air Controls: Factory equipped with motor-operated combustion-air damper and blower control to regulate burner fire according to load demand.
   7. Control Options:
      1. Oxygen Trim System: Continuously monitor and display oxygen concentrations in boiler flue gas and adjust fuel and airflow to maintain an adjustable oxygen-level set point. System shall compensate for changes in ambient temperature, barometric pressure, humidity, and variations in fuel characteristics.
      2. Draft Control: Microprocessor based control to maintain boiler outlet pressure within specified limits.
      3. Vibration Monitoring: Provide vibration monitoring of the fan blower motor to detect critical increases in over vibration level
      4. Remote IoT Monitoring: Provide boiler data monitoring via a cellular network, which does not require remote access to the customer’s network. Cellular data communication shall be secure and one-way communication only.
      5. DDC System Interface: Factory install hardware and software to enable system to monitor, control, and display boiler status and alarms.
         1. Communication Interface: Communication interface shall enable control system operator to remotely control on/off and capacity of boiler and monitor the boiler operation from an operator workstation. Control features are available, and monitoring points are displayed locally at boiler-control panel through the interface.
   8. Integrated Boiler-Control System:
      1. Integral control of burner management for flame safety, boiler modulation, and operator interface functions with features and functions indicated.
      2. Factory preconfigured.
      3. Utilizing PLC based controls and sensors to provide various control functions, including the following:
         1. Automatic sequencing of the boiler through standby, prepurge, pilot flame establishing period, main flame establishing period, run, flame proving and lockout, and postpurge.
         2. Full modulating control of air and fuel through Proportional-Integral-Derivative (PID) algorithm.
         3. c. Thermal shock protection.
         4. d. High and low limit alarms and shutdowns.
      4. Local operator interface through nominal 10-inch color touch screen graphical display for setup and monitoring.
         1. Manual control of the boiler-firing rate using control screens to increment or decrement firing rate.
         2. Indication of burner management controller status and diagnostics.
         3. Display of system alarms and faults.
         4. Display of history of alarms and faults.
         5. Display of recommendations for troubleshooting of fault conditions.
         6. Display of water-level indication and alarm(s).
         7. Stack flue-gas, combustion-air, and shell water-temperature indication.
         8. Boiler efficiency calculation and display.
         9. Low-fire hold with minimum temperature control.
         10. Assured low-fire cutoff (ALFCO).
         11. High stack temperature annunciation with auto cutoff.
         12. Audible alarm and silencing through touch screen intervention.
         13. Inlet and discharge water temperatures to and from economizer.
         14. Inlet and discharge stack temperatures to and from economizer.
      5. Fully integrated control of the following:
         1. Blower operation and combustion-air damper for varying operating conditions.
         2. Oxygen trim and monitoring to compensate for combustion-air variations.
         3. Parallel positioning for independent fuel and air control for enhanced fuel efficiency.
         4. Multiple boiler lead/lag control with hot standby.
   9. Control Enclosures:
      1. NEMA Type 12, options for Type 4 and 4X.
         1. Provide enclosure with integral vents, fans, heater, and air conditioner as required to automatically control temperature inside enclosure within safe operating limits of devices installed within the enclosure.
      2. Mounted on boiler assembly at a location convenient to operator.
      3. Provide hinged full-size door with latch and closure.
      4. Enclosure shall consist of multiple sections divided by a partition with a separate hinged door for each section. One section shall house low-voltage controls and other section shall house line voltage controls.
      5. Enclosure shall house the following:
         1. Control transformers with fuses.
         2. Labeled terminal strips.
         3. Controller(s) to provide control and alarm functions indicated.
         4. Audible indication of safety alarms.
      6. Face of enclosure shall provide the following:
         1. Visual indication of operating components and alarms.
         2. Auto/local capability to allow operator to manually operate boiler locally.
         3. Audible alarm-silence capability.
         4. Labels for switches, lights, and displays to provide clear indication of service.
   10. Control Instrument Enclosures: Control instruments and devices that are mounted on the boiler assembly and cannot be installed inside the control enclosure shall have same or higher level of protection indicated for control enclosures.
   11. Control Cable and Wire:
       1. Control cable and wiring shall be numbered and color-coded to match wiring diagram.
       2. Install cable and wiring located outside of enclosure(s) in a metal raceway. Use flexible conduit to make final terminations.
2. ELECTRICAL POWER
   1. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
      1. Enclosure: NEMA Type 12, option for Type 4 and 4X.
         1. Enclosure shall have integral vents, fans, heat, and air conditioner as required to automatically control temperature inside enclosure within safe operating limits of devices installed within the enclosure.
         2. Mounted on boiler assembly at a location convenient to operator.
         3. Enclosure shall have hinged full-size door with latch and closure.
      2. Wiring shall be numbered and color-coded to match wiring diagram. Provide a wiring diagram located inside enclosure.
      3. Install wiring outside of an enclosure in a metal raceway. Make final connections to motors using flexible conduit.
      4. Field power interface shall be to non-fused disconnect, with option for fused disconnect switch. Withstanding rating of disconnecting means shall protect equipment.
      5. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.
      6. Provide each motor with NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection. Provide variable-frequency controller with manual bypass and line reactors for each variable-speed motor as an option.
      7. Provide transformer with fuses and power wiring to power a 20-A 120-V duplex receptacle mounted in each boiler control panel for use in connecting analytical and testing equipment, as an option.
      8. Provide uninterruptible power supply for boiler control package during transfer of emergency power, as an option.
3. FINISH
   1. General:
      1. Paint boiler, using manufacturer's standard procedures, except comply with requirements indicated.
      2. Miscellaneous surfaces shall be finished to match continuous surfaces.
      3. Contractor shall field touch up or entirely repaint surface finishes, which were damaged during shipment, to original condition, using original materials and methods.
      4. Paint shall be suitable for temperatures encountered on painted surfaces.
      5. Requirements indicate minimum quality level. Provide more robust paint system if required to comply with other requirements indicated.
   2. Do not paint aluminum or stainless steel.
4. SOURCE QUALITY CONTROL
   1. Test and inspect factory-assembled boiler, before shipping, according to current ASME Boiler and Pressure Vessel Code.
   2. Burner and Boiler Package Shop Test:
      1. Factory mount the burner to the boiler and test equipment at low fire.
      2. The complete packaged boiler shall receive factory tests to check construction and function of all controls
      3. All shop tests may be witnessed by the purchaser, at their own cost, with sufficient notice to the company

# PART 3 – EXECUTION

1. EXAMINATION
   1. Before boiler installation, contractor shall examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and flue; piping; controls; and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.
      1. Boiler locations indicated on drawings are approximate. Determine exact locations before roughing-in for flue, piping, controls, and electrical connections.
   2. Examine areas where boilers will be installed for suitable conditions.
   3. Proceed with installation only after unsatisfactory conditions have been corrected.
2. BOILER INSTALLATION
   1. Contractor to coordinate size and location of bases. Cast anchor-bolt inserts into concrete bases. Concrete, reinforcement, and formwork requirements are the responsibility of the contractor.
   2. Equipment Mounting:
      1. Contractor to install boiler on cast-in-place concrete equipment base. Contractor to comply with requirements for equipment bases.
      2. Comply with requirements for vibration isolation devices.
      3. Comply with requirements for seismic restraint devices.
   3. Install gas-fired boilers according to NFPA 54 and in strict compliance with state and local codes.
   4. Install oil-fired boilers according to NFPA 31 and in strict compliance with state and local codes.
   5. Assemble and install boiler trim, components, and accessories that are not factory installed.
   6. Install control and electrical devices furnished with boiler that are not factory mounted.
   7. Install control and power wiring to field-mounted control and electrical devices furnished with boiler that are not factory installed.
   8. Perform boil-out and cleaning procedures according to chemical supplier’s written instructions after completion of hydrostatic testing and before performing other field tests. Boiler manufacturer's factory-authorized representative shall witness boil-out and cleaning procedures. Following boil-out and cleaning procedures, boiler shall be washed and flushed until water leaving boiler is clear.
   9. Protect boiler fireside and waterside from corrosion.
      1. Before boiler is filled with water, protect by dry storage method recommended by boiler manufacturer.
      2. After boiler is filled with water, and left not fired for more than 10 days, protect by wet storage method recommended by boiler manufacturer.
      3. Chemical Treatment: Quality of water in boilers shall be maintained by a professional water treatment organization that shall provide on-site supervision to maintain the required water quality during periods of boiler storage as well as during operating, standby, and test conditions.
3. PIPING CONNECTIONS
   1. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
   2. Where installing piping adjacent to boiler(s), allow space for service and maintenance.
   3. Connect gas piping to boiler gas-train inlet with dirt leg, shutoff valve, and union or flange. Piping shall be at least full size of gas-train connection. Provide a reducer if required. Piping shall be properly sized to minimize pressure drops for longer gas piping runs.
   4. Connect oil piping to oil-train connection with dirt leg, shutoff valve, and union. Piping shall be at least full size of oil-train connection. Provide a reducer if required. Provide drain valve with threaded plug at piping low point.
   5. Connect water supply and return piping boiler connections with union or flange at each connection. Provide each connection with shutoff valve, if shutoff valves are not factory furnished with boiler trim.
   6. Connect water piping to inlet and discharge of flue-gas economizer (if economizer is in the system) connections with union or flange at each connection. Provide each connection with shutoff valve and other accessories indicated and recommended by manufacturer.
   7. Install piping from safety valves and drip-pan elbows. Extend piping from safety valves and terminate to vent outdoors. Extend piping from drip-pan elbow drain to nearest floor drain.
   8. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
   9. Hot equipment drains connected to sanitary drainage system shall be cooled before discharging into the system, if required to comply with more stringent of governing code requirements and requirements indicated.
      1. Provide a temperature-controlled non-potable domestic cold water source to cool hot equipment drains to deliver a discharge temperature of 120°F. or less.
4. FLUE CONNECTIONS
   1. Connect breeching/stack/flue vent to full size of boiler outlet. Venting materials to be non-combustible and suitable for the installation application.
   2. Install easily accessible test ports for field testing of flue gas from each boiler.
   3. Install flue-gas economizer breeching transition sections to connect to boiler and to field-installed breeching (if economizer is included in the system).
5. ELECTRICAL POWER CONNECTIONS
   1. Connect wiring according to specification requirements.
   2. Ground equipment according to specification requirements.
6. CONTROLS CONNECTIONS
   1. Install control and electrical power wiring to field-mounted control devices.
   2. Connect control wiring between boilers and other equipment to interlock operation as required, to provide a complete and functioning system.
   3. Connect control wiring between boiler control interface and Direct Digital Control (DDC) system for remote monitoring and control of boilers.
7. NETWORK CONNECTIONS
   1. Connect LAN/WAN network cable to boiler controls to provide connectivity for remote monitoring through integrated boiler control system.
8. FIELD QUALITY CONTROL
   1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
   2. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
   3. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
      1. Perform installation and startup checks according to manufacturer's written instructions.
      2. Hydrostatic Leak Test: Repair leaks and retest until no leaks exist.
      3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
      4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
         1. Check and adjust initial operating set points and high-limit safety set point of fuel supply, water level, and hot water temperature.
         2. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
   4. Boiler will be considered defective if it does not pass tests and inspections.
   5. Prepare test and inspection reports.
   6. Occupancy Adjustments: When requested, within 12 months of date of Substantial Completion, provide onsite assistance in adjusting system to suit actual occupied conditions.
   7. Performance Tests:
      1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
      2. Boilers shall comply with performance requirements indicated, as determined by field-performance tests. Adjust, modify, or replace equipment in order to comply.
      3. Perform field-performance tests to determine the capacity and efficiency of boilers.
         1. For dual-fuel boilers, perform tests for each fuel.
         2. Test for full capacity.
         3. Test for boiler efficiency at low fire, 25, 50, 75, and high fire (100) percent of full capacity. Determine and document efficiency at each test point.
         4. For boilers equipped with flue-gas economizers, perform tests with and without flue-gas economizer operating.
      4. Test each safety valve. Record pressure at valve blowdown and reset. Test valve(s) with boiler operating at full capacity to ensure valve has capacity to prevent further rise in pressure or temperature.
      5. For boilers equipped with automatic oxygen trim control, conduct tests with automatic oxygen trim control on manual at zero trim and record performance. Repeat tests with automatic oxygen trim control under automatic control and record performance.
      6. Repeat tests until results comply with requirements indicated.
      7. Provide measurement and analysis equipment required to determine performance.
      8. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are inadequate.
      9. Notify Owner 21 days in advance of test dates.
      10. Document test results in a report and submit with informational submittals.
9. DEMONSTRATION
   1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers.