Volume 2
WATER BOILERS
(Hot Water Generating Systems)

Volume 2
WATER BOILERS
(Hot Water Generating Systems)
Table of Contents

1.0 DESIGN PARAMETERS/REQUIREMENTS

1.1 Requirements:

1.1.1 This volume of the design manual establishes VA requirements on the quantity, capacity, arrangement, and standby capability of the boilers and auxiliary equipment used to generate heating hot water for heating and environments control. It applies to the design of new hot water boiler (boiler), hot water boiler replacement, and modification of existing hot water boiler(s), in all climates.

1.1.2 The requirements of this manual shall apply to all boilers whether they are centralized or decentralized systems.

1.1.3 Decentralized systems shall comply with all the equipment requirements defined herein however the following elements shall only be required for mission critical, hospitals, CLCs and inpatient facilities.

1.1.3.1 The system shall be capable of supplying the maximum capacity with the largest boiler not operating, and with the largest pump of each service not operating (N+1 capacity)

1.1.3.2 Dual fuel capability with appropriate reserve capacity

1.1.3.3 Emergency generator power requirements

1.1.4 Boilers and associated equipment central and decentralized shall be located in a secure, conditioned, and protected building and shall provide the appropriate security and weather protection in all climates. Additionally, the building/rooms shall be equipment with combustible gas and CO monitoring that alarms locally as well as reports to a central location that is continuously monitored.

1.1.5 Emergency Temporary Rental Boiler connections: Connection for a rental boiler will be located on the external side of and external wall where a rental boiler and office can be easily located/accessed, preferable on a concrete pad. The connections will include all systems required for operation of the rental boiler: Steam, feed water, primary and secondary fuels blow-down (bottom and surface), electric, etc.

1.2 Load Determination Capacity Calculations:

1.2.1 Maximum loads shall be determined by adding existing demand, new connected loads with diversity factors, and an allowance (10 percent minimum) for future expansion required for planned projects. Boiler auxiliary equipment loads and distribution line losses shall be included in load calculations. Existing loads shall be determined by installing calibrated totalizing flow meters to monitor boiler flow data for winter periods when the outside temperature approaches ASHRAE design conditions, and for summer periods. The accuracy of the data shall be verified through review of meter calibration data and measurement logging criteria (i.e., hourly, hourly average, or peak hourly). In the review of the data, judgment must be utilized in determining realistic peak loads (loads which are sustained for at least ten minutes).

1.3 Boiler System Capacity:

1.3.1 The boiler system shall be capable of supplying the minimum demand with the smallest boiler in a normal mode of operation and with all auxiliary equipment operating within recommended turn-down ranges. The capacity of the smallest boiler shall be sufficient for peak demand in the non-heating season.

1.3.2 The boiler system shall be capable of supplying the maximum demand with the largest boiler not operating, and with the largest pump of each service not operating.

2.0 GENERAL CRITERIA

2.1 Graphic Standards:

2.1.1 Central plant heating and decentralized boilers work shall only be indicated on "MP"-series drawings (see *VA Design and Construction Procedure, Topic 2, Drawings).*

2.1.2 "MP"- series drawings shall include symbols and schedules, equipment lists, schematic piping diagrams, floor plans, upper level plan of boiler room, mezzanine and pit plans, sections, demolition plans, fuel tank plot plans and other work as necessary.

2.1.3 Drawings must show plan and elevation views of all valves and equipment which require access and have both North and True North annotated.

2.1.4 Flow sheets with instruments and flow/capacity shall be included in the design package. Instruments and equipment shall have unique tag numbers that are correlated to an instrument and equipment index. Tag numbers shall be coordinated with the shops to ensure standard nomenclature is aligned with local facility.

2.1.5 Water treatment systems shall be shown on "PL" drawings.

2.1.6 Fuel gas piping shall be shown on the MP drawings.

2.1.7 Structural drawings shall show sufficient structural detail for each hanger and support location.

2.1.8 Pipe size and construction shall be indicated for all piping including those referring to existing conditions.

2.1.9 Existing work which remains in service shall be identified in a way which easily distinguishes it from the new work.

2.1.10 The standard symbol for point of connection; new work to existing work shall be used. A similar symbol with the area entirely filled-in shall be used to indicate extent of demolition.

2.1.11 Dashed lines shall be used to distinguish material to be demolished.

2.1.12 Equipment shall be listed and scheduled in conformance with VA National CAD Standard details: https://www.cfm.va.gov/til/sDetail.asp#23

2.1.13 Show work on drawings using a minimum scale of 1:50 (1/4" = 1'0").

2.1.14 Heating hot water piping and equipment arrangement shall conform to the VA National CAD Standard.

2.2 Guidelines:

2.2.1 Heating systems (i.e., air handlers and associated piping and ancillaries' requirements shall follow the latest edition of the HVAC Design Manual for New, Replacement, Addition and Renovation of Existing VA Facilities.

2.2.2 Design all equipment and systems to comply with this design manual, and the current editions of VA Program Guides, VA Handbooks, Directives, Design Alerts, and VA Master Specifications. The design shall also meet the provisions of all codes and regulations having jurisdiction and referenced in this document.

2.2.3 Use the latest edition of the VHA boiler plant safety device testing manual to ensure the appropriate arrangement and equipment are provided on the boiler and associate systems to accommodate the required testing.

2.2.4 If state or local codes are more stringent than the above requirements request clarification from the VHA Authority Having Jurisdiction (AHJ).

2.2.5 Earthquake-resistive design shall comply with the requirements of Master Specification Section 13 05 41, Seismic Restraint Requirements for Nonstructural Components, and the latest edition of the H-18-8 Seismic Design Handbook.

2.2.6 The Boiler system/facility shall comply with the latest edition of the VA Physical Security and Resiliency Design Manual (PSRDM).

2.2.7 VHA Engineering standard ES-2018-001: installation or replacement of boilers, installation of new fuel burning equipment (burners and/or controls) on existing boilers, or re-tubing thirty (30) percent or more of a boiler. Designs for installation or replacement of boilers must be reviewed by HEFP and the VA Office of Construction and Facilities Management (CFM) at the 30%, 60% and 100% design stages, or their equivalents. Planned installation of boilers outside of the central boiler plant. VHA Facilities are to consult with HEFP during the development of the project application when contemplating decentralization. Adherence to safety, resiliency, and redundancy standards is required.

2.3 Equipment Selection

Equipment selection shall be non-proprietary. When as a standard of quality, model numbers are specified, the "Basis of design" or "VA approved equal" designation shall be added. When specifying by model number "Basis of design" or "VA approved equal", the salient characteristics of the specified item which equality would be judged shall also be included.

2.4 Life Cycle Cost Analysis

2.4.1 The DOE requires that agencies must estimate the life-cycle costs and energy consumption of a building and compare it to the minimum criteria set forth in the applicable baseline ASHRAE or IECC standard. This measure is meant to demonstrate and record the extent to which the mandated compliance is achieved.

2.4.2 Life Cycle analysis shall include at least three unique options for the solution of the project.

2.4.3 An engineering and economic analysis shall be performed in accordance with the procedure outlined by the DOE in the latest edition of the National Institute of

Standards and Technology (NIST) Handbook 135 - Life Cycle Costing Manual for the Federal Energy Management Program. The DOE 2 program shall be utilized when performing the required BLCC analysis using the following parameters:

2.4.3.1 Life-Cycle period:

Equipment	Useful Life Expectancy (in years)
i) Fire tube boilers and burners	30
ii) Water tube boilers and burners	40
iii) Hot water/condensing boilers	15
iv) Burner management controls	20
v) Combustion controls	20
vi) Instrumentation	20
vii) Boiler feed and condensate pumps	20
viii) Fuel oil pumps	40
ix) Fuel oil tanks	40
x) Valves, shut off and control	20
xi) Water treatment equipment	20

2.4.3.2 Discount factor as determined by DOE on Oct 1st of each year.

2.4.3.3 Include initial acquisition costs such as:

- Planning, design, purchase
- Construction and capital replacement costs
- Operating costs, such as energy used, water used,
- Operating, maintenance, and repair costs including staffing
- Taxes and insurance need not be included in the life-cycle cost analysis.

2.4.3.4 Analysis of options shall be based on the system maintained and operating as designed. If the existing system is found to be deficient in one of these areas the analysis shall estimate the cost of correction and use that as the basis of the analysis.

3.0 HEATING PLANT

3.1 General

Heating plants may be either centralized or decentralized. The determination of what style plant a facility should install or whether a conversion is appropriate requires a detailed evaluation of many elements including installation, operation, and maintenance. All new or converted plants shall analyze the following in a detailed engineering report prior to progressing to schematic engineering. The report shall be submitted to the Office of Capital Assets Management, Engineering and Support for review and comment.

3.1.1 Net present value of each option. The analysis shall consider

3.1.1.1 Capital cost

3.1.1.2 Cost of replacement equipment during operational period

3.1.1.3 Operational cost

3.1.1.4 Energy as discussed in VA sustainable Design & Energy Reduction Manual and VA Directive 0055.

3.1.1.5 Maintenance cost

3.1.1.6 Resilience and cost impact of vulnerable areas (such as cost of vacating a building due to loss of heating equipment or cost of repairs due to loss of heating equipment)

3.1.2 The building and site adjacent to the building shall be arranged to allow for future expansion of additional boilers, chillers, or other equipment that may be needed.

3.1.3 Locate the heating plant in a separate building or room constructed per all applicable codes.

3.1.4 The heating plant and the air conditioning chiller plant may be combined into an energy center building/central utility plant. For chiller plant requirements, refer to latest edition of the HVAC Design Manual.

3.2 Building Requirements

3.2.1 Pipe, Breeching and Stack Supports and Anchors

3.2.1.1 Provide a structural system which permits access to overhead members for pipe and duct support, maintenance, and allows for future expansion.

3.2.1.2 Detail the design and locations of all roller and spring-type hangers, anchors, trapezes, seismic bracing and special supports. Detail the anchor designs and seismic bracing designs. Detail the connections to the building structure when standard pipe hanger components cannot be used as building attachments.

3.2.1.3 Provide analysis of system stress and required expansion considerations and support/anchor requirements performed and stamped by a registered professional engineer.

3.2.1.4 Seismic bracing for systems that experience thermal expansion shall be designed to allow the thermal expansion without overstressing any components.

3.2.2 The building design shall permit all equipment to be installed (and removed in the future) without removal of any building structural element, walls or the roof (an exception is a designed knockout panel). This shall be clearly described and indicated on the design documents.

3.2.3 Locate the main boiler room floor above finished grade to preclude flooding (refer to PSDM for flood protection and prevention requirements) and to permit horizontal rigging of equipment in and out of the building.

3.2.4 Establish roof height to provide adequate clearance above all equipment and piping for maintenance and operations. Clearance shall be a minimum of 15 feet from the top of the boiler and ancillary equipment to the roof line or ceiling. Provide for present or future installation of economizers above the boilers.

3.2.5 Provide overhead roll-up doors through which all equipment can be rigged. Locate a roll-up security grill inside each door so that the doors can be opened and not compromise building security for summer ventilation.

3.2.6 Boiler room shall be designed with double access (two doors, swing out). There shall also be 2 entrances into the boiler room.

3.2.7 Combined Boiler and Chiller Plants (Energy Centers/Central Utility Plant)

3.2.7.1 Combining the boiler and chiller plant in one building is preferred when it can be economically justified. Each proposed energy center must be reviewed by VA Central Office.

3.2.7.2 The energy center shall house the boiler plant, chiller plant, Engineering Control Center (ECC), pumps, plumbing equipment, associated electrical switchgear and boiler plant emergency generator and co-generation equipment for the VA medical center. The boiler plant generator shall be in the boiler plant in a suitable enclosure or room that is accessible without the need to leave the plant. To the extent feasible other emergency generators and electrical substations and domestic hot water generators may be placed in the energy center.

3.2.7.3 The chiller area and the ECC shall be designed in accordance with the HVAC Design Manual.

3.2.7.4 The electrical equipment area shall be designed in accordance with design and construction procedure, and VA Design Manual for Engine-Generators and Distribution.

3.2.7.5 The building design shall be such that the safety relief valve vent piping shall exit the roof (for steam and gas) directly above the equipment for which it serves. The maximum directional change after the drip ell shall not exceed 90 degrees. All directional changes shall be accomplished with 45 degree elbows or long radius sweeping 90s. Liquid relief shall be tempered to below 140F and discharged to a safe location

3.3 Water Treatment Area (central or hub locations):

Provide an area which includes the chemical feed units and space for chemical storage and mixing. Cold water and drains shall be available in the area and there shall be an emergency eyewash and shower. Approximate floor space requirement for chemical storage is 100 square feet. The chemical storage area shall accommodate chemicals in barrels or bulk tanks that will be furnished by the chemical supplier. The storage area shall be accessible by hose from a tank truck parked outside the building. If dry chemical is used there shall be access from the outside for forklift or hand-truck transport and platforms for loading into system.

3.4 Water Test Area (central or hub locations):

Provide laboratory type sinks in a stainless steel countertop unit which includes cabinets below and above for storage of boiler water testing equipment. Locate boiler water sample coolers adjacent to the sink unit. The test area should be adjacent to the firing aisle.

3.5 Personnel Facilities

3.5.1 An air conditioned control room of at least 150 square feet floor area with view windows located to allow observation of boiler aisle and chillers. Where an ECC is provided additional floor area is required (see Chapter 230 of VA Handbook 7610 for required floor area).

3.5.2 A supervisors' office of approximately 100 square feet floor area.

3.5.3 Locker facilities on the main floor of boiler plants and energy centers for employees, one or more of which shall be for female employees. Facilities shall include separate showers and locker rooms for male and female employees. Twelve lockers shall be provided including a minimum of two lockers in the female locker area.

3.5.4 Two separate toilet rooms adjacent to the locker rooms each having a water closet and lavatory plus a urinal in male toilet.

3.5.5 Water cooler.

3.5.6 Break room with sink, storage cabinets, and electric service for microwave oven and refrigerator.

3.5.7 Housekeeping closet.

3.6 Access Platforms

3.6.1 Provide a platform above each boiler to provide access to valves and manways which are located on top of the boiler. Minimum width shall be 2.5 feet, with length to suit boilers furnished.

3.6.2 Provide a three feet x four feet boiler manway access platform at the rear of each boiler.

3.6.3 Provide platform for access to economizer valves and service panels.

3.6.4 Provide other platforms as necessary to allow access to equipment requiring maintenance which is located more than 5 feet above the floor.

3.7 Permanent ladders and stairs

3.7.1 Provide stairways to mezzanine, platform or pit levels which require frequent access.

3.7.2 Provide permanent ladders for access to all platforms. The design of ladders and platforms shall conform to OSHA requirements.

3.8 Acoustical Considerations

3.8.1 Provide acoustical treatment on building surfaces which are within three meters (10 feet) of burner fans or atomizing air compressors or co-generation engines. Provide noise control in the operations room/ECC and in the office in accordance with VA Design and Construction Procedure, Noise Transmission Control.

3.8.2 Provide a block wall partition between the chiller portion of the building and other areas for noise control. Also provide the same for the co-generation engine unless other noise reduction measures are taken.

3.9 Boiler Plant Building Hazardous Gas Detection System:

3.9.1 Industrial-type system with central alarm panel and multiple sensors is required. Provide carbon monoxide sensors at breathing level near the front of each boiler and in personnel spaces where there is exhaust ventilation.

3.9.2 If natural gas is a main fuel, provide combustible gas detectors at the ceiling of the boiler room. If propane is utilized as a main fuel or secondary fuel, provide combustible gas sensors at the low points in the boiler plant.

3.9.3 Alarm shall be audio visual inside and outside the plant and labeled to identify the system it is protecting.

4.0 EQUIPMENT LAYOUT

4.1 In a central plant arrange boilers, emergency generator room/enclosure, control panels, instrumentation panel, motor control center, and control room/ECC along an aisle on the main floor. Boiler, chiller, and emergency generator spaces must be observable from the control room/ECC. Locate boiler feed pumps, water treatment area and main header on the main floor.

4.2 Control and instrument panels shall be visible from aisle, and to the maximum extent possible, visible from the control room/ECC. Instrument panels may be located in the control room/ECC.

4.3 The electrical switchgear and engine-generator(s) (cogeneration equipment) shall be located within the plant in a separate room adjacent to an outside wall. The engine-generator(s) shall be visible via view windows from the room that contains their paralleling and distribution equipment.

4.4 Housekeeping Pads - All floor mounted equipment shall be placed on and anchored to housekeeping pads

4.5 Tube replacement for firetube boilers generally requires a space in front of the boilers which is equal to its longest length. (See manufacturer's installation manuals for exact area required for boiler tube pulls.)

4.6 The width of the clear space between the side of a boiler and a wall shall be not less than three feet six inches.

4.7 Passage clearance between boilers ≥36inches wide and ≥80inches high.

4.8 The clearance for the opening of boiler doors shall not be less than 12 inches from the edges of the doors in any position.

4.9 The clearance between floor mounted pumps shall not be less than three feet. The clearance between floor mounted pumps and walls shall not be less than two feet, preferably three feet, except where a greater clearance is required to maintain a walking aisle.

4.10 Where possible allow enough space between boilers to maneuver a forklift. This is mandatory for new construction.

4.11 All equipment and piping devices shall be accessible from the floor or from permanent platforms for operation, repair, maintenance and replacement.

4.12 Repair, maintenance and replacement shall be possible without requiring the removal of other major items of equipment, the removal of major portions of piping, or the removal of portions of the building.

4.13 Generally, there should be at least three feet of clear floor space around all items of equipment. Boiler access shall be reviewed in detail as some areas of the boiler such as tube-pull or cleaning will require a greater distance.

4.14 Where possible, valves shall be located not more than seven feet above a floor, mezzanine, or platform. Limited exceptions are permitted for valves that are rarely used, would not need to be operated in an emergency situation (an emergency isolation valve is an example that **cannot** be operated via a ladder), or can be reached with portable ladders or chain-wheels.

5.0 BOILER ROOM ENVIRONMENT

5.1 Heating Plant HVAC Requirements

5.1.1 Heating plant and energy center heating, ventilating, and air conditioning shall be provided as follows:

5.1.1.1 Combustion and ventilation air intakes through the building walls and roof. Provide combustion air make-up heating and ventilating units in colder climates.

5.1.1.2 The maximum plant temperature shall be limited to 104 degrees F (40 degrees C).

5.1.1.3 Install roof-mounted exhaust fans to provide a minimum of 12 air changes per hour in the boiler areas (or more to meet the maximum temperature limit required).

5.1.1.4 Heat occupied rooms (ECC, office, toilets, showers, break room) to maintain temperature, humidity, outside air, etc. according to the HVAC Design Manual.

5.1.1.5 Heat (if necessary) the boiler room, chiller room and other equipment spaces to maintain 40 degrees F.

5.1.1.6 Air conditioning shall be provided in the ECC, office, toilets, showers, break room only.

5.1.1.7 Boiler room and chiller room shall be mechanically ventilated to maintain a maximum of 104 F. If either area is in excess 90 F spot coolers shall be provided at key operational areas and a portable for maintenance. Evaporative coolers such as “swamp coolers” are prohibited due to a potential of exposure to Legionella.

6.0 SYSTEMS AND EQUIPMENT

6.1 Hot Water Heating Systems

6.1.1 Quantity of Boilers: A minimum three units are the most cost effective and operationally practical. In some cases, two large and one smaller boiler for use in the summer load period is optimal (not applicable for modular condensing type boilers). The selection shall be based on the load profile developed by the design engineer and a life cycle cost analysis. Preferred method shall be to use separate smaller boiler for summer and larger

boilers for winter. A maximum number of five units may be utilized when multiple units are necessary. Approval by HEFP is required for use of more than five units.

6.1.2 Every boiler or modular boiler shall have a shutoff valve in the supply and return. For multiple boiler installations, each shall have such valves installed. Shutoff valves shall be monitored by the control system or LOO to ensure safety.

6.1.3 Double-wall heat exchangers shall be provided for domestic hot water heating applications.

6.1.4 Boilers shall not exceed 160 psi. Each boiler shall have a pressure and temperature gauge, or combination installed.

6.2 Boiler Capacity (non-condensing type):

6.2.1 The boiler system shall be capable of supplying the minimum demand with the smallest boiler in a normal mode of operation and with all auxiliary equipment operating within recommended turn-down ranges. The capacity of the smallest boiler shall be sufficient for peak demand in the non-heating season.

6.2.2 The boiler system shall be capable of supplying the maximum demand with the largest boiler not operating, and with the largest pump of each service not operating.

6.3 Pressure Requirements

6.3.1 Prevent steaming, by providing a certain amount of over pressure to keep the water from flashing to steam. Use typical charts provided by the boiler manufacturers indicating the maximum system operating temperature (High Limit Control Setting), the minimum recommended boiler operating pressure curve, in order to determine the necessary boiler/system pressure.

6.4 Safety and Design Considerations

6.4.1 Provide two (2) safety relief valves on the top or side of the boiler that relieve to an atmospheric vented flash tank with accommodation for cooling of the overflow.

6.4.2 Some safety devices within the VHA Safety Device Test manual may not be applicable for a specific type of boiler (i.e., hot water vs steam), equivalent devices shall be included in design and construction and site-specific safety device tests shall be adapted to accommodate these devices. Such devices are, but not limited, to the ones needed for a high steam pressure limit; while the system should be equipped with a high pressure alarm it shall also require a high temperature limit as well.

6.4.3 Recommended hot water supply temperature for space heating is 170-180 degrees F.

6.4.4 Unless a fully condensing boiler design, avoid supply water temperatures lower than 170 degrees F. Under such conditions combustion gases are reduced in temperature to a point where water vapor condenses, causing corrosion in the boiler and possibly in the breeching.

6.5 Boiler Criteria and Types.

6.5.1 High-Efficiency Non-Condensing Boilers: Total Heating Load-greater than 4 million Btuh [1172 kW]. Provide a minimum of three boilers, each generally sized to meet 50% of the demand, each complete with pumps, piping, controls, etc., to make a complete working

system. A maximum number of five units may be utilized when multiple units are necessary. Approval by HEFP is required for use of more than five units.

6.5.2 Gas and/or Oil Fired Boilers:

6.5.2.1 Packaged fire tube units up thru 6,900 kW (700 boiler horsepower) are acceptable. Packaged water tube units are acceptable for any capacity requirement. The choice between water tube and fire tube units must be based on life cycle costs, and available space in the boiler room.

6.5.2.2 Furnace Design: Furnace design and burner installation shall be coordinated to ensure that there is no flame impingement on furnace tubes and walls.

6.6 Water Treatment Equipment

6.6.1 "Zero Hardness" water shall be supplied for boiler makeup.

6.6.2 Water Treatment shall be provided if alkalinity in the makeup water exceeds 50 ppm. The design engineer shall obtain a current analysis of the water supply and determine the type of treatment which is necessary. The design engineer shall determine if the treated water will cause any substantial corrosion problems and recommend preventative methods.

6.6.3 Life cycle cost studies shall be performed to evaluate which type of water treatment equipment will be applied (ion-exchange softener, dealkalizer, reverse osmosis, and other systems) which have proven successful with local water conditions.

6.6.4 Softeners shall be dual tower to ensure supply during regeneration. Bulk brine storage shall be used where possible to avoid material handling salt storage space adjacent to water softener and dealkalizer. The area shall be accessible using a forklift for transport of bulk salt and a platform/lift table provided for loading the tanks.

6.6.5 Boiler Plant Chemical Feed Systems

6.6.5.1 Provide a separate continuous feed system (proportioning pump and tank) for each boiler.

6.6.5.2 System shall utilize premixed chemicals with multiple metering pumps for injection to eliminate the need for mixing and handling of the chemicals.

6.6.5.3 Provide sample coolers and sample points on feedwater, Hot water header supply and return and in the system as directed by the chemical treatment vendor.

6.6.6 Expansion tanks

6.6.6.1 Expansion Tanks shall be sized to handle the thermal fluctuations of the system during startup and shutdown. An expansion tank is required if a hot water system is equipped with a check valve or pressure reducing valve in the cold water line.

6.6.6.2 The expansion tank shall be a diaphragm type for the air from the boiler to be removed by an automatic-type air vent piped directly to the air vent tapping on the top of the boiler. Otherwise, an auto-vent shall be located on the expansion tank.

6.6.6.3 Expansion tank design shall account for the desired system pressure and changes in the specific volume of water from 60 °F (ambient temperature) to the maximum operating temperature of the boiler and related system. This analysis shall include the total volume of water in the flooded boiler and system. Expansion tanks shall be equipped with a bladder and charged with air at a pressure slightly higher than the static pressure on the tank with the system at ambient temperature.

6.6.7 Make-up Water

6.6.7.1 The design shall make provisions for properly introducing metering and treating make-up water.

6.6.7.2 Make-up Water Meter: A continuous meter shall be supplied as part of the installation to provide data to the plant control system indicating what the makeup rates and totals are.

6.6.8 System Air eliminator:

6.6.8.1 All hot water outlet connections shall include a dip tube, which extends 2 to 3 inches into the boiler. The dip tube shall not allow any air, which may be trapped at the top of the drum, to get back into the system.

6.6.8.2 An air vent tapping on the top center line of the boiler shall be piped into the expansion or compression tank or fitted with an automatic air vent valve. Dip tube assemblies shall also be supplied for external mounting into the boiler return connection, or system air separators, may also be equipped with an air vent tapping.

6.6.9 Low Load Operations: Water tube boilers should not be required to cycle on and off and prevented through proper sizing and number of boilers. Cycling of fire tube boilers shall be minimized.

6.7 Pumps

6.7.1 Provide a minimum of two pumps with one standby pump for each service. Pumps shall operate continuously rather than on-off. Motor hp (kW) shall be selected to be non-overloading at any point on the pump performance (head - capacity) curve with the largest available impeller. Variable frequency drives (VFD) controlling discharge pressure shall be applied on pumps equal to or greater than 7.5 hp.

6.7.2 Piping Insulation: Water piping above 120 degrees F shall be insulated for safety and conservation of energy.

6.8 Emergency Power

6.8.1 A UPS shall be provided to ensure that the control system is functional during power outages and transition.

6.8.2 Engine-Generators: Central plant shall be equipped with a dedicated generator/ Automatic Transfer Switch (ATS) located in rooms/enclosure separate from the boiler room however accessible by the operator without leaving the plant.

6.8.3 Any boiler that is decentralized shall be equipped with a dedicated ATS and powered by the facility electrical emergency service.

6.8.4 Generators, ATS, and other components which comprise the Emergency Power Supply System (EPSS) shall be installed, operated, tested, and maintained in accordance with the latest edition of NFPA 110, Standard for Emergency and Standby Power Systems and with VHA Directive, Electrical Power Distribution System.

7.0 FUEL

7.1 General

7.1.1 Perform an engineering economic analysis to determine the lowest life cycle cost of various fuel options. If a fuel other than fuel oil is proposed, it must be approved by CFM and VHA HEFP. A full life cycle cost analysis, narrative of the analysis and justification and a full risk analysis of the operation of the system must be submitted for review and approval.

7.1.2 When considering fuel options, determine the reliability of the supply and the feasibility of using each fuel. Where natural gas is utilized, provide a second fuel (such as fuel oil or propane), stored on the site, as a standby.

7.1.3 Analysis of fuel shall consider permitting and emission limit impacts on equipment.

7.1.4 Conform to local, federal and state emissions regulations.

7.1.5 Boiler fuel of choice is natural gas for reasons of supply security, equipment life and environmental compliance.

7.1.6 Propane shall be used for the operation of igniters (pilots) when natural gas is not available or has been interrupted. If natural gas is normally utilized, the LP gas igniter system is for emergency use only. The LP gas igniter system shall operate at five psig or less. The VAMC shall supply replaceable propane cylinder tanks. The A/E shall design the tank piping, valve system, and provide concrete pad and chains for supporting the tanks. Locate the tanks outside with setback as defined by code and protection as required by VA PSDM.

7.1.7 Provide emergency gas shut off valve and shunt trip for fuel oil pumps with emergency stop buttons at each exit from the plant or room. Protect buttons from accidental activation and provide signage to identify the purpose

7.1.8 Standby Reserve Fuel Storage Quantity

7.1.8.1 Facilities firing oil as fuel shall maintain a supply of fuel sufficient to meet the normal demands of continuous operation for a period of 15 January days. If the facility is equipped with a backup source of fuel such as natural gas, propane or coal, the oil supply can be reduced to 10 days. The combination of on-site primary and backup fuel supply must be sufficient for 15 days of continuous operation in January. Plants that generate less than 50 percent of their annual steam demand by natural gas for two consecutive years are considered to be oil-fired and shall meet the supply requirements for oil-fired plants.

7.1.8.2 Facilities firing natural gas as the main fuel with fuel oil or propane back-up shall maintain a sufficient supply of back-up fuel to meet the normal demands of continuous operations for a period of 10 January days.

7.1.8.3 Sites with electric steam generators must have those generators connected to either the facility's essential electrical system (emergency power system) or a standby power system(s) dependent on the facility's risk analysis. On-site storage of generator fuel for boiler use must be sufficient for a minimum of 96 hours of continuous operation.

7.2 Natural Gas

7.2.1 Header pressure in the boiler plant shall be as low as practical which, for water tube boilers is 70 - 100 kPa (10 - 15 psig) and, for fire tube boilers is 35 - 70 kPa (5 - 10 psig). Higher gas pressures may be required for low-NOx burners or high turndown burners. Coordinate system design with requirements of local gas supplier.

7.2.2 Provide a separate gas meter for the boiler plant; locate the meter in the boiler plant.

7.3 Fuel Tanks

7.3.1 May be located underground or aboveground. Provide secondary containment systems on tanks and piping. All steel buried tanks, piping, and secondary containment shall be coated and cathodically protected.

7.3.2 Provide electronic leak detectors located in the interstitial spaces of the tanks and in piping systems between the carrier pipes and outer casings. Provide spill and overfill prevention measures as required by pollution control authorities.

7.3.3 The use of day tanks is not preferred and shall only be used when the situation mandates such an arrangement and is VA approved.

7.3.4 Tanks shall have an automatic system for monitoring/measuring fuel level and alarming high and low levels. The system shall have both audible and visual indication and annunciation locally and at the operator station.

7.3.5 Tanks shall be equipped with recirculation filtering systems to ensure fuel quality.

7.4 Fuel Pumps

7.4.1 Gear, lobe, or screw pump shall be used for boiler feed.

7.4.2 Fuel oil pumps shall be sized to accommodate the maximum flow based on the maximum design steam output with a 10% safety factor for future expansion or the known master plan expansion plan whichever is greater.

7.4.3 Fuel oil pumps shall be located above grade and protected from potential flooding due to weather or other action. There shall be a housekeeping pad for each pump or pump system.

7.4.4 Pumps arrangement shall be duplex with one operating and one standby.

7.4.5 Pump skid shall be equipped with a duplex strainer on the suction of the pumps and connections on the supply and discharge for emergency connection to the system.

7.4.6 Each pump will be equipped with a safety relief valve that relieves to the tank return complete with site glass to inspect for flow. The system shall have a backpressure control valve and associated pressure.

7.4.7 The system shall have a supply and return flow meter in the piping to the boilers system.

7.4.8 Refer to standard detail on the TIL for additional information.

7.4.9 Pumps shall be of a type suitable for the application and shall generally be selected to operate at 1750 rpm.

7.5 Fuel Oil piping

Oil piping shall be located in trenches to reduce hazard caused by leaks and air binding. Provide accessible drains in trenches for cleaning and removal of water from plant or rain. All drains serving chemical and petroleum systems shall be equipped with an oil/water separator (OWS). OWS shall be accessible for pumping by a vacuum truck.

8.0 BURNERS

8.1 Automated Shutdown- When water temperature or pressure is in excess of demand sensed, the following shall occur:

8.1.1 The damper will return to low fire position

8.1.2 The operating limit control opens

8.1.3 The main fuel valve circuit is de-energized, main fuel valve closes.

8.1.4 Flame is extinguished

8.1.5 The running lights on the control panel turn off

8.1.6 The blower motor continues to force air through the boiler for the post purge period.

9.0 COMBUSTION AIR

9.1 An adequate air supply provides for clean, safe combustion and minimizes the formation of soot.

9.2 The boiler room shall have two combustion air openings to ensure adequate combustion air and proper ventilation: one within 12 inches of the ceiling and the other within 12 inches of the floor. Each opening shall have a minimum free area of one square inch per 2000 BTU/hr. rating (of all burners required to carry maximum load at full capacity). The designer shall ensure the plant is not negative with all boilers required to carry maximum load running at full load.

9.2.1 Calculations for combustion air openings must include the boilers required to carry the peak load operating at 100 percent. Note: In most cases this will be the two largest boilers at 100 percent.

9.2.2 The emergency generators must have their own fresh air intake independent of the intake calculated for the boilers

9.2.3 CO-Gen/CHP equipment shall be calculated separately and have separate fresh air intakes

9.3 Combustion air fans shall be equipped with VFDs.

9.4 Combustion dampers shall be interlocked with the boiler firing cycle. Manually operated dampers prohibited.

9.5 Burners:
Provide low excess air design, with oxygen trim, on larger water tube boilers when justified by life cycle cost analysis. Provide low NOx burners (not to exceed 30 ppm) unless lower emission concentration is required by emissions authorities and local AHJ. Written confirmation of the AHJ's requirements shall be obtained for the record.

9.5.1 Dual Fuel Burners: Dual burners are required for VA Hospital applications. Burners shall be of the low pressure, air atomizing (nozzle) type. Burners feature ignition by spark-ignited gas pilot flame. With either fuel, the burner operates with full modulation. A switch permits changeover from automatic fully modulated firing to manually set firing at any desired rate between minimum and maximum. Additional safeguards assure that the burner always returns to minimum firing position for ignition. Dual burners are designed for automatic, unattended operation except for periodic inspection and maintenance. After selecting the proper overload settings for the starter, the rest of the control panel components require little attention except for occasional cleaning and Preventative Maintenance. Burner fuels to be used shall be based on availability and frequency of service interruption. When gas is available, gas shall be the primary fuel.

9.5.1.1 The change from gas to oil must contain hard wired switch interlocks to ensure the controls align with the fuel supply. Additionally, the changeover shall not require changes to the fuel system piping or control by the operator and should be able to be accomplished in 20 minutes.

9.5.1.2 Operating Controls: The burner is supplied with a remote control panel and with a burner mounted junction box.

9.5.1.3 The control panel contains a flame safeguard programming control, motor starters, relays, time delays and terminal strips mounted internally on a panel sub-base. Lights, switches, potentiometers, a control circuit breaker and flame safeguard displays are mounted externally on the panel. The burner control circuit operates on 115-volt, single phase, 60 hertz (or 50 hertz when required) alternating current.

9.5.2 Gas Burners:

9.5.2.1 Gas train shall be in accordance with International Risk Insurance (IRI) Standards and shall meet the requirements of NFC 85 – Boiler and Combustion Systems Hazard Code – paragraph six. Single fuel burners are not recommended for Hospital applications.

9.5.2.2 The burners shall be the power type and constructed of stainless steel.

9.5.2.3 The firing shall be electronically controlled and shall continually monitor the water temperature, modulating the burner for the most efficient operation. The controls will allow for manual/auto operation of the firing rate of the burner.

9.5.2.4 Gas burners shall be maintained, serviced, inspected, and operated in accordance with the manufacturer's operation and service manual.

9.5.3 Oil Burners:

9.5.3.1 Oil burners must atomize and vaporize oil to get the oil into combustible form. Large burners usually prepare the oil for combustion by first atomizing the fuel and injecting it into the combustion space for final heating, vaporization and mixing with combustion air. Single fuel burners are not recommended for Hospital applications. Atomization is generally obtained by one of the following methods:

9.5.3.1.1 Horizontal Rotary Cup type:
In this method, a thin film of oil is spun from the rim of a cup being rotated at high speed. The oil enters a cone of high velocity primary combustion air where atomization is obtained. This type of burner is capable of high maintenance costs and efficiencies.

9.5.3.1.2 Mechanical Pressure Atomizing type:
This method expands the oil by pressure through a small orifice thereby breaking it into a spray of very fine droplets. This burner is not adaptable to appreciable modulation as a drop in pressure results in rapid deterioration in atomization efficiency. Mechanical atomization requires the highest oil pressure and yields the poorest performance.

9.5.3.1.3 High-Pressure Air Atomizing type:
High-pressure air atomizing burners utilize air pressures of 30 psi and above and can operate within the same range of oil pressures and preheat temperatures as the steam atomizing type.

9.5.3.1.4 Low pressure Air-Atomizing type:
This system generally operates within ½ to five psi air pressure and five to 20 psig oil pressure.

9.5.3.1.5 Low-Excess Air type:
These burners are designed to operate with excess air down around 5 percent. Low excess air burners are used mainly to reduce nitrogen oxide (NOx) emissions. Only provide low NOx burners if required by the emissions authorities.

9.5.3.1.6 Low-NOx type:
Low-NOX burners have a wide variety of designs. The principle of all low-NOx burners is the same; they inherently generate lower NOx emissions due to internal staging of fuel combustion. The Low NOx burners are equipped with a Flue Gas Recirculation system (FGR). The flue gases are duct to the air housing and the burner combustion air fan is used to pull flue gases from the stack. The FGR rate is controlled by damper blade linked to the modulating motor. Top or bottom connection is used with a flanged adaptor to the damper box. Fresh air and FGR is mixed and injected in the combustion zone. All FGR duct piping should be covered with a minimum of two inches of insulation and supported as required. The burner is designed to operate with < 30 ppm NOx corrected @

three percent O2 throughout the firing range, when firing natural gas. See reference: EPA/625/5-86/020, Nitrogen Oxide Control for stationary Combustion Sources. Follow burner manufacturer's recommendations for optimum operational efficiency at low NOx burner operation.

9.5.3.2 All oil burners shall have two guns, one active and one spare so that one may be removed for cleaning while the other is available for immediate use.

10.0 BOILER STACK AND EMISSIONS

10.1 Boiler stack location, height, and diameter shall be determined by an engineering study conducted by a licensed professional engineer, which considers boiler/burner operational requirements, air flow around the stacks and the boiler plant and adjacent buildings, and emissions regulations. Stack gases shall not affect fresh air intakes of building ventilating or air conditioning systems. Comply with federal, state and local emissions regulations.

10.2 Generally, individual stacks on each boiler are required. A common breeching and single stack system for all boilers may be approved if documentation is provided to support the need of the request due to specific project conditions. A request for variance shall be submitted in writing through HEFP for review and approval.

10.3 Locate diesel engine exhaust outlets so that they do not mix with building intake air.

10.4 Stacks shall be designed to provide adequate natural draft. A stack generally shall extend at least 10 feet above the highest point on the roof.

10.5 The size of the stack shall not be smaller than that recommended by the boiler manufacturer. Wherever possible, the outlet area should be sized to provide a discharge velocity at a maximum gas flow of 2000 to 3000 feet per minute.

10.6 Vents, stacks, and chimneys shall comply with NFPA 54 and NFPA 210.

10.7 Gas mains, burner headers, gas piping, etc., shall be vented according to the criteria in NFPA 85A, Prevention of Furnace Explosions in single Burner, Boiler-Furnaces and NFPA 85B, Prevention of Furnace Explosions in a Gas Multi-Burner Boiler.

10.8 Boilers shall be equipped with outlet air dampeners regardless of whether the boiler has a dedicated stack.

11.0 CONTROLS AND INSTRUMENTATION

11.1 Controls

11.1.1 Multi-loop industrial safety critical process programmable digital controllers are required for all control functions except burner management where specialized digital controllers are required.

11.1.2 Parallel-positioning combustion controls are required for boilers ranging from 100 through 900 boiler Horsepower. For smaller fire tube boilers, a single-point positioning control is more practical.

11.1.3 Controls added to existing systems shall be the same manufacture and type as existing, unless directed otherwise by COR.

11.2 Safety devices

11.2.1 In addition to the requirements of the manufacturer an automatic shunt trip and two remote emergency stop button (one in the area of the unit and one at a centrally monitored location) shall be provided on the electrical power supply

11.2.2 Provide high temperature limit switch to cause a safety shutdown by closing fuel valves, shutting down burner equipment, activating visual and audible alarm in the event that the boiler water temperature rises to the high temperature limit setting. A manual reset shall be required.

11.2.3 Low water cutoff shall be provided to shut off the boiler in case of low water level in a boiler. Provide float actuated type low water level cutoff switch to cause a safety shutdown by closing fuel valves, shutting down burner equipment, activating visual and audible alarm in the event that the boiler water level drops below the lowest safe permissible water level as defined by the boiler manufacturer and ASME BPVC SEC IV. A manual reset shall be required.

11.2.4 Emergency fuel cut-off switches (panic buttons) shall be located at each point of egress from the plant and in the control room. The switches will close the Natural Gas shutoff valve to the plant and shut down all fuel oil pumps.

11.3 Automatic/Remote Starting(light off)

11.3.1 There shall be no automatic/remote restart of boilers after the occurrence of a fault. Faults shall activate a latching switch which must be manually reset at the boiler.

11.3.2 There shall be no lead-lag systems with automated/remote cycling of boiler.

11.3.3 In addition to digital controls, the boilers shall come with an analog local loop control system for manual operation when the digital system is non-operable.

11.3.4 All controls shall meet the requirements of ANSI Standard Z21.13 and NFC 85 – Boiler and Combustion Systems Hazard Code – paragraph six for automatically fired boilers. The controls include ignition safeguard, high temperature limit, operating temperature control, gas pressure regulator, redundant electric gas valve, water flow sensing, and a manual shut off valve.

11.4 Monitoring and data management:

11.4.1 BACNet or LONWORKS protocol Direct Digital Controls (DDC) shall be used for connection to the Building Automation System (BAS).

11.4.2 Centralized Boilers and system data shall be monitored by the BAS for data collection and logging.

11.4.3 Distributed boilers shall be monitored through a BAS at a centrally monitored location. The control system shall monitor alarms, safety equipment, & safety devices, log status & faults and be supervised. Data shall be logged for review of performance and faults.

11.4.4 Shall be by means of a Supervisory Control and Data Acquisition (SCADA) program on a computer work station reserved for only boiler system monitoring. There shall also be annunciation of alarms, pressure switches, and other operating displays on instrument

panels within easy view of the attendant/operator. Controls added to existing systems shall be the same manufacture and type as existing.

12.0 OPERATION OF BOILERS

12.1 Operational Requirements

Designer shall ensure that all of the operational requirements defined below can be accommodated with the equipment and systems provided. In some cases, additional connections or specific equipment for testing and calibration may be required and must be specified and designed into the system (sample taps, test equipment, etc.).

12.2 Inspections

12.2.1 A testing and commissioning plan shall be developed and approved prior to the start of construction to ensure all elements are in place to accommodate successful completion. All systems shall be designed to allow for field calibration, inspection, and testing upon completion of the boiler installation. The appropriate documentation shall be provided for the purpose of receiving an operating certificate.

12.2.2 Boilers and safety devices shall be designed and installed to accommodate testing as defined in the VHA Boiler Safety Device Test Manual and in accordance with the laws of the local jurisdiction.

12.3 Cleaning

12.3.1 Boilers: New and repaired boilers will contain internal surfaces that have been coated with oil. This must be removed prior to operation to avoid corrosion. A boil out chemical compound shall be used. This process requires prior planning and coordination therefore the manufacturer shall be consulted to develop a written plan and schedule for the process.

12.3.2 Chemical cleaning shall be used to remove any hard scale from interior surfaces. The manufacturer shall be consulted, and the process approved by HEFP prior to executing work. Any sort of deposit will reduce the effectiveness of the heat transfer process.

12.3.3 All steam, condensate, and oil piping within the plant shall be flushed and cleaned to remove all dirt, debris, oil, and scale. The flushing shall be accomplished at a minimum of 3 fps and the cleaning shall address the removal of mill scale and other contaminants in the pipe. A detergent flush shall be used to remove oils used in packaging of the piping.

13.0 FREEZE PROTECTION

13.1 Heat tracing systems are not recommended for systems inside the building. It is not visually apparent that a heat cable has failed.

13.2 When terminal devices are in contact with freezing ambient air, steam is the preferred choice for the heat source.

13.3 The condensate created when steam is used for freeze protection may be returned to the boiler.

14.0 MODIFICATIONS TO EXISTING PLANT

14.1 In addition to the equipment required for operation, the design shall provide a standby boiler and standby pumps during all phases of construction.

14.2 Temporary boilers and other equipment may be employed if cost effective.

15.0 CODES & STANDARDS

ASME section IV Heating Boilers
- ASME B31.1 – Code for Pressure Piping
- ASME B31.9 – Code for Pressure Piping (Plants which do not generate steam over 15psig)

National Fire Protection Association
- NFPA 31 – Standard for the Installation of Oil Burning Equipment
- NFPA 70 – National Electrical Code
- NFPA 70E – Standard for Electrical Safety in the work place
- NFPA-85 – Boiler and Combustion Systems Hazard Code
- NFPA 110 – Standard for Emergency and Standby Power Systems

VHA Directive 1028 – Electrical Power Distribution System

Comply with all federal, state and local codes, laws and regulations whichever is more stringent. Comply with federal executive orders and all nationally recognized industry standards (NFPA, ASHRAE, etc.).

16.0 REFERENCES

16.1 Design Manuals (PG-18-10); HVAC Design Manual for New, Replacement, Addition and Renovation of Existing VA Facilities: Department of Veterans Affairs, Office of Construction and Facilities Management.

16.2 ASME Boiler and Pressure Vessel Code, Section I,II,V and IX

16.3 NFPA 85, 8501, 8502 or 8504

16.4 Unified Facilities Criteria (UFC) Central Heating Plants UFC 3-430-08N

16.5 GSA P100 Facility Standards for Public Buildings Service

16.6 EPA/625/5-86/020, Nitrogen Oxide Control for Stationary Combustion Sources.

16.7 Heating Boiler Operators Manual, Mohammad A. Malek, 2007 McGraw-Hill

16.8 Cleaver Brooks – Boiler Room Guide

16.9 Code Requirements – International Mechanical Code 2012

16.10 The VA Safety Device Testing Manual

16.11 VA Directive - Boiler and Boiler Plant Operations

16.12 VHA Directive 1028, Electrical Power Distribution System

16.13 VHA standard details on the TIL.

16.14 VA CFM Physical Security Design Manual (PSDM), latest edition

16.15 29 CFR 1910