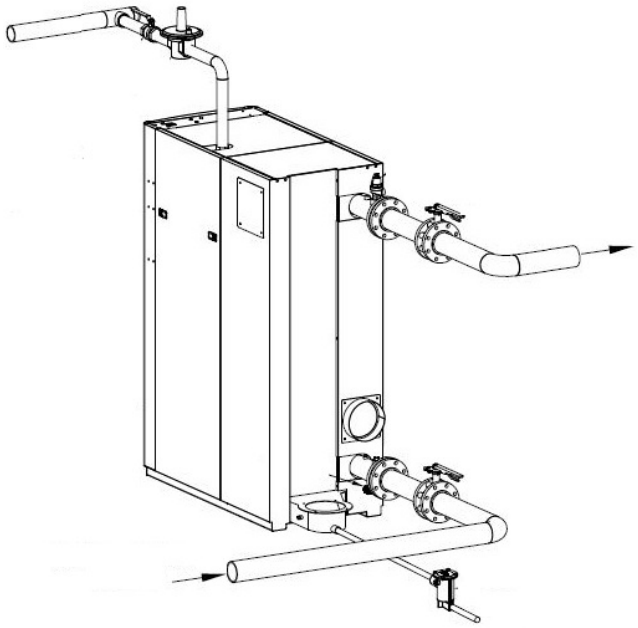
BENCHMARK BOILER APPLICATION GUIDE

Natural Gas, Propane Gas, or Dual Fuel Fired Modulating, Condensing Boilers

For models:

BMK750 to BMK6000

BENCHMARK Series
Gas-Fired Boilers



Revised: 10/22/2013

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TABLE OF CONTENTS

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1. GENERAL

AERCO BENCHMARK (BMK) boilers can be used in any hydronic closed-loop heating system application, within the limitations of temperature and pressure ratings. Because of their extreme flexibility and precise control, they can be used to supplement any hot water system. This guide is intended to help designers apply AERCO boilers to the most common types of systems. If a special application is needed, please call your local AERCO Representative or the AERCO factory for specific application information. CAD drawing packages are available for layout specification.

2. SINGLE AND MULTIPLE APPLICATIONS

AERCO BMK boilers can be applied either as stand-alone single units or in multiple batteries of boilers with unlimited input. BMK multiple boiler systems minimize floor space requirements and more importantly, modulate under partial loads to match the changing requirements of the energy input.

Actual boiler sizing and selection are the responsibility of the designer. ASHRAE standards recommend sizing equipment with a minimum of over sizing for maximum system efficiency. A multiple BMK boiler installation matches any load fluctuation from 0 to 100% without overshoot. AERCO subscribes to and recommends the methods used by ASHRAE and IBR to develop required loads and sizes.

3. PIPING

3.1 Pressure, Temperature, and Flow Restrictions:

With the exception of the BMK 6000, all other BMK Series units are ASME certified for working pressures of up to 160 psig. The maximum working pressure for the BMK 6000 is 80 psig or 150 psig. BMK boilers cannot be used in applications where their allowable pressure ratings can be exceeded, or irreparable damage may result. Individual ASME pressure relief valves are supplied on each boiler in setpoints of 30, 50, 60, 75, 100, 125, 150, or 160 psig, as specified.

NOTE

The piping connections illustrated throughout this bulletin are based on the BMK 2000. See dimensional drawings for connection locations for BMK 750, BMK 1000, BMK 1500, BMK 2500, BMK 3000 and BMK 6000 units.

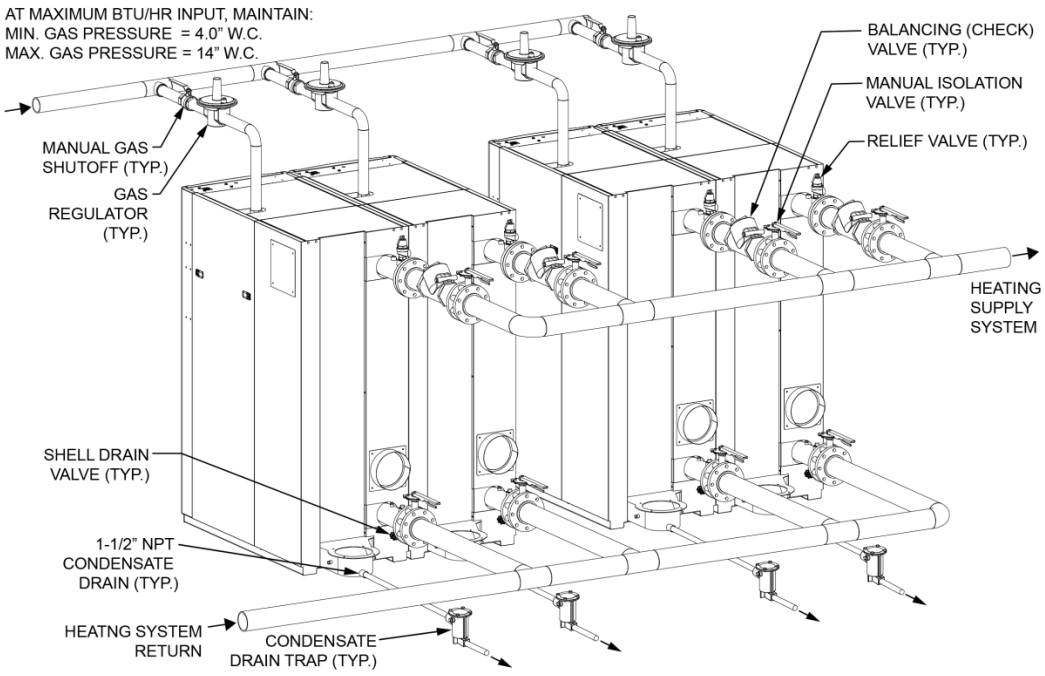


Diagram 1: Proper Multiple Boiler Piping

AERCO BMK boilers require the following minimum flow per boiler for proper and stable boiler temperature control operation:

- BMK 750 = 25 gallons per minute
- BMK 1000 = 25 gallons per minute
- BMK 1500 = 25 gallons per minute
- BMK 2000 = 25 gallons per minute
- BMK 2500 = 25 gallons per minute
- BMK 3000 = 25 gallons per minute
- BMK 6000 = 75 gallons per minute

To prevent erosion of construction materials, maximum flows are limited to the following:

- BMK 750 = 175 gallons per minute
- BMK 1000 = 175 gallons per minute
- BMK 1500 = 250 gallons per minute
- BMK 2000 = 350 gallons per minute
- BMK 2500 = 350 gallons per minute
- BMK 3000 = 350 gallons per minute
- BMK 6000 = 700 gallons per minute

Whenever BMK boilers are employed in systems where ancillary flow devices (such as three-way valves) are not used, minimum flows must be maintained for proper boiler operation.

BMK units are applicable to systems with temperatures from 50°F to 180°F. Due to their condensing design, normal low temperature restrictions do not apply. While most common heating applications are designed with a 20°F temperature drop, BMK boilers are capable of 100°F temperature drop through the heat exchanger without thermal stress.

3.2 Multiple Boiler Piping Design

For multiple boiler installations, the piping must be designed to ensure balanced flow through all the boilers. This can be accomplished by using reverse-return piping or a balancing valve at the outlet of each boiler. Failure to balance flow evenly through the boilers will prevent full delivery of boiler capability at design conditions and may cause over-cycling and unnecessary stress on the boilers.

3.3 Service Provisions

For maintenance purposes, each BMK boiler should be individually valved on supply and return from the system. The BMK boiler is approved for “0” side clearance in two-unit pairs in applications where space is at a premium. Piping should be located to allow free access between boilers. Each unit has an individual factory-installed drain in the boiler shell.

3.4 Hydronic System Accessories

AERCO BMK boilers must be used in conjunction with appropriate hydronic accessories, such as pumps, expansion tanks and air elimination equipment.

Normal commercial and industrial systems employ constant-speed pumping equipment. Variable-flow pumping equipment may also be employed, as long as the system is operated within the recommended minimum and maximum boiler flow limits. Controls should activate heating pumps whenever BMK boilers are in operation.

Air elimination in conjunction with pre-charged diaphragm expansion tanks is preferable to air control. Compression tanks may be used, but create a maintenance task for system operators. Make-up systems must be employed as required by codes.

Fill valves must be used with backflow preventers, as required. Traditional flow control or mixing devices (primary-secondary pumping, 3-way valves) are not required with AERCO BMK boilers. However, when such devices are employed, they should always provide the minimum flows required for a single or multiple boiler installation. When used with a refrigeration (chiller) system, the boiler must be installed so as to prevent the chilled medium from entering the boiler. Consult your local AERCO representative for application advice.

3.5 Condensate Piping

Each AERCO BMK boiler has a separate indirect condensate drain and is supplied with a trap that must be permanently piped as part of the installation. BMK boilers must be installed on a 4-inch pad, minimum, to enable the condensate to drain from the exhaust outlet connection.

Each unit will produce the following approximate condensate quantities in the full condensing mode, depending on the local temperature and humidity:

- BMK 750 = 6 gallons per hour
- BMK 1000 = 8 gallons per hour
- BMK 1500 = 9 gallons per hour
- BMK 2000 = 10 gallons per hour
- BMK 2500 = 17 gallons per hour
- BMK 3000 = 20 gallons per hour
- BMK 6000 = 40 gallons per hour

Condensate drain systems must be sized for full condensing mode.

In multiple boiler applications, it is common to manifold these drains together in a plastic pipe manifold to a floor drain. Condensate manifolds must be large enough to handle the anticipated flow and must be properly secured and protected. Manifolds are generally located behind the boilers so that short runs of plastic tubing into the manifold can be used for the condensate drain. A base drain must be installed at the bottom of vertical common flue piping (see Figure 13a of AERCO Technical Bulleting GF-2050).

Condensate can be drained by gravity to a floor drain, or condensate may be drained into a small condensate pump (such as used with air conditioning equipment) and pumped to a convenient drain.

The pH level of the condensate produced by BMK boilers ranges between 3.0 and 3.2. The installation should be designed in accordance with local codes that specify acceptable pH limits. If the condensate pH level needs to be raised to comply with local codes, the AERCO Condensate Neutralizer Kit may be used. See Technical Instructions TID-0029 for details. When using the AERCO Condensate Neutralizer Tank, for proper condensate drainage, the neutralizer tank must be installed in a pit OR the boiler and the AERCO Condensate Trap must be elevated higher than 4" above the floor. See Condensate Tank instructions TID-0074 for details.

4. CONTROLS

4.1 Safety Control

BMK boilers are equipped with a manual reset high-limit aquastat. Each BMK boiler has safety controls that comply with ASME Section IV for low pressure heating boilers. These controls are factory wired and installed to simplify field installation. An internal, electric, probe-type, low water cutoff and a manual-reset high-limit temperature device comply with ASME standards. Other locally-required external safety devices (flow switches, pressure controls, etc.) should be provided and installed locally. Designers should check with local authorities having jurisdiction to assure compliance with all applicable codes.

4.2 Internal Boiler Operating Control Options

BMK boilers are shipped complete with both combustion safeguard controls and operating controls installed in each unit. When used in a single boiler application, boiler control modes must be specified and ordered with those found in the following table:

Boiler Control Modes to be Specified at Time of Order

Description	Output
Internal Setpoint	Constant Discharge Temp
External Setpoint	Outdoor Reset
Modbus AERCO ACS	Fire Rate Response to ACS signal, 9 or more boilers

Factory software and testing facilitate a simple installation, with minimum field wiring required.

When 9 or more BMK boilers and an AERCO Control System (ACS) are applied in a multiple-boiler application, all the modules should be specified and ordered as ACS compatible. In this configuration, simple field control wiring consisting of two twisted wires connects the ACS Panel to the individual boilers.

4.3 Field Sensor Location

When a single BMK boiler is used, all water sensors are internal to the boiler unit and factory positioned. When multiple boilers with on-board sequencing or ACS are used, with common sensors such as the Header Sensor, the water sensor must be located in the field piping. **It should be placed in the common supply at least 2 to 10 feet downstream of the point where the last boiler connects into the supply header.**

All outdoor air sensors should be positioned on the North wall of the building served, and not in direct sunlight. The outdoor air sensor should not be placed inside the boiler air inlet duct, or near the boiler exhaust outlet connection. A sunshield is provided as part of the outdoor air sensor kit.

4.4 Multiple Boiler Control

An AERCO Control System (ACS) is available for multiple boiler applications. The ACS maximizes the plant efficiency by running the boilers at their lowest possible input. It has the capability of controlling up to 32 boilers as well as auxiliary equipment. Refer to ACS specification sheet for full details of the ACS flexibility. When used with an ACS, BMK units should be specified and ordered with the ACS control configuration (see table above).

5. TYPICAL APPLICATIONS

BMK boilers can be used in any closed-loop heating system within their design limitations. The following typical piping and wiring schematic diagrams represent the most common types of installation detail. These diagrams are not intended for any particular system, but are rather composites of how AERCO boilers interface with heating applications in the real world.

The designer should incorporate BMK boiler(s) in each system so as to achieve maximum operating efficiency. With ultimate control over the energy transfer process under a broad range of temperatures, the designer should first consider how the system best needs the supplied energy. The boilers should then be applied in the manner that best enables them to use their finite control and capability to supplement the system, using minimum applied energy.

The following examples illustrate typical piping and wiring diagrams with brief explanations of design considerations and sequences of operation.

The examples include:

- Single Heating Boiler — Indoor/Outdoor Reset Control Mode (Diagrams 2)
- System Pump Start – Using Pump Relay or Separate Contact Relay (Diagrams 3)
- Multi Boiler Heating Plant — Indoor/Outdoor Reset Mode with ACS (Diagrams 4)
- Three Boiler Heating Plant - ACS with individual motorized isolation valves (Diagrams 5 and 6)
- Primary/Secondary Pumping (Diagram 7)
- Three Boiler Combination Heating & Domestic Water Plant. (Diagram 8)

Designers are encouraged to work with their AERCO representative to fully explore and apply the ultimate exchange of energy with control in hydronic heating.

5.1 Single Heating Boiler — Heating Only

Sequence of Operation:

Boiler plant should be activated by a system start device, such as an outdoor air thermostat or building management system.

A manual switch can be used, but it would place the burden of starting and stopping on the boiler attendant. Automatic controls are more desirable.

Using the optional BENCHMARK boiler pump relay (factory installed), the system's circulating pump should be started with the BMK unit and should be constant run, as illustrated in Diagram 3. A flow switch or other method should be used to prevent the BMK unit from firing under no flow. If used, the flow switch shall be wired to the delayed interlock of the BMK C-More Controls (see C-More Manual GF-112 for details. A unit energized to fire with insufficient or no flow will trip out on high temperature limit.

Once activated, the internal boiler temperature controls will modulate the input of the boiler to match the control algorithm set.

With indoor/outdoor reset mode, the temperature of the boiler water to the system will increase as the outdoor temperature decreases. The rate of change can be varied by the adjustable reset ratio on the boiler control panel. If ordered with an internal setpoint control system, the boiler will maintain a water temperature that is constant at any adjustable setpoint from 50°F to 180°F.

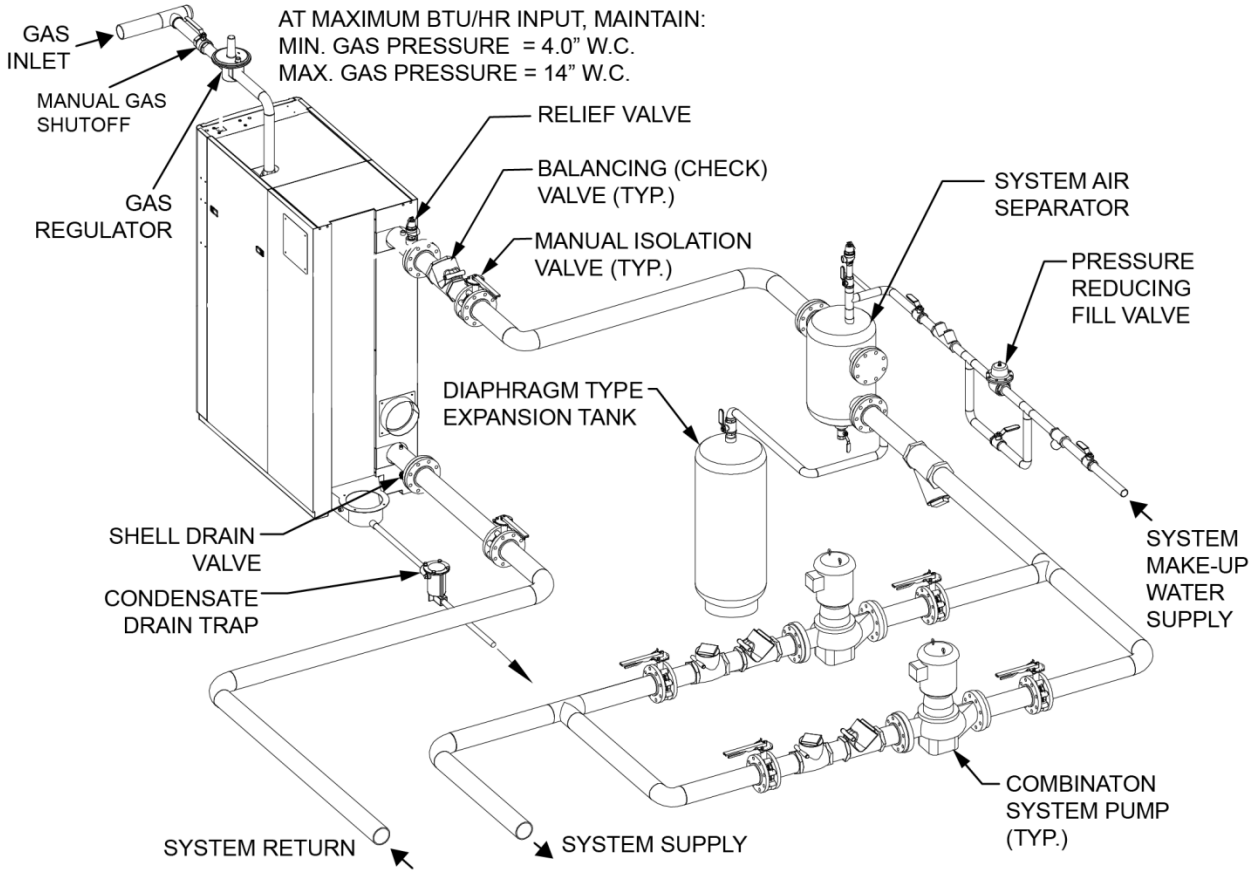


Diagram 2: Single Boiler Piping Schematic (BMK 2000 shown above)

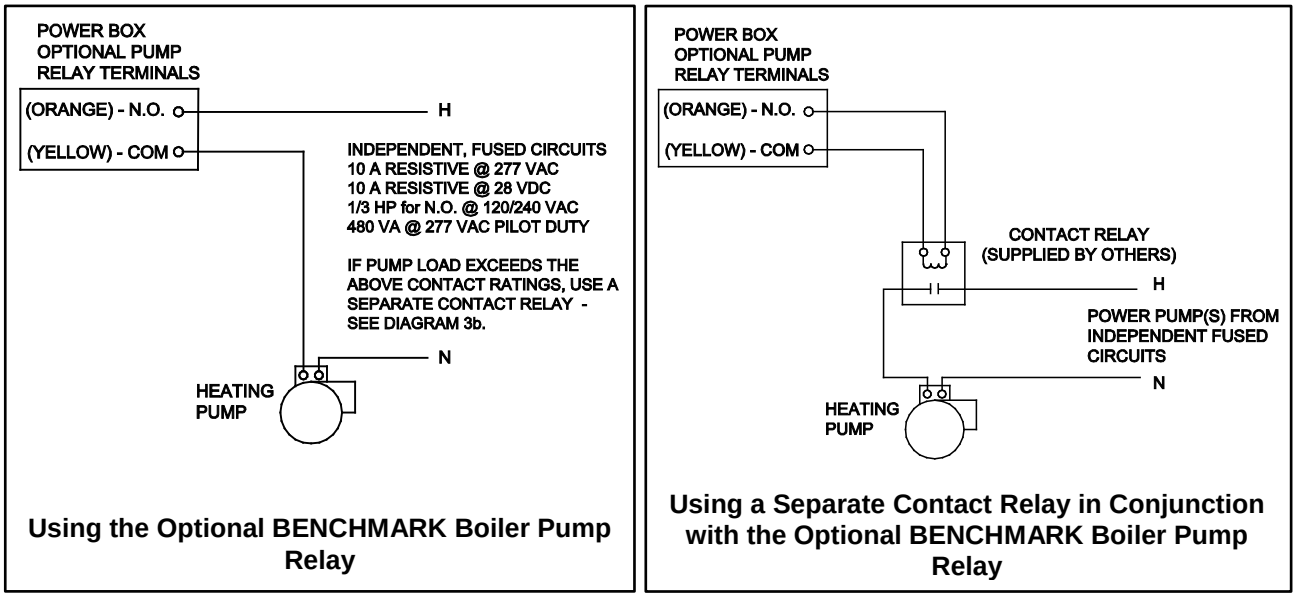


Diagram 3: Schematic – System Pump Start

5.2 Multiple Boiler — Heating Only

BMK multiple boiler plants provide the ultimate energy conversion for building space heating, longevity and ease of installation. Boiler plants incorporating from 2 to 8 boilers can be controlled via AERCO'S on-board Boiler Management Sequencer (BMS). Boiler plants greater than 8 and up to 32 boilers can be controlled from a separate single AERCO Control System (ACS). Boilers can be arranged in back-to-back or inline piping applications, as space permits. Boiler plant layouts should incorporate sufficient space for normal maintenance and operation.

Sequence of Operation:

In a multiple-boiler plant consisting of 2 to 8 boilers, utilizing the on-board BMS is recommended. The Multiple boiler plant consisting of 8-32 boilers, an ACS is recommended. The BMS/ACS have an Internal Plant Start adjustment that can be set for a 32°F to 100°F outdoor air temperature range. When the boiler plant is activated, the system pump should be started simultaneously. This can be controlled from the building automation system (BAS) or from the BMS/ACS via the system start relay (see Diagram 5). A flow switch or other method should be interlocked with the BAS to prevent the boilers from firing in the no-flow state. When activated, the BMS/ACS will stage on the first boiler and increase the boiler input to increase header temperature. The first boiler will increase input, as required, until a percentage of input that is twice the boiler start level percentage (user programmed in the BMS/ACS) is reached.

At that point, the BMS/ACS will start a second boiler and run both at their start level percentage. The two boilers will continue to increase their energy input, as required by the BMS/ACS. When the two firing boilers reach a combined percentage input that is three times the boiler start percentage, the BMS/ACS will start a third boiler and run all three at their start level percentage to minimize temperature fluctuation. As the load increases as described above, the BMS/ACS will stage the fourth boiler on at the start level percentage transfer setpoint and bring input on all boilers up as needed. Boiler inputs will modulate down in response to the BMS/ACS in a reverse manner. Each boiler will come off line at the boiler stop level percentage transfer setpoint to maximize condensing. Whether the BMS/ACS is set in a constant temperature or modulating temperature mode, it will use its modulating ability to prevent header temperature fluctuation and maximize efficiency. Also, the BMS/ACS can enable auxiliary equipment, such as system pumps and fans. Refer to the on-board BMS or ACS Product Specification for details.

**On-Board Boiler Management Sequencer (BMS) available December 2013*

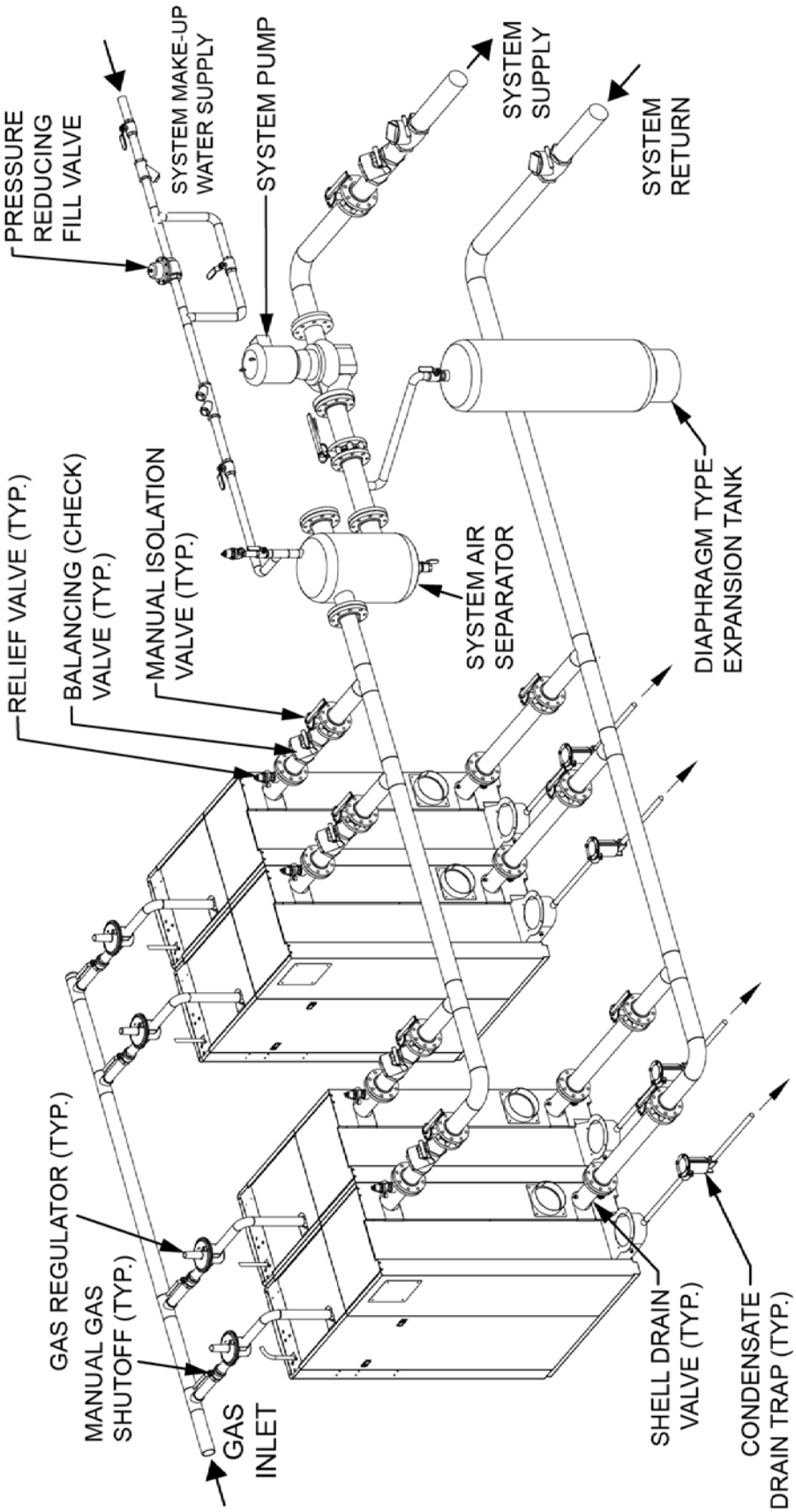


Diagram 4: Multiple Boiler Piping Schematic (BMK 1500/2000 units shown)

5.3 Multiple Boiler Heating Plant — with Individual Isolation Valves

Systems designed with variable speed pumps (VFD) enable plants to use less pump energy during low heating load conditions. For these types of systems, the following must be observed.

1. When idle boilers are isolated from the system during low load conditions, the VFD system must operate within the recommended minimum flow requirement of the operating boilers. As an example, consider a system with four BMK6000 boilers: when two boilers are idle and isolated from the system during low-load conditions, the flow rate to the two operating boilers must be at least 75 gpm x 2 = 150 gpm.
2. When an operating boiler is satisfied and becomes idle, operators should allow a minimum of 2 minutes before isolating it from the system flow. This ensures that heat is dissipated from the heat exchanger and prevents nuisance over-temperature conditions.

Sequence of Operation:

An AERCO boiler can be used to manage the isolation of idle boilers from the system flow. The boiler is wired to the isolation valves and to the boiler auxiliary relays. During demand, the auxiliary relay signals the panel to open the corresponding isolation valve. Isolation valves MUST have proof-of-open switch. The switch shall be interlocked to the boiler (Delayed Interlock) to prevent the unit from firing until the valve is fully open.

After the boiler load is satisfied, the isolation valve opens for a programmed interval (default = 2 minutes) before closing. When the system load is satisfied, the panel will open the isolation valves for all of the boilers.

Diagram 5 illustrates a typical wiring of isolation valves to the boiler. Diagram 6 illustrates a three-boiler plant with individual motorized isolation valves.

5.4 Primary-Secondary Pumping

The typical piping layouts discussed in the previous paragraphs cover most BMK applications. Ordinarily, primary-secondary pumping is not required for proper operation of BMK boiler systems. However, if the system is designed with primary-secondary pumping, Diagram 7 provides a guideline for near-boiler piping to ensure correct boiler flow rate. A water source heat pump is an example of an application in which primary-secondary pumping may be used.

If an ACS is used in a primary-secondary application (see Diagram 7), then:

1. A header sensor must be installed at A.
2. The header sensor must be installed between 2 to 10 feet from the pipe junction (B).
3. If desired, individual boiler pumps may be enabled through the optional BENCHMARK boiler pump relay (see Diagram 3).

Sequence of Operation:

In water source heat pump systems, the boilers supplement the loop to maintain a constant water temperature. The 60°F to 90°F temperature range is too low for conventional fossil fuel boilers because condensation will form in the firesides causing corrosion. AERCO BMK units are built with a 439 stainless steel heat exchanger to withstand condensation. BMK boilers excel in this type of application because the low return water temperature maximizes their condensing capability.

Normally, the boiler plant is activated from the Main Heat Pump Control/Sequence Panel when the system requires auxiliary heat. Once activated, the boilers will modulate independently to maintain the loop temperature. If an ACS panel is used, the Main Controls will activate the ACS, which in turn modulates the boilers to maintain the loop temperature. Extremely close tolerances to the temperature setpoint will be maintained.

5.5 Three Boiler Combination Heating and Domestic Water System

A combination heating and domestic hot water plant can be specified to share the loads among common boilers. Some benefits of combining heating and domestic load into a single plant include first-cost control, simplified venting, and simplified operation.

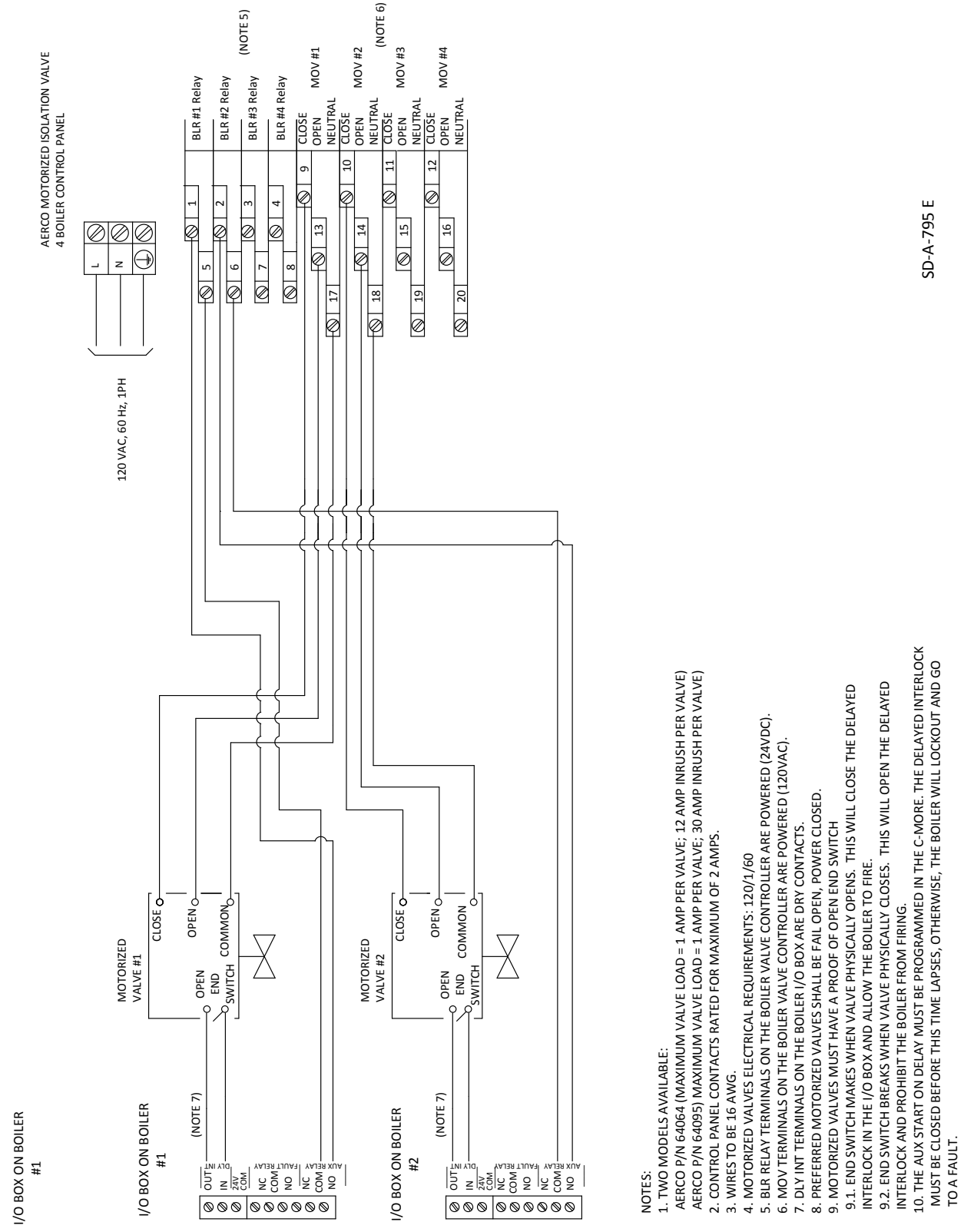
The heating load should be developed from ASHRAE or industry standard methods, and the domestic water load should be sized using conventional sizing criteria.

The domestic water can be generated in an external hot water storage generator (a storage tank with a water-to-water exchanger), or through an instantaneous or semi-instantaneous system. When using a hot water storage generator design for a replacement system, the size of the storage tank is fixed and sufficient recovery must be provided. For a new application, tank storage should be sized with sufficient capacity to prevent the boiler(s) from short-cycling under low loads.

When using instantaneous or semi-instantaneous systems, thermal mass must be added to the boiler water loop as a buffer to dampen out fast transitions and minimize boiler cycling. These conditions can occur either during zero load or during low load situations in which the only load is generated by recirculation piping losses.

Diagram 8 illustrates proper piping for a buffer tank and AERCO's packaged plate heat exchanger (SmartPlate), piped as a zone with the boilers and the combination heating/domestic hot water system.

Sequence of Operation: The SmartPlate setpoint is set for the desired domestic water temperature. As domestic load occurs, the SmartPlate will open its control valve to permit boiler water to flow through the plate heat exchanger. The ACS Panel will fire the boilers as necessary to deliver the required energy (see the ACS/DHW Application Guide TAG-0050 for details). The pump between the SmartPlate and the buffer tank will constantly circulate boiler water, by-passing the plate heat exchanger when the domestic load is satisfied.



4 – BOILER /120V MODEL SHOWN ABOVE. SEE BOILER VALVE CONTROLLER O & M GF-126 FOR OTHER MODELS

Diagram 5: Multiple BMK 2000 Boilers and Motorized Control Valves

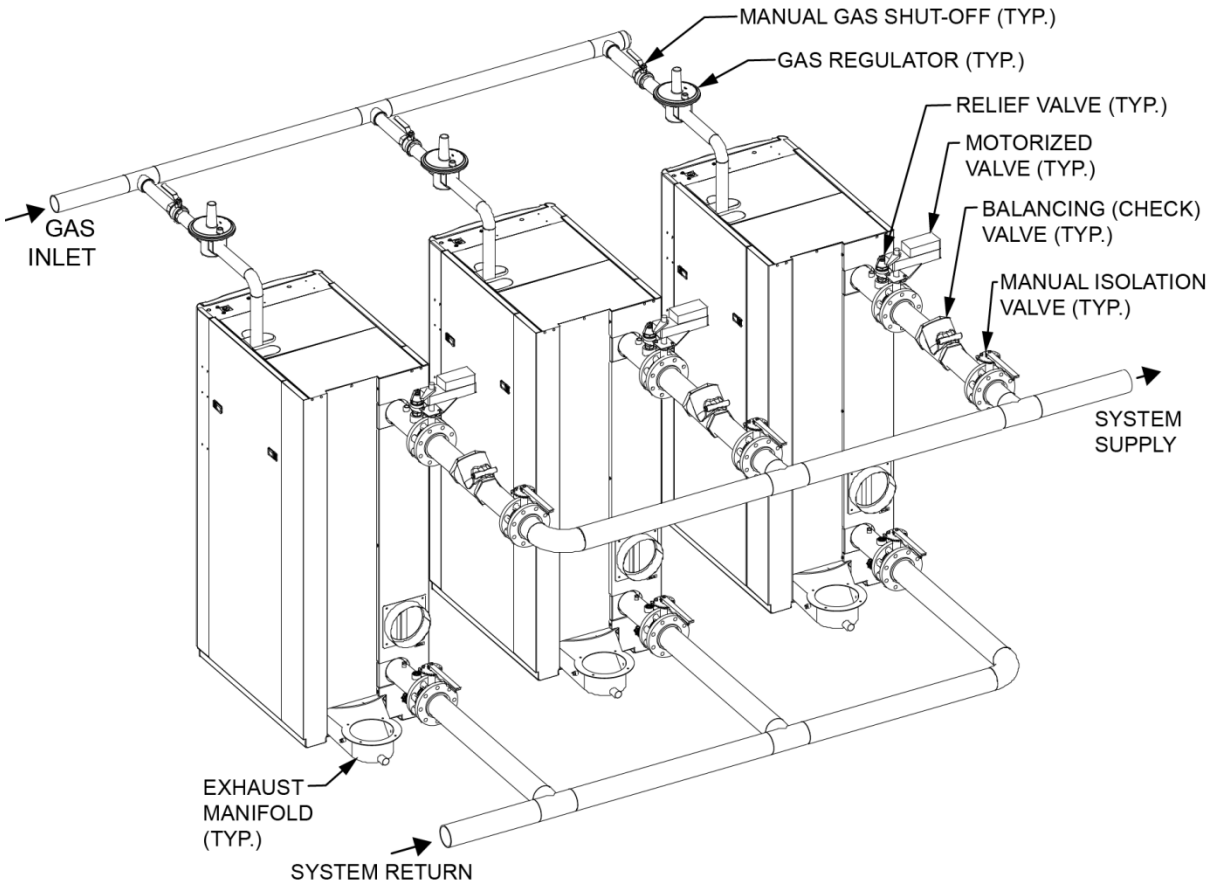
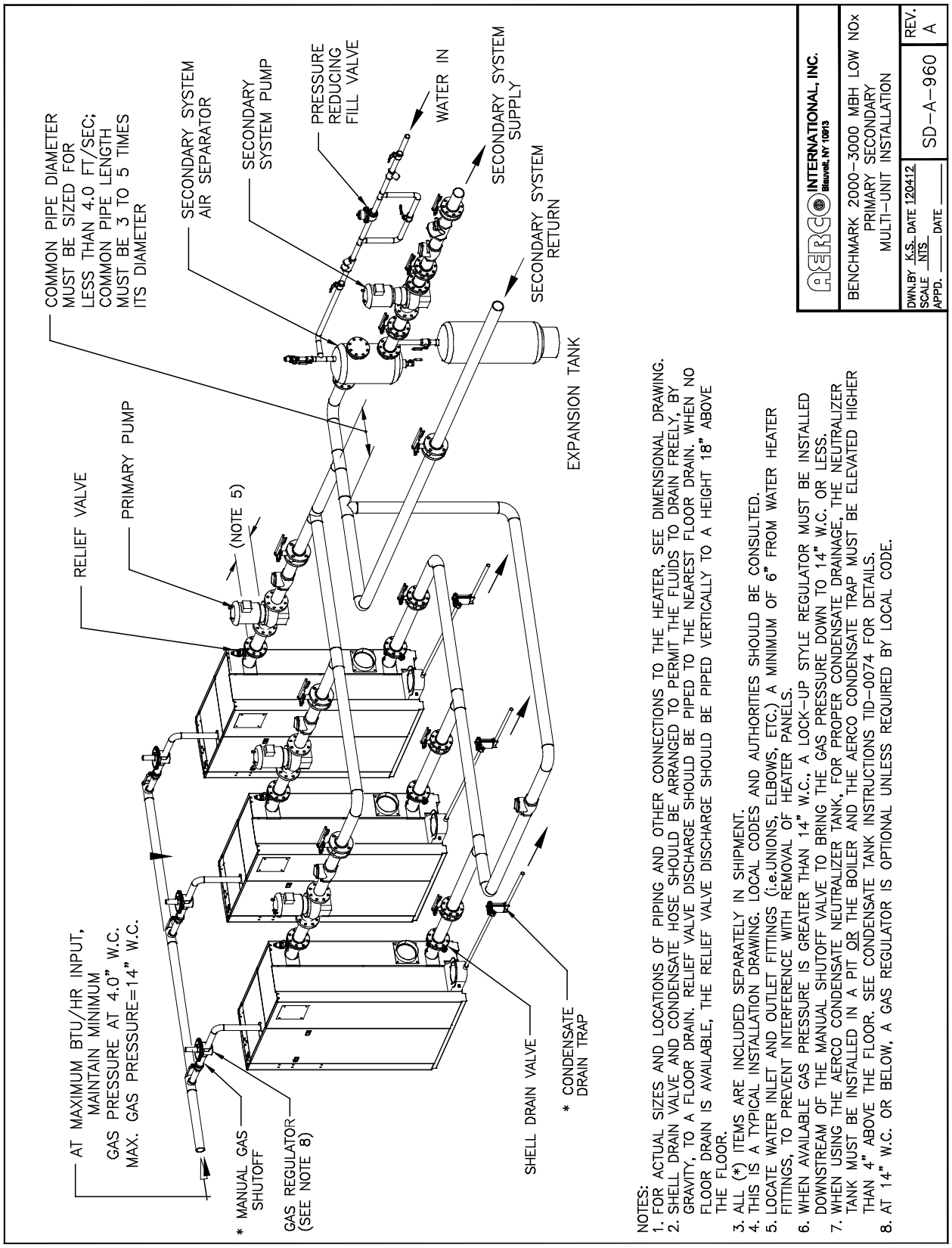


Diagram 6: Multiple Boiler Piping Schematic with Motorized Valves (BMK 1500/2000 units shown)



NOTES:
1. FOR ACTUAL SIZES AND LOCATIONS OF PIPING AND OTHER CONNECTIONS TO THE HEATER, SEE DIMENSIONAL DRAWING.
2. SHELL DRAIN VALVE AND CONDENSATE HOSE SHOULD BE ARRANGED TO PERMIT THE FLUIDS TO DRAIN FREELY, BY GRAVITY, TO A FLOOR DRAIN. RELIEF VALVE DISCHARGE SHOULD BE PIPED TO THE NEAREST FLOOR DRAIN. WHEN NO FLOOR DRAIN IS AVAILABLE, THE RELIEF VALVE DISCHARGE SHOULD BE PIPED VERTICALLY TO A HEIGHT 18" ABOVE THE FLOOR.
3. ALL (*) ITEMS ARE INCLUDED SEPARATELY IN SHIPMENT.
4. THIS IS A TYPICAL INSTALLATION DRAWING. LOCAL CODES AND AUTHORITIES SHOULD BE CONSULTED.
5. LOCATE WATER INLET AND OUTLET FITTINGS (i.e.UNIONS, ELBOWS, ETC.) A MINIMUM OF 6" FROM WATER HEATER FITTINGS, TO PREVENT INTERFERENCE WITH REMOVAL OF HEATER PANELS.
6. WHEN AVAILABLE GAS PRESSURE IS GREATER THAN 14" W.C., A LOCK–UP STYLE REGULATOR MUST BE INSTALLED DOWNSTREAM OF THE MANUAL SHUTOFF VALVE TO BRING THE GAS PRESSURE DOWN TO 14" W.C. OR LESS.
7. WHEN USING THE AERCO CONDENSATE NEUTRALIZER TANK, FOR PROPER CONDENSATE DRAINAGE, THE NEUTRALIZER TANK MUST BE INSTALLED IN A PIT OR THE BOILER AND THE AERCO CONDENSATE TRAP MUST BE ELEVATED HIGHER THAN 4" ABOVE THE FLOOR. SEE CONDENSATE TANK INSTRUCTIONS TID–0074 FOR DETAILS.
8. AT 14" W.C. OR BELOW, A GAS REGULATOR IS OPTIONAL UNLESS REQUIRED BY LOCAL CODE.

Diagram 7: Two Module Water Source Heat Pump Piping

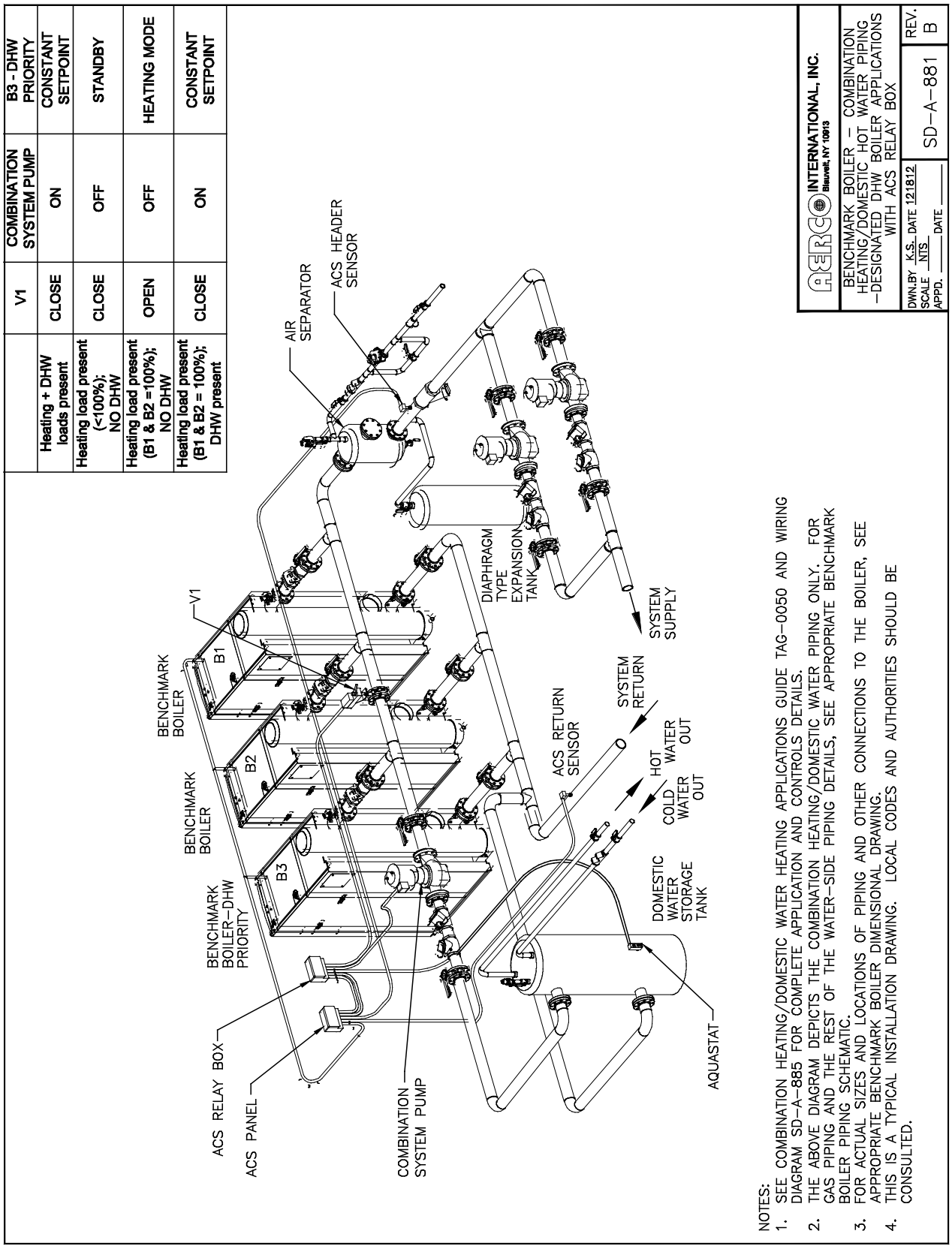


Diagram 8. Three Boiler Combination Heating and Domestic Water System

Change Log

Date	Description	Changed By
09/13/2013	Rev H: Updated for release of new Benchmark models: BMK 1500, BMK 2000, BMK 2500; removed references to BMK 1.5 and BMK 2.0. Added new piping drawings.	Curtis Harvey
10/22/2013	Rev I: in section 3.1 (top of page 6) changed minimum and maximum flow rates for the BMK 1500, 2000, 2500 and 3000.	Chris Blair