Series GM™

Gas Boilers

FLEX-HEAT®
HYDRONIC COMFORT SYSTEM

Design & Application Guide

PeerlessBoilers.com

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1. INTRODUCTION TO FLEX-HEAT® MODULAR BOILER SYSTEMS

The FLEX-HEAT® System consists of a wide array of components designed to provide high energy efficiency, simple installation, and increased comfort from your PB Heat, LLC Series GM™ boilers.

A. MODULAR VS MULTIPLE BOILERS

The FLEX-HEAT® System is designed to be installed as a modular boiler system as defined by ASME[1]:

1. Modules can be no larger than 400 mbh gas input. All Series GM™ boilers meet this requirement.
2. No isolation or stop valves can be placed between modules and the main headers (installation requirement).

Modular boiler systems have the advantage of requiring fewer limit controls than multiple boiler systems. On a multiple boiler system, two limit controls are required on each individual boiler (Figure 1.1). On modular boiler systems, only one limit control is required on each module and one system limit control is required (Figure 1.2).

The FLEX-HEAT® System may be installed as either a modular boiler system or multiple boiler system.

Low Water Cut-off(s) - The Hydrolevel Hydrostat® limit controls used on Series GM™ boilers meet ASME[1] low water cut-off requirements when used in either modular or multiple boiler installations. The Hydrostat® controls meet ASME CSD-1 low water cut-off requirements when set to manual reset.

B. PB HEAT, LLC FLEX-HEAT® SYSTEM

1 Modular systems have higher overall boiler plant efficiency. (Figure 1.3).

a) Higher part load efficiency. Atmospheric gas boilers operate most efficiently at full gas input rate. The FLEX-HEAT® system energizes each module at its full gas input and efficiency and instead controls the system by modulating the number of energized modules.

b) Lower Stand-by losses. Since the FLEX-HEAT® system energizes only the number of modules needed to meet the heat loss, less heat is dissipated to the boiler room and less heat escapes up the chimney. Primary-Secondary inatallations further reduce stand-by losses by preventing heated water from flowing through idle modules.

2. Modular systems are redundant. If a single boiler installation goes down, it's a no heat situation. On a modular boiler system, if a single boiler shuts down, the remaining modules will provide heat until the problem boiler can be corrected.

3. Modular systems can be faster to maintain. Disassembling and reassembling a large boiler to replace a section can take a large amount of time. Since the FLEX-HEAT® modules are pre-packaged and fit through a standard doorway, much less time is required to replace a module.

[1] ANSI/ASME Boiler and Pressure Vessel Code, Section IV: Rules for Construction of Heating Boilers

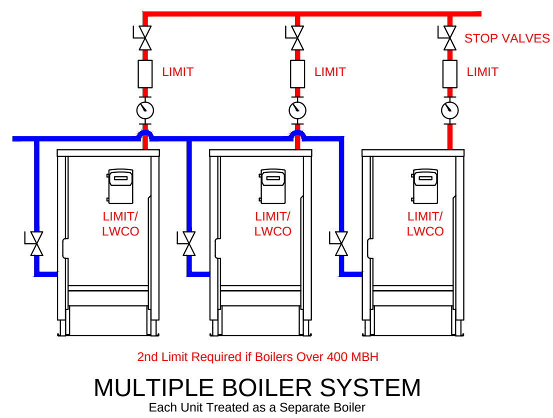


Figure 1.1: Multiple Boiler System

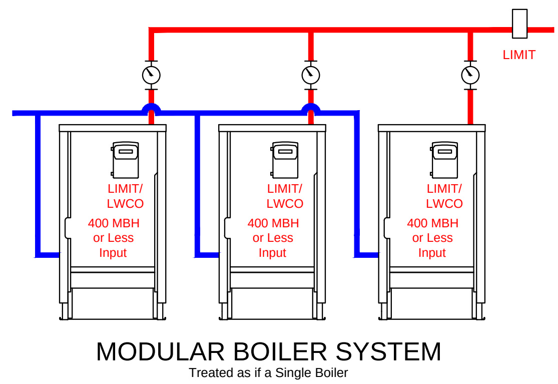


Figure 1.2: Modular Boiler System

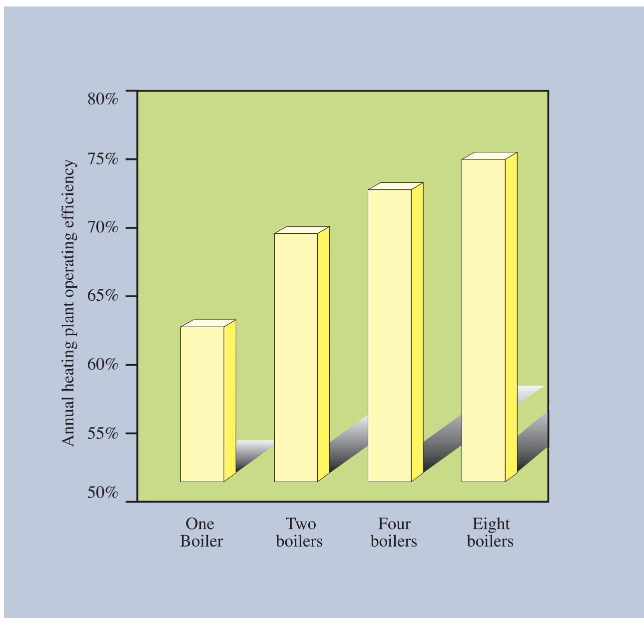


Figure 1.3: Boiler Plant Operating Efficiency

2. FLEX-HEAT® SYSTEM COMPONENTS AND RATINGS

A. SERIES GM™ GAS BOILERS

1. The Series GM™ is available in four sizes suitable for modular boiler (or multiple boiler) installations – 214.5 MBH, 268 MBH, 342 MBH, and 399 MBH input (Figures 2.1 and 2.4).
2. All controls are accessible from the front of the boiler, and the return piping is connected to the front of the block. This allows very close spacing of the modules from side to side.
3. Series GM™ Gas Boilers are atmospheric design, using a vertical draft hood (Figure 2.1).
4. The rugged design of this boiler provides wide waterways and generous heating surface.

B. FLEX-HEAT® SEQUENCERS

1. FLEX-HEAT® sequencers are made by tekmar®, a proven leader in control design for hydronic systems, available in a four stage version with expansion up to a 16 stage version; each standard with outdoor reset (Figure 2.2).

tekmar® is the trade-mark of tekmar® Control Systems Ltd., used under license by PB Heat, LLC

Figure 2.2: FLEX-HEAT® Sequencer, Typical

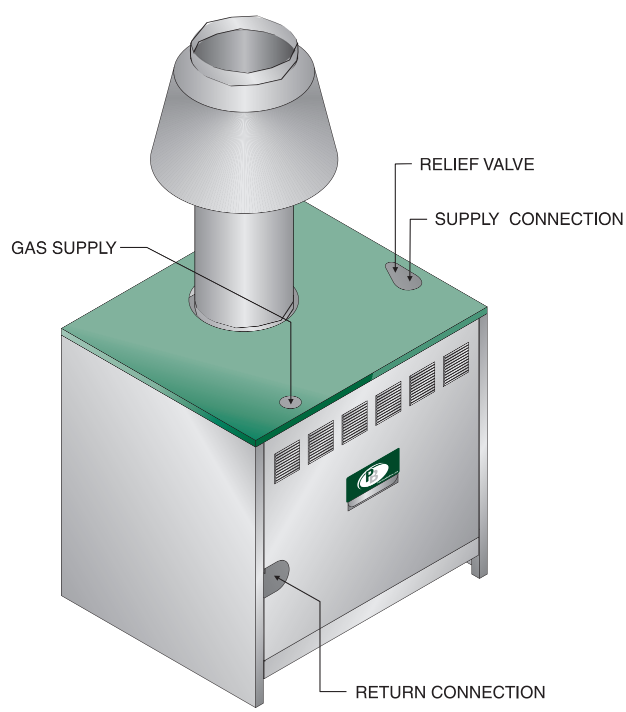


Figure 2.1: Series GM™ Atmospheric Gas Boiler

C. DOMESTIC WATER HEATING

Use FLEX-HEAT® modular boilers with the Peerless® Partner® indirect-fired water heaters for high recovery and energy-efficient service water heating. Partner PP models feature high grade 316L stainless steel construction. Partner PV models feature seamless, long-life thermoplastic construction. See Figure 2.3, 2.5, and 2.6.

D. FLEX-HEAT® MANIFOLDS

1. Optional FLEX-HEAT® manifolds provide an easy to install piping system for parallel piping of modular boilers.
   a) The FLEX-HEAT® system uses self-retaining gaskets and bolt-on clamps sized to adapt to 3 pipe (Figure 5.2).
   b) The kits include the supply and return manifolds (for either 2 or 3 modules) and the clamps and fittings needed to connect from the manifolds to the boiler supply and return connections (Figure 5.2).

E. FLEX-HEAT® SYSTEM RATINGS

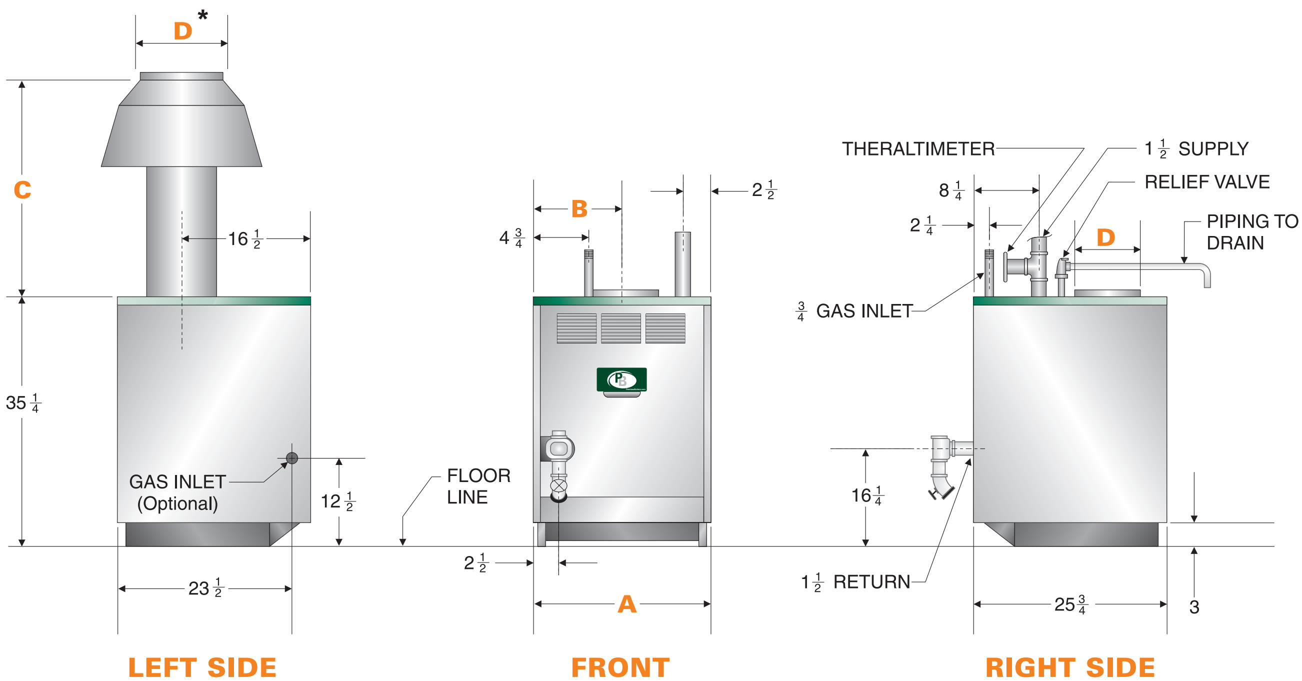
FLEX-HEAT® system sizes and ratings are shown in Table 2.1.

Figure 2.3: Peerless® Partner® Indirect-Fired Water Heaters (Partner PP models shown)

Table 2.1: FLEX-HEAT® System Ratings

TYPICAL FLEX-HEAT® MODULAR BOILER SYSTEMS

System Number	Module Quantity & Size	Input (MBH)	Gross Output (MBH)	Gross Output (H.P.)	Net Output (MBH)
FH-429	(2) 5 section	429	364	10.9	316
FH-482	(1) 5 section, (1) 6 section	482	408	12.2	355
FH-536	(2) 6 section	536	452	13.5	394
FH-610	(1) 6 section, (1) 7 section	610	501	15.0	436
FH-684	(2) 7 section	684	550	16.4	478
FH-741	(1) 7 section, (1) 8 section	741	595	17.8	517
FH-798	(2) 8 section	798	640	19.1	556
FH-804	(3) 6 section	804	678	20.3	591
FH-878	(2) 6 section, (1) 7 section	878	727	21.7	633
FH-952	(1) 6 section, (2) 7 section	952	776	23.2	675
FH-1026	(3) 7 section	1026	825	24.6	717
FH-1140	(1) 7 section, (2) 8 section	1140	915	27.3	795
FH-1197	(3) 8 section	1197	960	28.7	834
FH-1220	(2) 6 section, (2) 7 section	1220	1002	29.9	872
FH-1368	(4) 7 section	1368	1100	32.9	956
FH-1482	(2) 7 section, (2) 8 section	1482	1190	35.6	1034
FH-1539	(1) 7 section, (3) 8 section	1539	1235	36.9	1073
FH-1596	(4) 8 section	1596	1280	38.2	1112
FH-1710	(5) 7 section	1710	1375	41.1	1195
FH-1824	(3) 7 section, (2) 8 section	1824	1465	43.8	1273
FH-1881	(2) 7 section, (3) 8 section	1881	1510	45.1	1312
FH-1938	(1) 7 section, (4) 8 section	1938	1555	46.5	1351
FH-1995	(5) 8 section	1995	1600	47.8	1390
FH-2052	(6) 7 section	2052	1650	49.3	1434
FH-2166	(4) 7 section, (2) 8 section	2166	1740	52.0	1512
FH-2280	(2) 7 section, (4) 8 section	2280	1830	54.7	1590
FH-2394	(6) 8 section	2394	1920	57.4	1668
FH-2508	(5) 7 section, (2) 8 section	2508	2015	60.2	1751
FH-2622	(3) 7 section, (4) 8 section	2622	2105	62.9	1829
FH-2736	(1) 7 section, (6) 8 section	2736	2195	65.6	1907
FH-2793	(8) 7 section	2793	2240	66.9	1946
FH-2850	(6) 7 section, (2) 8 section	2850	2290	68.4	1990
FH-2964	(4) 7 section, (4) 8 section	2964	2380	71.1	2068
FH-3021	(3) 7 section, (5) 8 section	3021	2425	72.4	2107
FH-3078	(2) 7 section, (6) 8 section	3078	2470	73.8	2146
FH-3192	(8) 8 section	3192	2560	76.5	2224
FH-3306	(5) 7 section, (4) 8 section	3306	2655	79.3	2307
FH-3363	(4) 7 section, (5) 8 section	3363	2700	80.7	2346
FH-3420	(3) 7 section, (6) 8 section	3420	2745	82.0	2385
FH-3534	(1) 7 section, (8) 8 section	3534	2835	84.7	2463
FH-3591	(9) 8 section	3591	2880	86.0	2502
FH-3648	(6) 7 section, (4) 8 section	3648	2930	87.5	2546
FH-3762	(4) 7 section, (6) 8 section	3762	3020	90.2	2624
FH-3876	(2) 7 section, (8) 8 section	3876	3110	92.9	2702
FH-3990	(10) 8 section	3990	3200	95.6	2780



SERIES GM™ BOILER DIMENSIONS					
Boiler Model Number	Width "A"	Distance From Left "B"	Height Less Vent Damper "C"	Height With Vent Damper "C"	Outlet Diameter "D" *
GM-e-05	19-1/4"	9-3/4"	29"	35-7/8"	7" *
GM-e-06	22-3/4"	11-1/2"	30"	38-7/8"	8" *
GM-07	26-1/4"	13-1/4"	31"	41-7/8"	10"
GM-08	29-3/4"	15"	31"	41-7/8"	10"

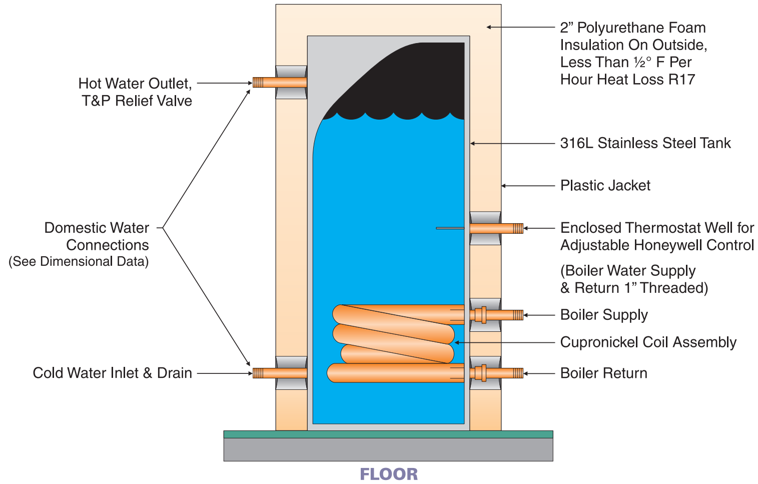
* Vent Diameter is determined by outlet diameter of vent reducer (provided) installed on outlet of vent damper.
8" to 7" reducer on GM-e-05, 9" to 8" reducer on GM-e-06.

SERIES GM™ RATINGS — AHRI CERTIFIED® www.ahridirectory.org

Boiler Model Number	Input, MBH	Output[1,2] MBH	Net Ratings Water[3,4] MBH	Intermittent Ignition AFUE[1], %	Water Content (Gallons)
GM-e-05	214.5	182	158	84.2	6.15
GM-e-06	268	226	197	84.0	7.2
GM-07	342	275	239	—	8.25
GM-08	399	320	278	—	9.3

(1) Output is Heating Capacity for models with inputs <300 MBH and Gross Output for models with inputs ≥ 300 MBH.
Heating Capacity and Annual Fuel Utilization Efficiency (AFUE) ratings are based on U.S. Government test.
(2) Gross Output Rating determined in accordance with AHRI requirements.
(3) Net water ratings based on an allowance of 1.15.
(4) Consult factory before selecting a boiler for installations having unusual piping and pickup requirements, such as intermittent system operation, extensive piping systems, etc.

Figure 2.4: Series GM™ Dimensions and Ratings



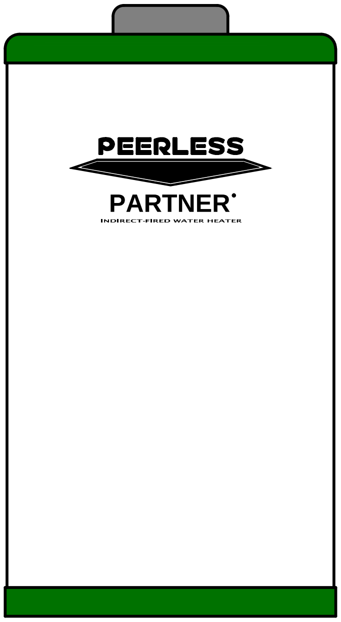
PEERLESS® PARTNER® PP DIMENSIONS									
Model Number	Dimensions						Pressures (psig)		Tank Capacity (U.S. Gallons)
	Diameter	Height	Floor to "Boiler In'	Floor to "Boiler Out'	Floor to "Cold-Drain'	Floor to "Hot-T&P'	Test	Working	
PP-30-LB	23-1/4"	28-1/2"	9-3/4"	5-1/4"	5-1/4"	22"	300	150	30
PP-40	19-1/4"	52-1/2"	9-3/4"	5-1/4"	5-1/4"	46"	300	150	45
PP-60	23-1/4"	52-1/2"	9-3/4"	5-1/4"	5-1/4"	46"	300	150	60
PP-80	23-1/4"	72"	29"	6"	6"	64"	300	150	80
PP-120	27"	73-1/2"	30-1/4"	7-1/4"	7-1/4"	66"	300	150	119

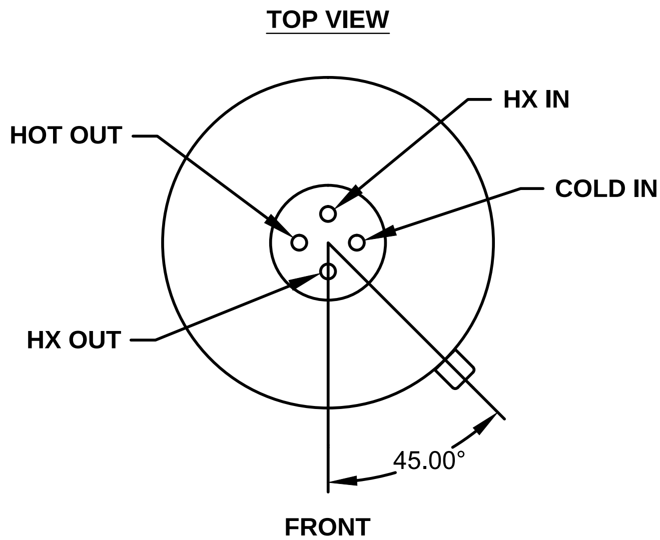
PEERLESS® PARTNER® PP RATINGS AND FLOW SPECIFICATIONS							
Model Number	Peerless® Partner® Ratings				Peerless® Partner® Flow Specifications		
	First Hour Rating[1] (Gallons)		Minimum Boiler Output[2] to Achieve First Hour Rating (Btu per hour)	Heat Exchanger Surface Area (ft^2)	Recommended Flow Rate	Heat Exchanger Pressure Drop	Domestic Water Connection Sizes
	140°F	115°F					
PP-30-LB	169	234	114,000	15	8 gpm	6.0 ft.	3/4 NPT
PP-40	212	292	141,000	20	10 gpm	7.9 ft.	3/4 NPT
PP-60	266	370	174,000	20	10 gpm	7.9 ft.	1 NPT
PP-80	330	440	212,000	34	12 gpm	9.1 ft.	1-1/2 NPT
PP-120	423	564	269,000	34	14 gpm	11.3 ft.	1-1/2 NPT

(1) First hour rating based on heating water frim 50°F to 140/115°F with 180°F boiler water temperature. Gas- and Oil-fired and electric water heater first hour ratings based on DOE test procedure using 90°F temperature rise (55°F to 145°F).
(2) Net I=B=R Output, Water.

Figure 2.5: Peerless® Partner® PP Dimensions and Ratings

PEERLESS® PARTNER® PV DIMENSIONS AND RATINGS





PEERLESS® PARTNER® PV TANK DIMENSIONS				
Water Heater Model Number	Domestic Water Connection Sizes, NPT	Boiler Connection Sizes, NPT	Height (to connections), Inch	Tank Diameter, Inch
PV-40	3/4”	3/4”	40.5”	22.75”
PV-60	3/4”	3/4”	41”	28”
PV-80	1-1/2”	1”	53.5”	28”
PV-120	1-1/2”	1”	74”	28”

PEERLESS® PARTNER® PV RATINGS							
Water Heater Model Number	Potable Water Volume, gallons	Standby Loss, °F/h	Continuous Draw, gal/h	First Hour Rating, gal/h	Min Heat Source output, MBH	Min Heat Source Flow, gpm	Heat Source Friction Loss, Feet w.c.
PV-40	30.0	0.8	177	199	115000	8.0	18.7
PV-60	55.0	0.6	177	217	115000	8.0	18.7
PV-80	80.0	0.4	315	381	199000	14.0	16.0
PV-120	119.0	0.4	381	477	244000	14.0	20.0

These ratings were obtained with a heat source output and heat source flow rate as listed in the chart using the parameters of the Domestic Cold Water inlet at 58°F , Domestic Temperature Rise of 77°F and Boiler Temperature Output of 180°F. Other results will be obtained under differencet conditions.

Figure 2.6: Peerless® Partner® PV Dimensions and Ratings

3. MECHANICAL ROOM LAYOUT

A. CODE COMPLIANCE

1. The suggestions in this Guide are based primarily on the National Fuel Gas Code, ANSI Z223.1 and ASHRAE recommendations for piping, etc.
2. The guidelines for installation and control of the equipment are consistent with the ASME Code Section IV. Where ASME CSD-1 compliance is required, be sure to utilize manual reset limits and low water cut-offs as required.
3. Make sure that the final design and execution of the modular boiler installation complies with all applicable local codes and jurisdictions.

B. GUIDELINES

1. Air Openings: Provide air openings for combustion and ventilation as required by ANSI Z223.1 and local requirements (Figures 3.1, 3.6 and 3.7).

   a) <u>Required Combustion Air Volume:</u> The total required volume of indoor air is to be the sum of the required volumes for all appliances located within the space. Rooms communicating directly with the space in which the appliances are installed and through combustion air openings sized as indicated in this section are considered part of the required volume. The required volume of indoor air is to be determined by one of two methods.

      1. ***Standard Method:*** The minimum required volume of indoor air (room volume) shall be 50 cubic feet per 1000 BTU/Hr (4.8 m^3/kW). This method is to be used if the air infiltration rate is unknown or if the rate of air infiltration is known to be greater than 0.6 air changes per hour. As an option, this method may be used if the air infiltration rate is known to be between 0.6 and 0.4 air changes per hour. If the air infiltration rate is known to be below 0.4 then the Known Air Infiltration Rate Method must be used. If the building in which this appliance is to be installed is unusually tight, PB Heat, LLC recommends that the air infiltration rate be determined.
      2. ***Known Air Infiltration Rate Method:*** here the air infiltration rate of a structure is known, the minimum required volume of indoor air for appliances other than fan assisted and for the Series GM™ Boiler shall be determined as follows:

$$\text{Required Volume}_{other} = \frac{21\ ft^3}{ACH}\left(\frac{I_{other}}{1000\ {}^{Btu}/_{hr}}\right)$$

where:

I_{other} = Input of appliances other than fan assisted in Btu/hr

ACH = air change per hour (percent of the volume of the space exchanged per hour, expressed as a decimal)

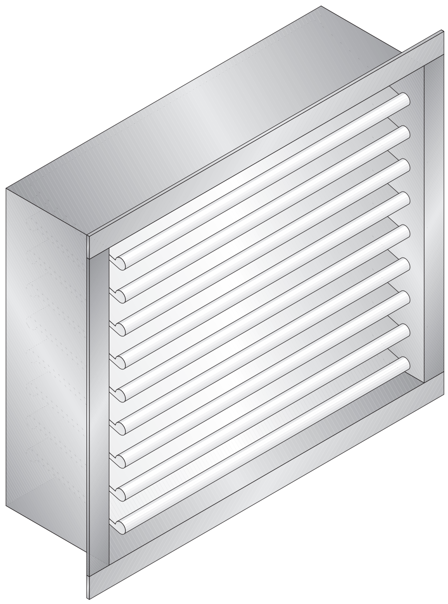


Figure 3.1: Provide Air Openings for Combustion and Ventilation Air

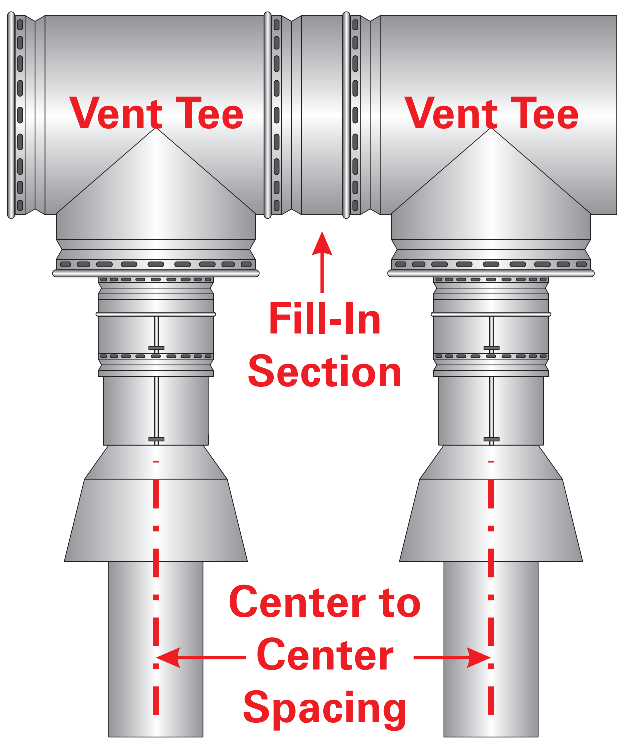


Figure 3.2: Consider Minimum Centers for Vent System when Laying Out Boiler Plan

For fan assisted appliances, calculate the required volume of air using the following equation:

$$\text{Required Volume}_{fan} = \frac{15\ \text{ft}^3}{\text{ACH}} \left(\frac{I_{fan}}{1000\ {}^{\text{Btu}}/_{\text{hr}}} \right)$$

I_{fan} = Input of the fan assisted appliances in Btu/hr

Note: These calculations are not to be used for infiltration rates greater than 0.60 ACH.

b) Combination Indoor and Outdoor Combustion Air: If the required volume of indoor air exceeds the available indoor air volume, outdoor air openings or ducts may be used to supplement the available indoor air provided:

1. The size and location of the indoor openings comply with Figure 3.6.
2. The outdoor openings are to be located in accordance with Figure 3.7.
3. The size of the outdoor openings are to be sized as follows:

$$A_{req} = A_{full} \left(1 - \frac{V_{avail}}{V_{req}} \right)$$

where:
A_{req} = minimum area of outdoor openings.
A_{full} = full size of outdoor openings calculated in accordance with Figure 3.7.
V_{avail} = available indoor air volume
V_{req} = required indoor air volume

2. Boiler Room Pressure: The boiler room must at all times be neutral or slightly positive pressure relative to the outside. Otherwise the vent system will not work and flue gas will spill into the building.
3. Wiring: DO NOT run electrical wiring conduits under the boiler slab area. The temperature will be too high, likely to cause wiring failures.
4. Vent System Spacing
   a) Consider the minimum required spacing between tees for the vent system when laying out the boiler plan (Figure 3.2).
   b) Note that FLEX-HEAT® manifolds position modules on 32" centers. When the modules are vented with a combined vent larger than 20 inch diameter it may not be possible to use FLEX-HEAT® manifolds because the spacing may be too close for B vent (Venting Section Table 4.1).
5. Combustible Flooring: The Series GM™ boiler is NOT suitable for mounting on combustible flooring. If it is necessary to build a non-combustible floor pad over top of an existing combustible floor, construct pad as stated in the National Fuel Gas Code Handbook Part 6, Installation of Specific Equipment.
6. See Figures 3.3 and 3.4 for typical mechanical room lay-out.
7. See Figure 3.5 for clearances to combustible construction and for accessibility.

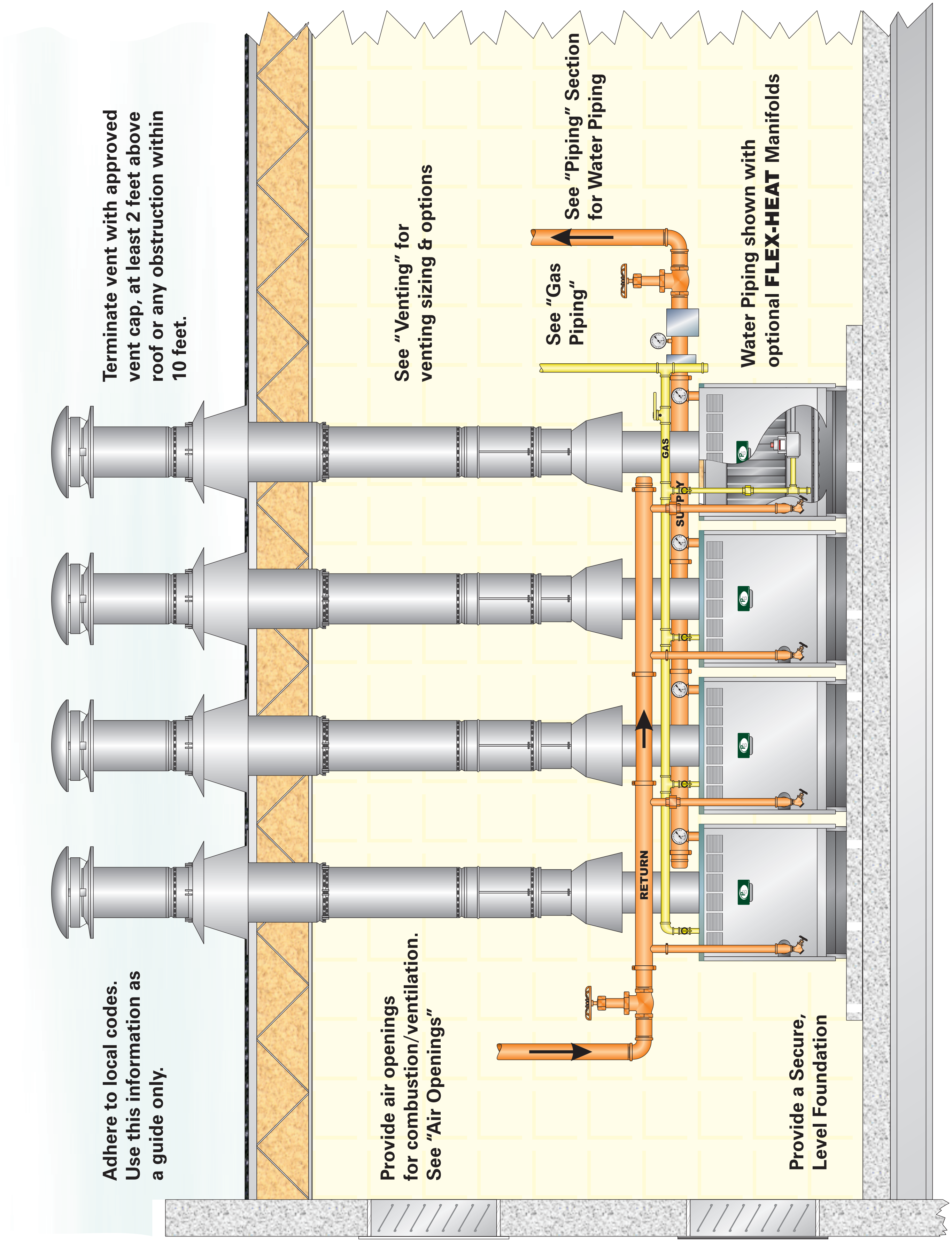


Figure 3.3: Typical Mechanical Room Layout with Four Modules and Individual Venting

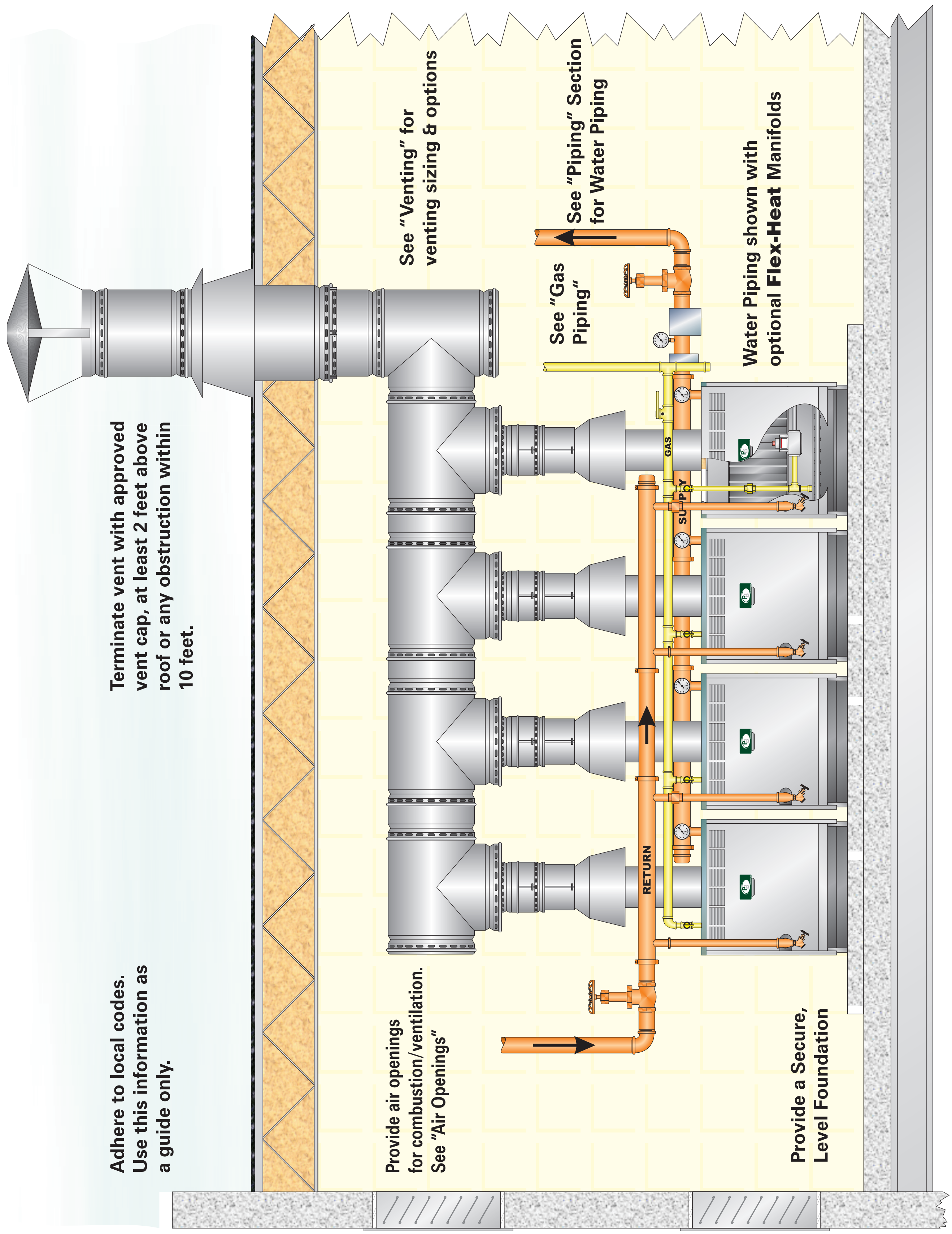


Figure 3.4: Typical Mechanical Room Layout with Four Modules and Manifolded Vent

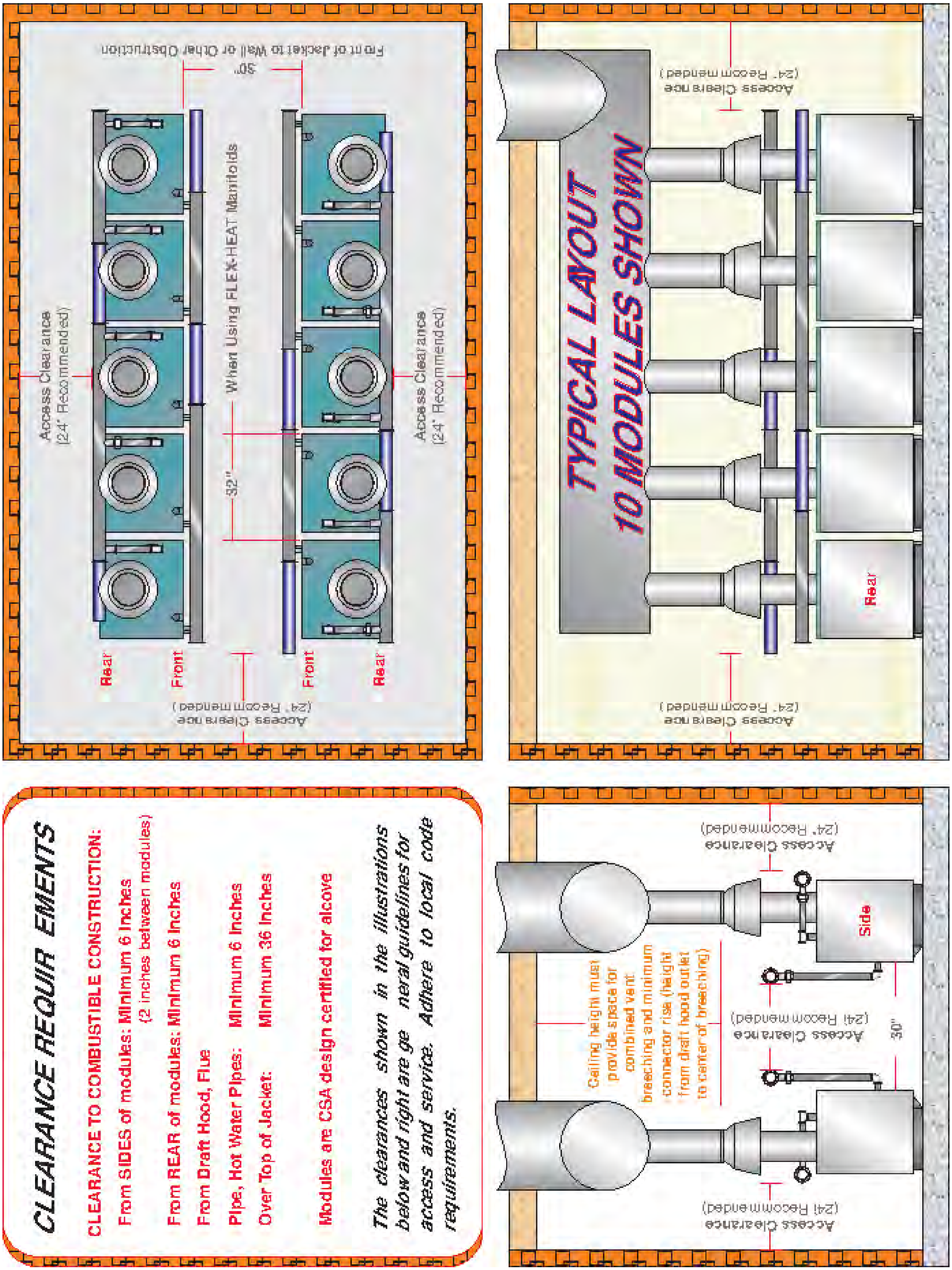


Figure 3.5: Clearances to Combustible Construction and for Accessibility

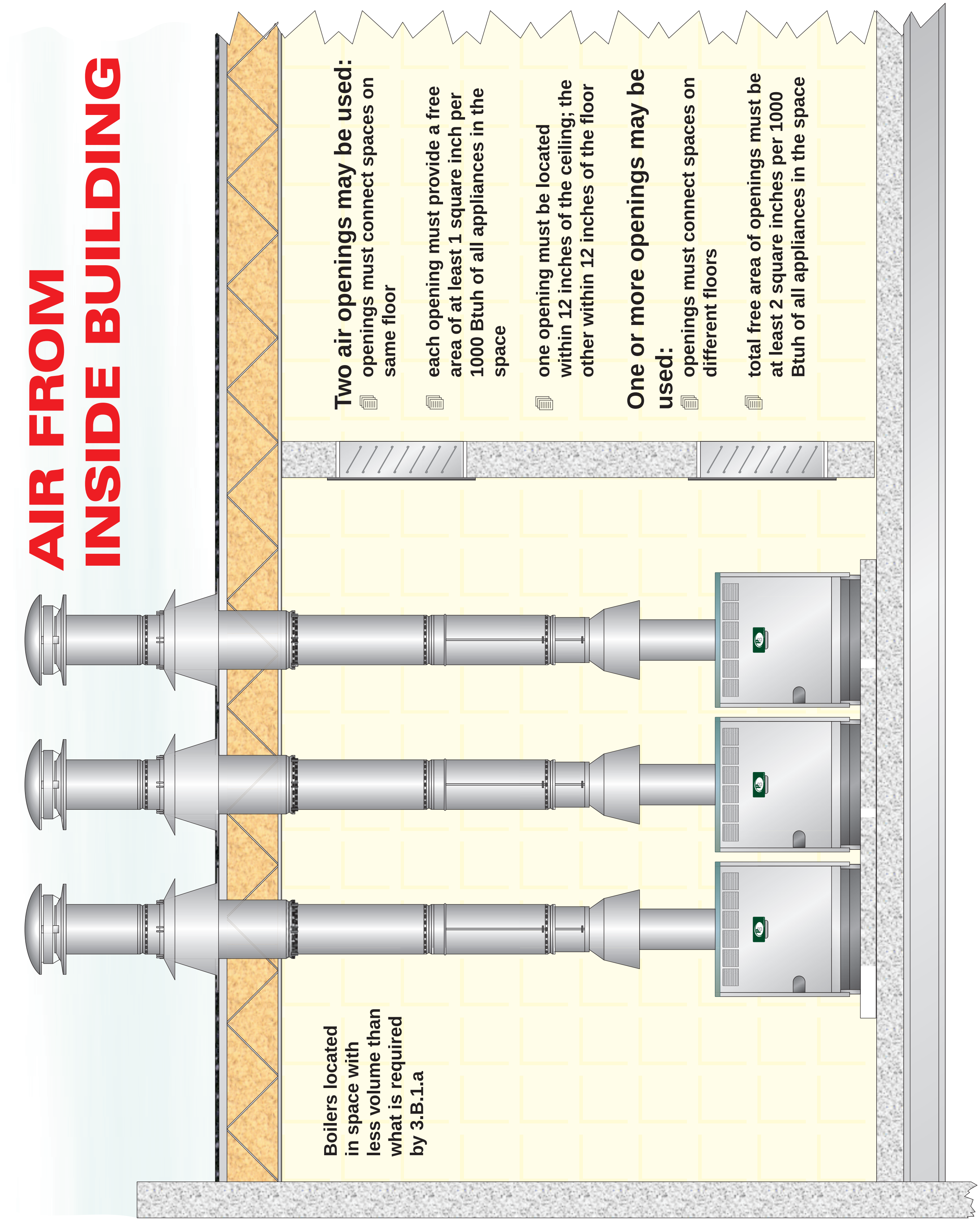


Figure 3.6: **Provide Combustion/Ventilation Air Openings as Required by Codes.**

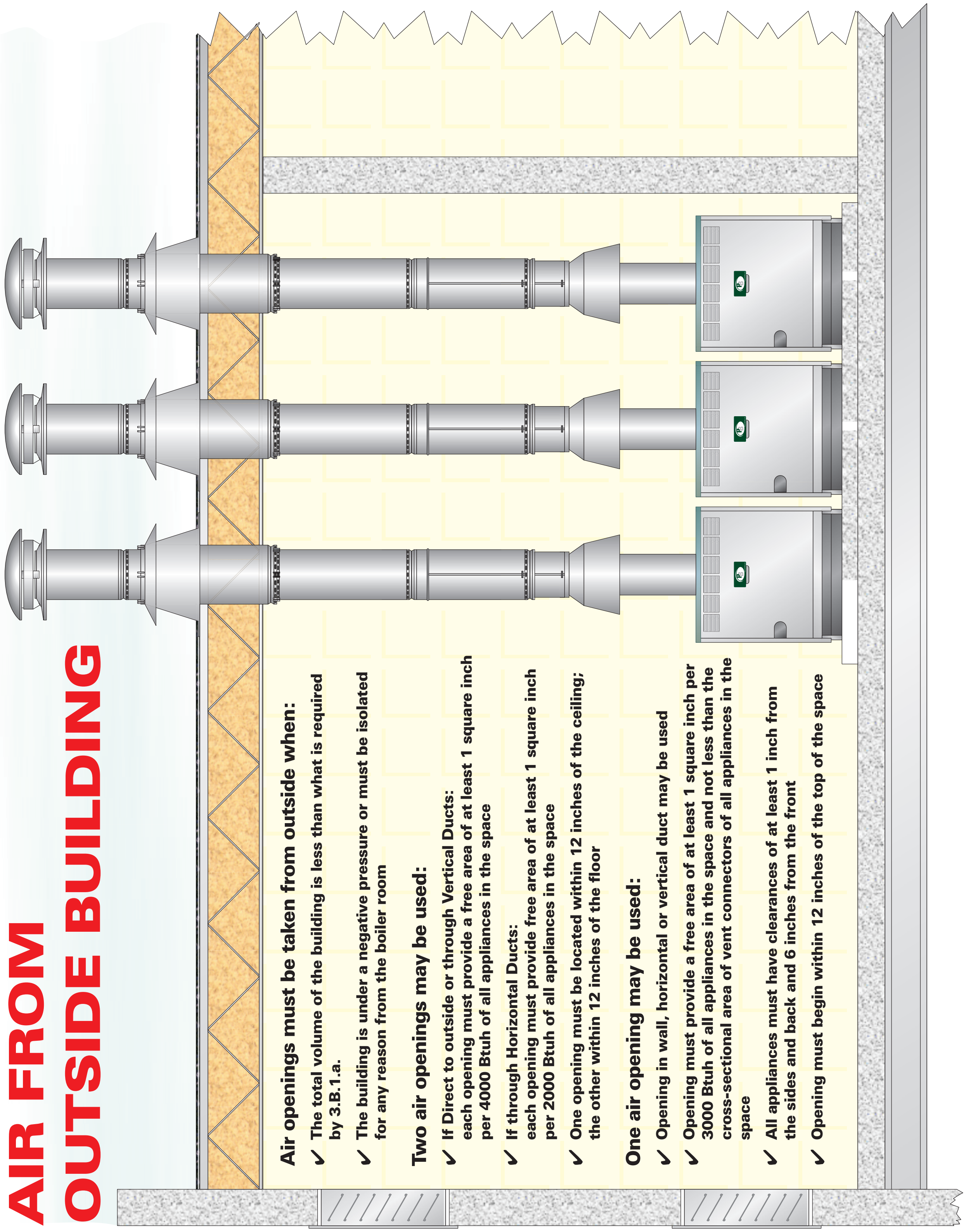


Figure 3.7: **Provide Combustion/Ventilation Air Openings as Required by Codes. Openings Must Connect to Outside if the Total Volume of All Interconnected Indoor Spaces is Less Than What is Required by 3.B.1.a.**

4. VENTING

A. GENERAL

1. Vent construction - National Fuel Gas Code Requirements

   a) The National Fuel Gas Code requirements for venting have changed significantly. National laboratories and research groups have concentrated for some time on problems of condensation and poor draft in over-sized vent systems.

   b) The most noticeable changes are in the restriction on size of the vent versus the size of the smallest connected appliance draft hood. The National Fuel Gas Code, ANSI Z223.1, restricts the vent cross sectional area to no more than 7 times the area of the smallest appliance draft hood outlet connected to the vent (paragraph 13.2.18, “Vertical Vent Size Limitation”).

   c) Exterior masonry chimneys must be lined with a metal chimney liner. Without a lining these chimneys will condense (causing mortar deterioration) and possibly not develop a draft (causing spillage).

   d) Single wall vent is more prone to condensation than B vent, so the new vent tables are more restrictive in the application of single wall vent. The vent sizing information in this Guide is based on type B vent. Consult the factory or apply the National Fuel Gas Code tables where single wall vent is to be used.

   e) The suggestions for venting in this Guide are based on the vent tables and notes in the 2006 edition of the National Fuel Gas Code, ANSI Z223.1. As allowed in the Code, other vent system designs may be specially engineered using accepted engineering practices.

   f) Because of the limitations of single wall vent, this Guide focuses mostly on type B vent applications. For use of single wall vent or masonry construction refer to local codes and/or the National Fuel Gas Code, ANSI Z223.1.

2. Boiler Spacing - Vent Considerations

   a) See Table 4.1 for typical limitations on spacing of adjacent modules when using B vent. This table is based on data taken from one manufacturers vent instructions.

   b) Note that FLEX-HEAT® manifolds are only available for 32-inch centers. When the modules are vented with a combined vent larger than 20 inch diameter it may not be possible to use FLEX-HEAT® manifolds because the spacing would be too close for B vent (if the dimensions of fittings are as shown here).

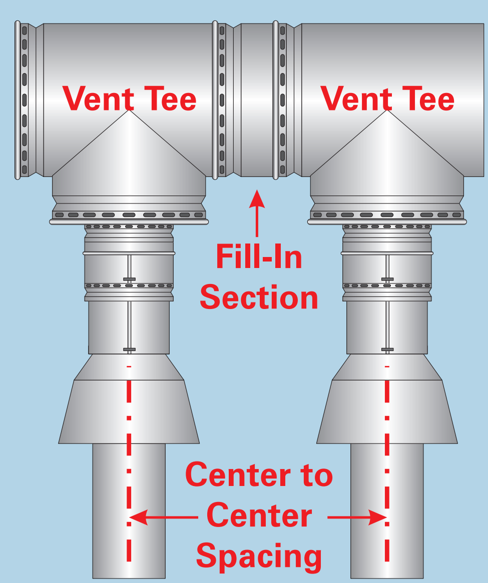
3. Vent Priming - Consider Sequence

   a) We recommend always beginning the sequence with the module(s) closest to the vertical vent. This will assure better priming of the vent system.

   b) If using a sequencer which rotates the sequence, set the module closest to the vent to always come on first and rotate the rest.

Table 4.1: Minimum Module Center to Center Spacing Based on One Manufacturer’s Vent Tee Data

Vent Diameter Inches	Installed Width of Tee Inches	Minimum Width of Fill-In Section Inches	Resulting Minimum Center to Center Spacing Inches
10	16 ¾	4 ¾	21 ½
12	18 ¾	4 ¾	23 ½
14	20 ¾	4 ¾	25 ½
16	22 ¾	4 ¾	27 ½
18	24 ¾	4 ¾	29 ½
20	26 ¾	4 ¾	31 ½
22	28 ¾	4 ¾	33 ½
24	30 ¾	4 ¾	35 ½



B. SIZING GUIDE RESTRICTIONS

1. No other appliances can be connected to the vent when using the sizing information in this Guide.
2. Where the mechanical room does not have enough height for manifolded venting as suggested in this Guide the vent system may need to be custom engineered for application of a draft inducer sized and applied for the application by others.

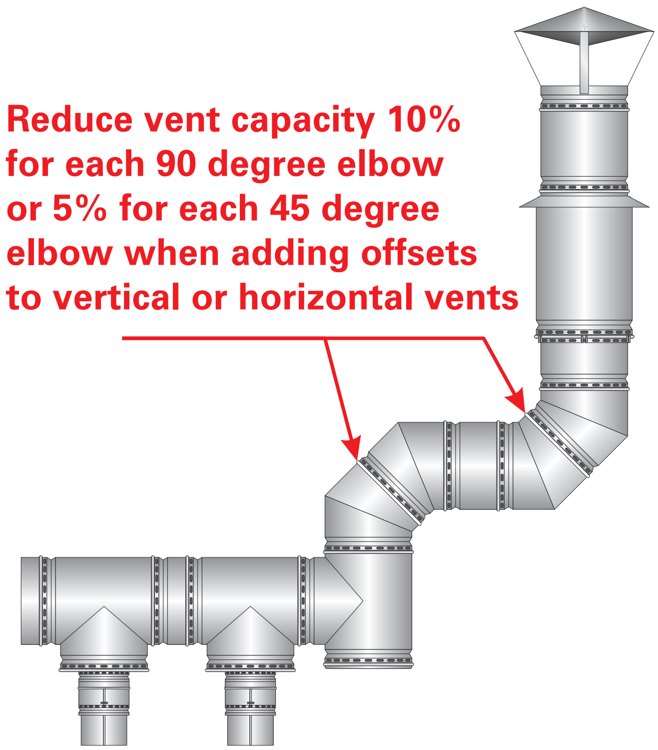


Figure 4.1: Reduce Vent Capacity if Vertical is Offset Rather Than Straight Up

3. The boiler room must be under a neutral or slightly positive pressure – never negative.
   a) The boiler room MUST meet this criteria in order to use atmospheric gas boilers.
   b) If the negative pressure is due to the pressure in the building, isolate the boiler room securely so proper conditions can be maintained.
   c) Do not use exhaust fans in the building or boiler room which could operate while the boilers are in operation unless the application is custom engineered and the air openings are enlarged adequately to eliminate the possibility of negative pressure in the room.
4. The vent sizing information in the manual does not allow for offsets in the vertical vent section. If the vertical vent is offset, reduce the vent capacity by 20% for each set of 90 degree elbows in the offset or 10% for each set of 45 degree elbows in the offset (Figure 4.1).
5. The vent tables in this guide apply to interior chimneys. See National Fuel Gas Code for sizing guidelines when using exterior chimney(s).
6. The National Fuel Gas Code states that the vent tables do not apply when vent dampers are used. When using vent dampers and a tile-lined masonry chimney, close attention must be paid to the potential for condensation. Exterior masonry chimneys must have an approved metal liner when using vent dampers.
7. Corrugated chimney liners:
   a) When using corrugated metal lining in the chimney reduce vent capacity shown in these tables by 20%.
   b) If offset, use an additional reduction of 10% per 90 degree elbow, 5% per 45 degree elbow equivalent.
8. High altitude applications: Use sea level input ratings to determine maximum capacity for high altitude installation. Use actual input (derated for altitude) to determine minimum capacity for high altitude installation. See National Fuel Gas Code for minimum capacity requirements.

C. VENT TERMINATION

1. Always use a vent cap to reduce wind effects and downdrafts (Figure 4.2).

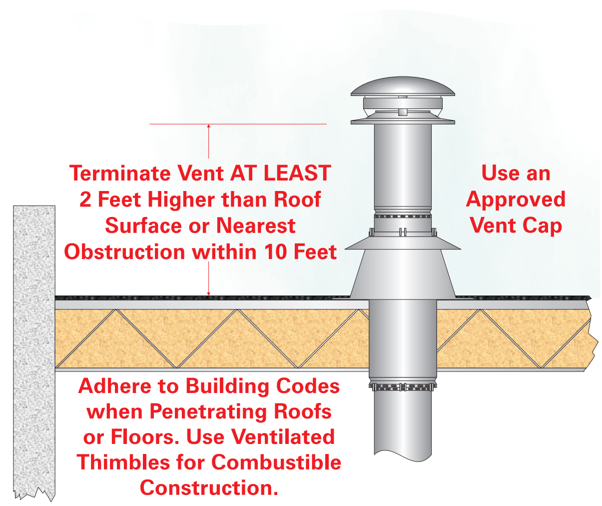


Figure 4.2: Vent Termination

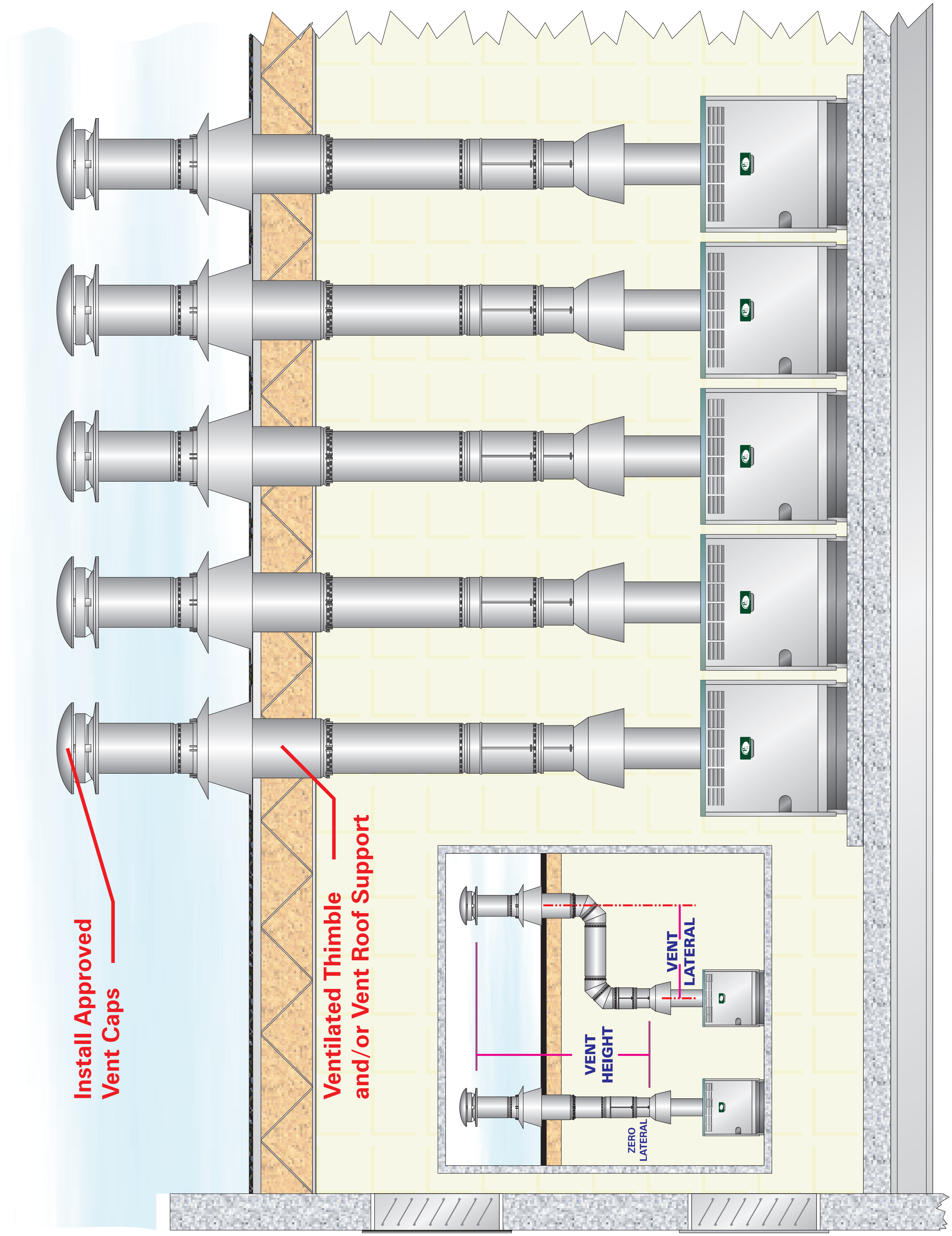


Figure 4.3: Individual Venting – See Table 4.2 for Vent Sizing

Table 4.2: Individual Vent Sizing Using Type B Vent or Single Wall Metal Pipe

VENT SIZING TABLE - GM™ MODULAR Individual Venting									
Vent Height Feet	Vent Lateral Feet	GM-e-05		GM-e-06		GM-07		GM-08	
		Single Wall	Type B	Single Wall	Type B	Single Wall	Type B	Single Wall	Type B
Module Input, MBH		214.5		268		342		399	
Module Vent OD		7 inch		8 inch		10 inch		10 inch	
6	0	7	7	8	8	10	9	10	9
	2	8	8	10	8	10	9	10	10
	5	8	8	10	9	10	9	12	10
8	0	7	7	8	8	10	9	10	9
	2	8	7	10	8	10	9	10	9
	5	8	7	10	8	10	9	10	9
	8	8	8	10	8	10	9	10	10
10	0	7	7	8	8	9	9	10	9
	2	7	7	8	8	10	9	10	9
	5	8	7	8	8	10	9	10	9
	10	8	7	10	8	10	9	10	9
15	0	7	7	8	8	9	9	8	9
	2	7	7	8	8	9	9	10	9
	5	7	7	8	8	10	9	10	9
	10	8	7	8	8	10	9	10	9
	15	8	7	8	8	10	9	10	9
20	0	7	7	8	8	9	9	9	9
	2	7	7	8	8	9	9	10	9
	5	7	7	8	8	9	9	10	9
	10	7	7	8	8	9	9	10	9
	15	7	7	8	8	10	9	10	9
	20	8	7	8	8	10	9	10	9
30	0	7	7	8	8	9	9	9	9
	2	7	7	8	8	9	9	9	9
	5	7	7	8	8	9	9	9	9
	10	7	7	8	8	9	9	10	9
	15	7	7	8	8	9	9	10	9
	20	7	7	8	8	9	9	10	9
	30	8	7	8	8	10	9	10	9

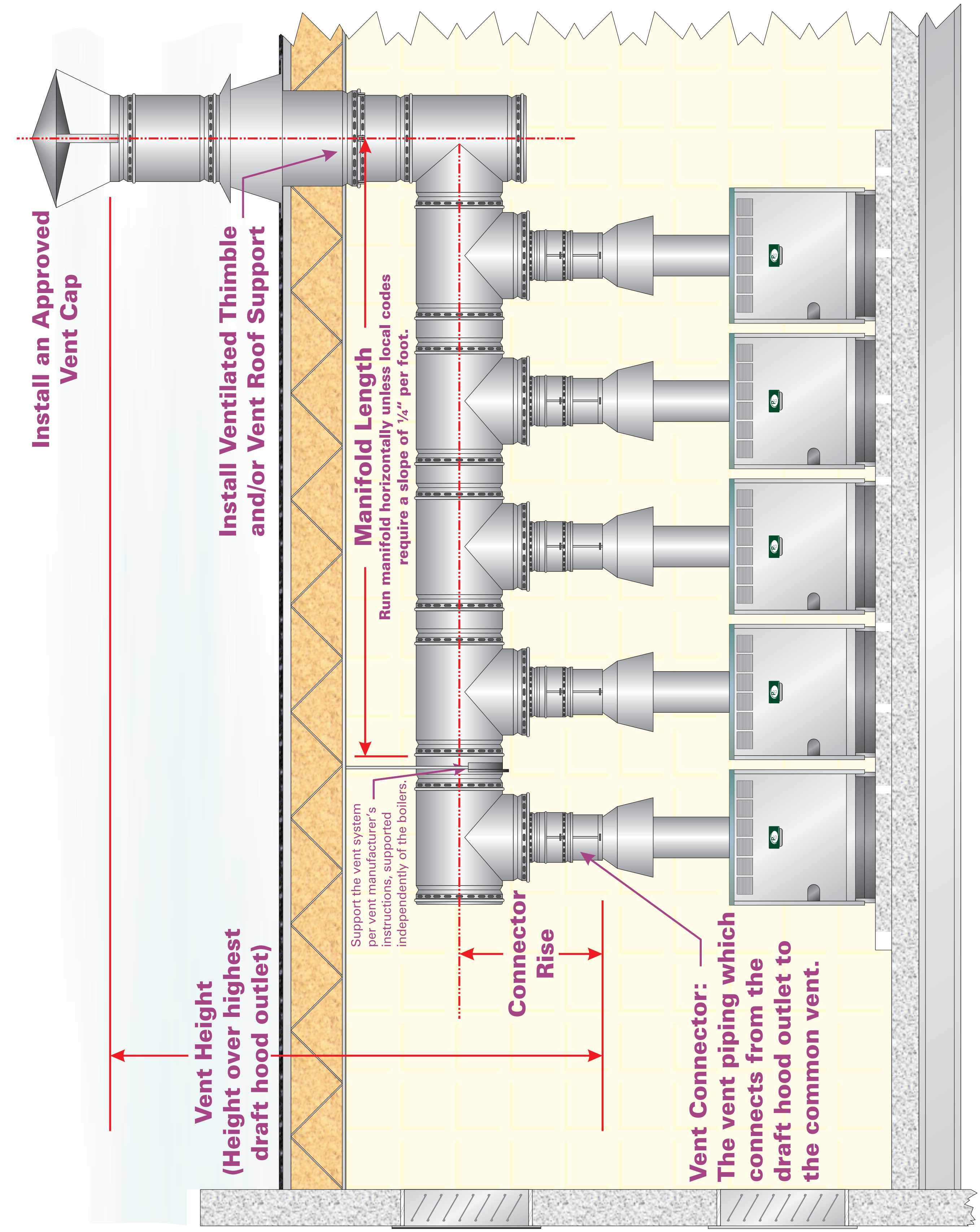


Figure 4.3: Combined Venting, Constant Diameter Manifold – See Sizing Tables 4.3 & 4.4

Table 4.3: Combined Vent Sizing and Connector Requirements for Typical FLEX-HEAT® Systems for Vent Heights of 10 Feet and 15 Feet, For Type B Vent Only

VENT HEIGHT 10 FEET								
Model	Input MBH	Module	Qty	Common Combined Min Vent Inside Dia Inches	Max Manifold Length Feet	Individual Vent Connector Min Inside Dia, Inches With Connector Rise Of:		
						1 Foot	2 Feet	3 Feet
FH-429	429	GM-e-05	2	12	18	9	8	8
FH-482	482	GM-e-05	1	12	18	9	8	8
		GM-e-06	1			10	9	8
FH-536	536	GM-e-06	2	12	18	10	9	8
FH-610	610	GM-e-06	1	12	18	NR	9	8
		GM-07	1				10	10
FH-684	684	GM-07	2	14	21		10	10
FH-741	741	GM-07	1	14	21		10	10
		GM-08	1				12	10
FH-798	798	GM-08	2	14	21		12	10
FH-1197	1197	GM-08	3	18	27		12	10
FH-1596	1596	GM-08	4	20	30		12	10
FH-1995	1995	GM-08	5	22	33		12	10

VENT HEIGHT 15 FEET								
Model	Input MBH	Module	Qty	Common Combined Min Vent Inside Dia Inches	Max Manifold Length Feet	Individual Vent Connector Min Inside Dia, Inches With Connector Rise Of:		
						1 Foot	2 Feet	3 Feet
FH-429	429	GM-e-05	2	10	15	9	8	8
FH-482	482	GM-e-05	1	12	18	9	8	8
		GM-e-06	1			10	9	8
FH-536	536	GM-e-06	2	12	18	10	9	8
FH-610	610	GM-e-06	1	12	18	NR	9	8
		GM-07	1				10	9
FH-684	684	GM-07	2	12	18		10	9
FH-741	741	GM-07	1	12	18		10	9
		GM-08	1				12	10
FH-798	798	GM-08	2	14	21		12	10
FH-1197	1197	GM-08	3	16	24		12	10
FH-1596	1596	GM-08	4	18	27		12	10
FH-1995	1995	GM-08	5	20	30		12	10
FH-2394	2394	GM-08	6	22	33		12	10

Table 4.4: Combined Vent Sizing and Connector Requirements for Typical FLEX-HEAT® Systems for Vent Heights of 20 Feet and 30 Feet, For Type B Vent Only

VENT HEIGHT 20 FEET								
Model	Input MBH	Module	Qty	Common Combined Min Vent Inside Dia Inches	Max Manifold Length Feet	Individual Vent Connector Min Inside Dia, Inches With Connector Rise Of:		
						1 Foot	2 Feet	3 Feet
FH-429	429	GM-e-05	2	9	13.5	9	8	7
FH-482	482	GM-e-05	1	10	15	9	8	7
		GM-e-06	1			9	9	8
FH-536	536	GM-e-06	2	10	15	9	9	8
FH-610	610	GM-e-06	1	12	18	NR	9	8
		GM-07	1				10	9
FH-684	684	GM-07	2	12	18		10	9
FH-741	741	GM-07	1	12	18		10	9
		GM-08	1				10	10
FH-798	798	GM-08	2	12	18		10	10
FH-1197	1197	GM-08	3	16	24		10	10
FH-1596	1596	GM-08	4	18	27		10	10
FH-1995	1995	GM-08	5	20	30		10	10
FH-2394	2394	GM-08	6	22	33		10	10
FH-2793	2793	GM-08	7	22	33		10	10

VENT HEIGHT 30 FEET								
Model	Input MBH	Module	Qty	Common Combined Min Vent Inside Dia Inches	Max Manifold Length Feet	Individual Vent Connector Min Inside Dia, Inches With Connector Rise Of:		
						1 Foot	2 Feet	3 Feet
FH-429	429	GM-e-05	2	9	13.5	8	8	7
FH-482	482	GM-e-05	1	9	13.5	8	8	7
		GM-e-06	1			9	9	8
FH-536	536	GM-e-06	2	10	15	9	9	8
FH-610	610	GM-e-06	1	10	15	NR	9	8
		GM-07	1				9	9
FH-684	684	GM-07	2	10	15		9	9
FH-741	741	GM-07	1	12	18		9	9
		GM-08	1				10	10
FH-798	798	GM-08	2	12	18		10	10
FH-1197	1197	GM-08	3	14	21		10	10
FH-1596	1596	GM-08	4	16	24		10	10
FH-1995	1995	GM-08	5	18	27		10	10
FH-2394	2394	GM-08	6	20	30		10	10
FH-2793	2793	GM-08	7	20	30		10	10
FH-3192	3192	GM-08	8	22	33		10	10

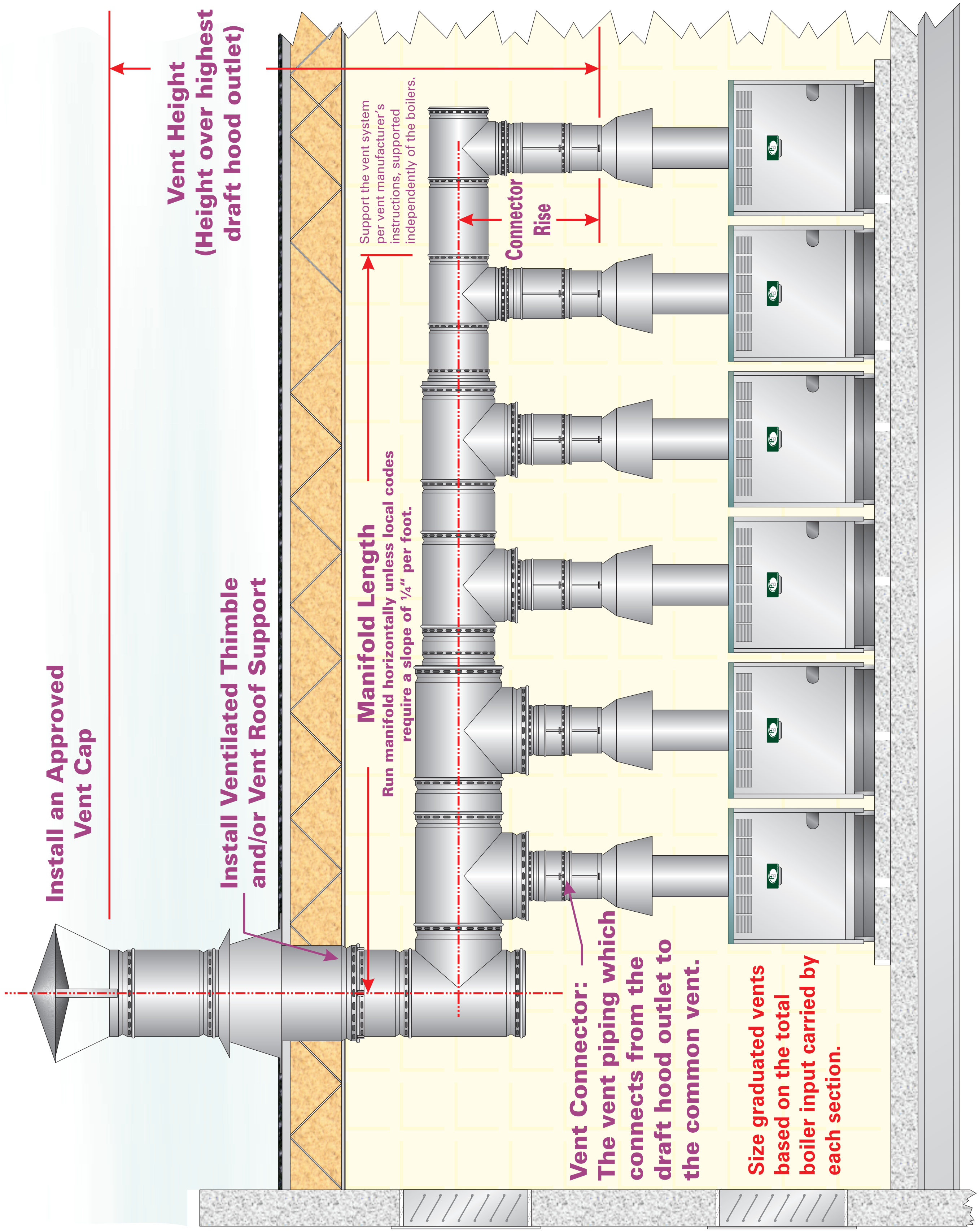


Figure 4.4: Combined Venting, Graduated Vent Diameter – See Table 4.5 for Sizing

Table 4.5: Vent Capacities for Type B Combined Venting with Type B or Single Wall Metal Connectors

Combined Vent Capacities (MBH) – Type B Gas Vent & Connector								
Vent Height Feet	Vent Diameter, Inches							
	9	10	12	14	16	18	20	22
6	302	369	529	734	959	1211	1494	1773
8	340	419	587	821	1071	1359	1674	1980
10	365	446	641	896	1170	1481	1827	2160
15	419	509	743	1042	1359	1719	2124	2511
20	471	576	824	1161	1521	1926	2376	2808
30	545	666	923	1373	1791	2268	2799	3312
50	635	774	1152	1677	2187	2768	3420	4050
100	720	878	1503	2205	2880	3645	4500	5328
Maximum Manifold Length, Feet (Reduce vent capacity by 10% for each multiple of the maximum over the maximum) (Reduce vent capacity by 10% for each 90 degree elbow anywhere in the combined vent)								
	13.5	15	18	21	24	27	30	33
Capacities above are based on the National Fuel Gas Code, ANSI Z223.1, 1996								

Vent Connector Minimum Inside Diameter Using Type B Vent Connectors												
Vent Height Feet	GM-e-05 (214.5 MBH Input)			GM-e-06 (268 MBH Input)			GM-07 (342 MBH Input)			GM-08 (399 MBH Input)		
	1-Foot Rise	2-Foot Rise	3-Foot Rise	1-Foot Rise	2-Foot Rise	3-Foot Rise	1-Foot Rise	2-Foot Rise	3-Foot Rise	1-Foot Rise	2-Foot Rise	3-Foot Rise
6	9	9	8	10	10	9	12	10	10	12	12	12
8	9	8	8	10	9	9	12	10	10	12	12	10
10	9	8	8	10	9	9	12	10	9	12	12	10
15	9	8	8	10	9	8	12	10	9	12	12	10
20	9	8	7	9	9	8	10	10	9	12	10	10
30	8	8	7	9	9	8	10	9	9	12	10	9
50	8	7	7	9	8	8	10	9	9	10	10	9
100	8	7	7	9	8	8	10	9	9	10	9	9
Maximum length of vertical and horizontal connector piping is 1.5 feet per inch of connector diameter.												

Vent Connector Minimum Inside Diameter Using Single Wall Metal Vent Connectors												
Vent Height Feet	GM-e-05 (214.5 MBH Input)			GM-e-06 (268 MBH Input)			GM-07 (342 MBH Input)			GM-08 (399 MBH Input)		
	1-Foot Rise	2-Foot Rise	3-Foot Rise	1-Foot Rise	2-Foot Rise	3-Foot Rise	1-Foot Rise	2-Foot Rise	3-Foot Rise	1-Foot Rise	2-Foot Rise	3-Foot Rise
6	9	9	8	10	10	9	NR	10	10	NR	NR	NR
8	9	8	8	10	9	9	NR	10	10	NR	NR	10
10	9	8	8	10	9	9	NR	10	10	NR	NR	10
15	9	8	8	10	9	9	NR	10	9	NR	NR	10
20	9	8	8	10	9	8	NR	10	9	NR	10	10
30	8	8	7	9	9	8	10	9	9	NR	10	10
50	8	8	7	9	8	8	10	9	9	NR	10	9
100	8	7	7	9	8	8	10	9	9	NR	10	9
Maximum length of vertical and horizontal connector piping is 1.5 feet per inch of connector diameter.												

5. PIPING

A. PIPING ISSUES

1. FLEX-HEAT® Manifolds
   a) When using or specifying these manifolds please verify that local codes and jurisdictions accept flexible joints.
   b) The building piping must be rigidly secured where it ties to the manifolds to prevent movement. Movement of the system piping could cause loosening or failure of the flexible joints.
   c) FLEX-HEAT® Manifolds can be connected in series of 2-module and 3-module manifolds to pipe up to 10 boilers modules in parallel (Figure 5.2). If using more than 10 boilers, divide boilers into groups smaller than 10 and pipe the boiler/manifold groups in parallel with each other. See Section E for pressure drops through boiler modules and manifolds.
   d) The FLEX-HEAT® Manifolds may also be used with the FLEX-HEAT® Circulator kits in primary/secondary pumping as shown in Figure 5.4.
2. Manifold Joint Detail (Figure 5.2 detail)
   a) Slide the gasket retainer over the pipe.
   b) Carefully slide the gasket with internal steel retaining ring onto the end of the pipe. To simplify installation, install lower portion of gasket halfway onto the pipe first, leaving the split area in the internal steel retaining ring free at the top. Then, stretch the gasket and split area of the retaining ring until they slip over the pipe. Installation of the gaskets can be made easier by dipping gaskets in water. The use of other rubber lubricants can be detrimental to the life of the gaskets.
   c) Slide the gasket about 1-1/2" from the end of the pipe and past any pipe threads.
   d) When the pipes are positioned and aligned, slide the pipe until the gasket is pressed against the flange of the manifold. The gasket must be seated on an unthreaded section of pipe at least 1 inch from the end.
   e) Apply the clamp and tighten the following torque values: 3 inch Joint–220-240 inch-lbs. 1-1/2" Joint–140-160 inch-lbs.
3. Control Header

   Install the system controls in the control header as shown in Figure 5.1. See Section I, Introduction to FLEX-HEAT® Modular Boiler Systems, for the control requirements for Modular versus Multiple boiler systems.

   Low Water Cut-off - The Hydrolevel Hydrostat® limit controls used on Series GM™ boilers meet ASME low water cut-off requirements when used in either modular or multiple boiler installations. The Hydrostat® controls meet ASME CSD-1 low water cut-off requirements when set to manual reset. If a separate system low water cut-off is added, install in control header as shown in Figure 5.1.
4. Pump Location

   ALWAYS pump away from the expansion tank on commercial systems or when using high head pumps (Figure 5.3).
5. Size the piping based on the design flow rate. Design the piping for a minimum flow rate equivalent to 0.75 feet per hundred feet head loss in the piping and a maximum flow rate not to exceed 4 feet per hundred feet (Table 5.1).

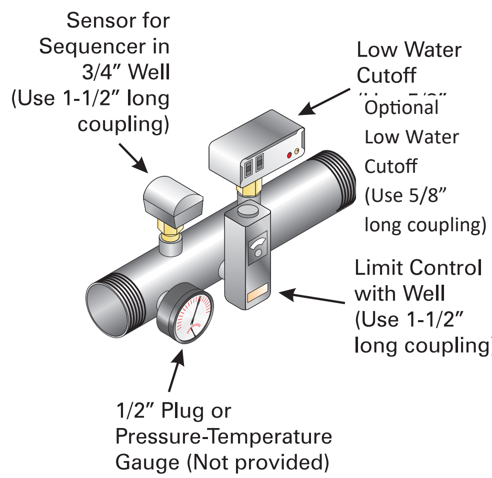


Figure 5.1: Control Header

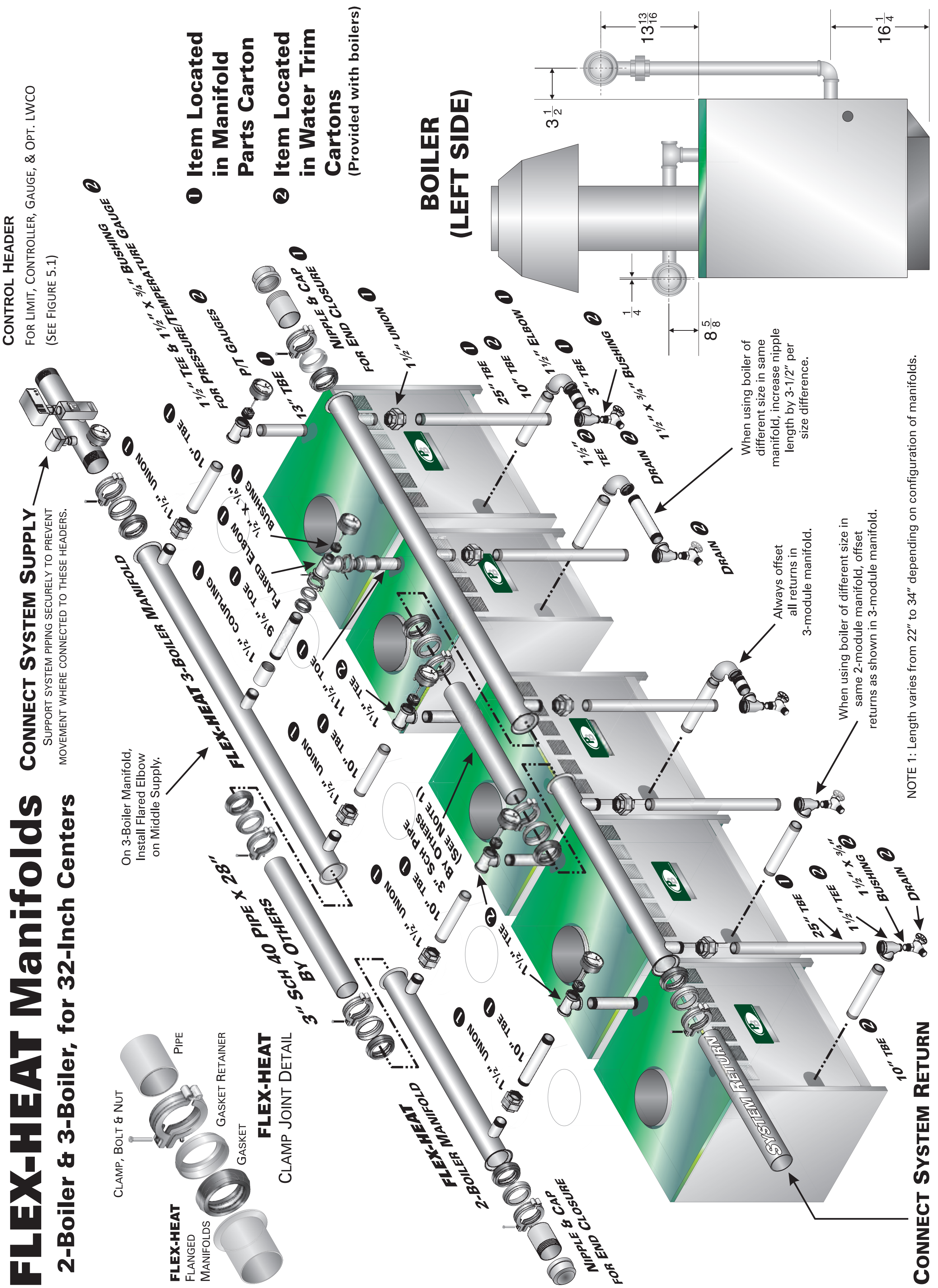


Figure 5.2: Optional FLEX-HEAT® Manifolds

B. AIR ELIMINATION

1. Always use an in-line air separator to accelerate air removal from the system. Even when boilers are equipped with internal separation, the in-line air separator will improve air removal.
2. Pump and Expansion/Compression Tank Location (Figure 5.3).
   a) Always locate the system pump with its suction side as near as possible to the compression tank or expansion tank connection.
   b) The pressure at the expansion tank only changes if the volume of the water changes (due to water expansion or contraction, leakage or addition of water to the system) or if the tank charge pressure is changed manually.
   c) By locating the pump suction at the expansion tank, then, the pump discharge pressure adds to the system pressure.
   d) Air is more soluble at high pressure and low temperature, so pressurizing the system with the pump keeps the air in solution better. The air is pushed through the system back to the separator and expansion tank – the place in the system with the lowest pressure and highest temperature.
   e) If the pump discharge were at the expansion tank connection, the pump pressure would subtract from the system pressure. It can't increase the pressure at the expansion tank. This would lower the system pressure, causing the air to come out of solution at the top of the system instead of returning to the air separator and expansion tank.

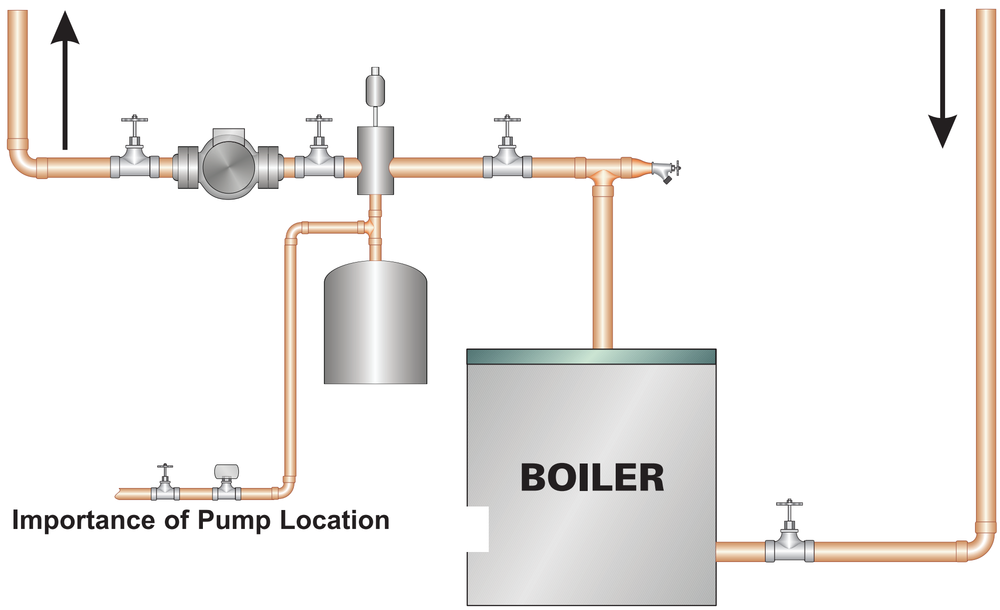


Figure 5.3: Importance of Pump Location

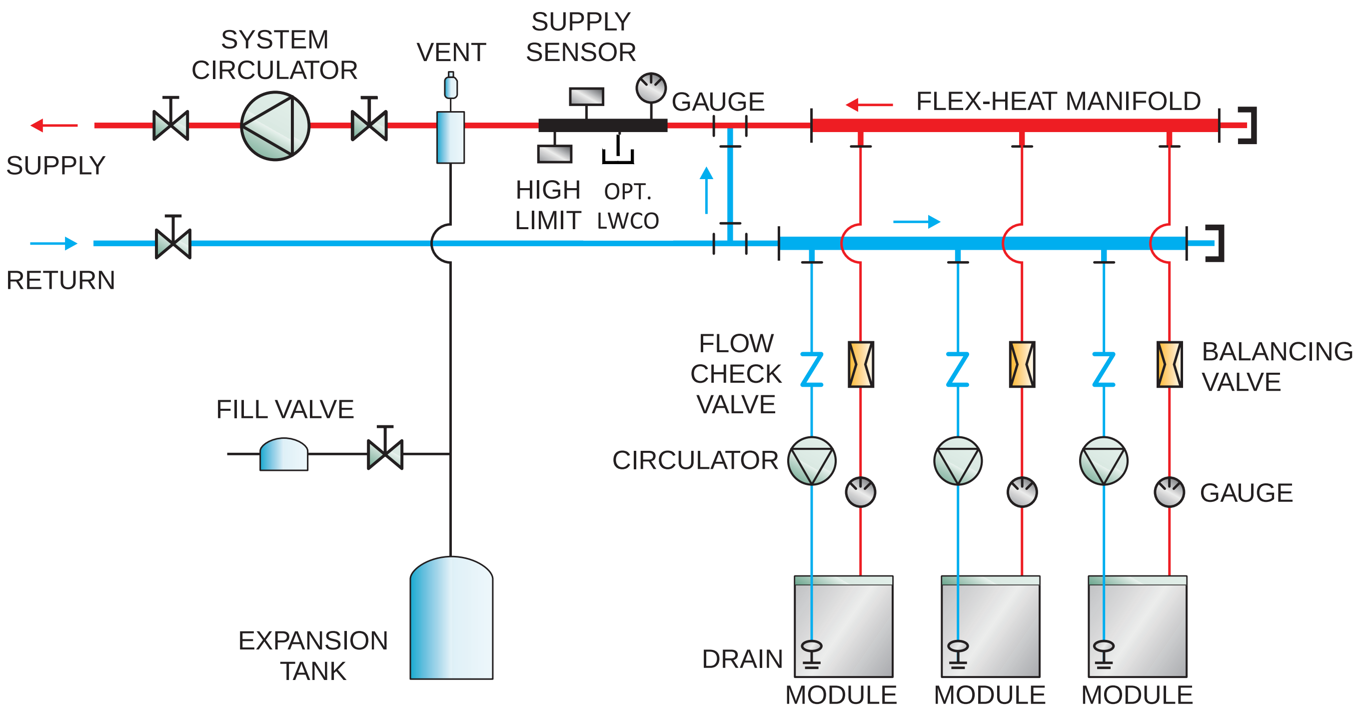


Figure 5.4: **Boiler Piping Primary-Secondary Pumping Using Flex-Heat® Manifolds, Systems That Have Return Water Temperature Always Above 130° F**

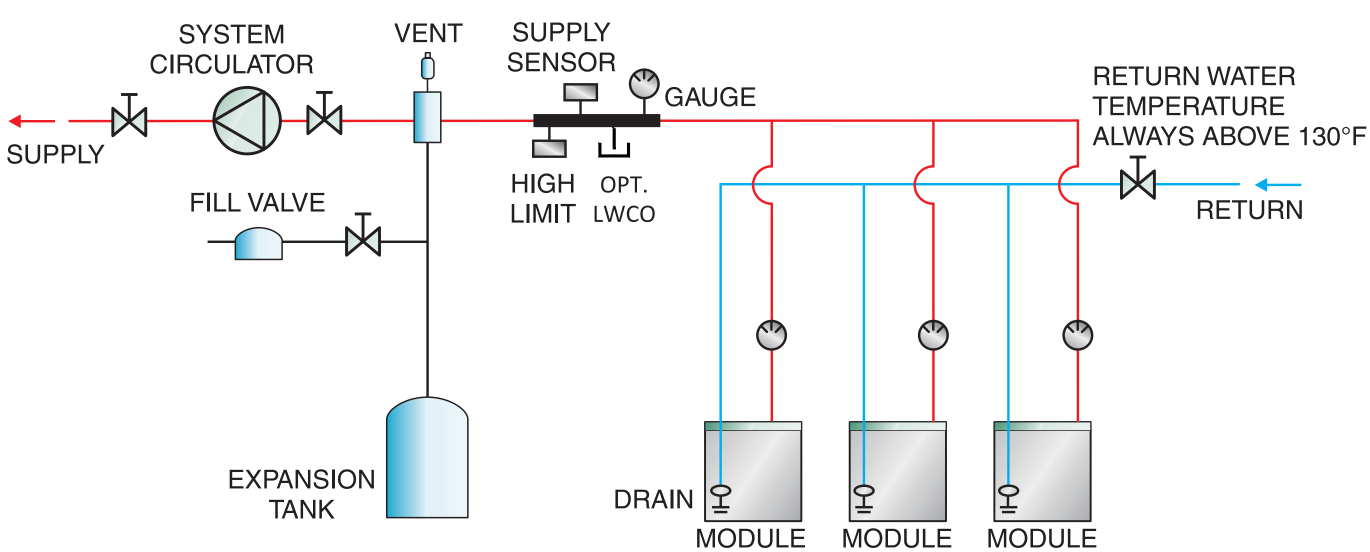


Figure 5.5: **Boiler Piping Parallel Pumping, Systems That Have Return Water Temperature Always Above 130° F**

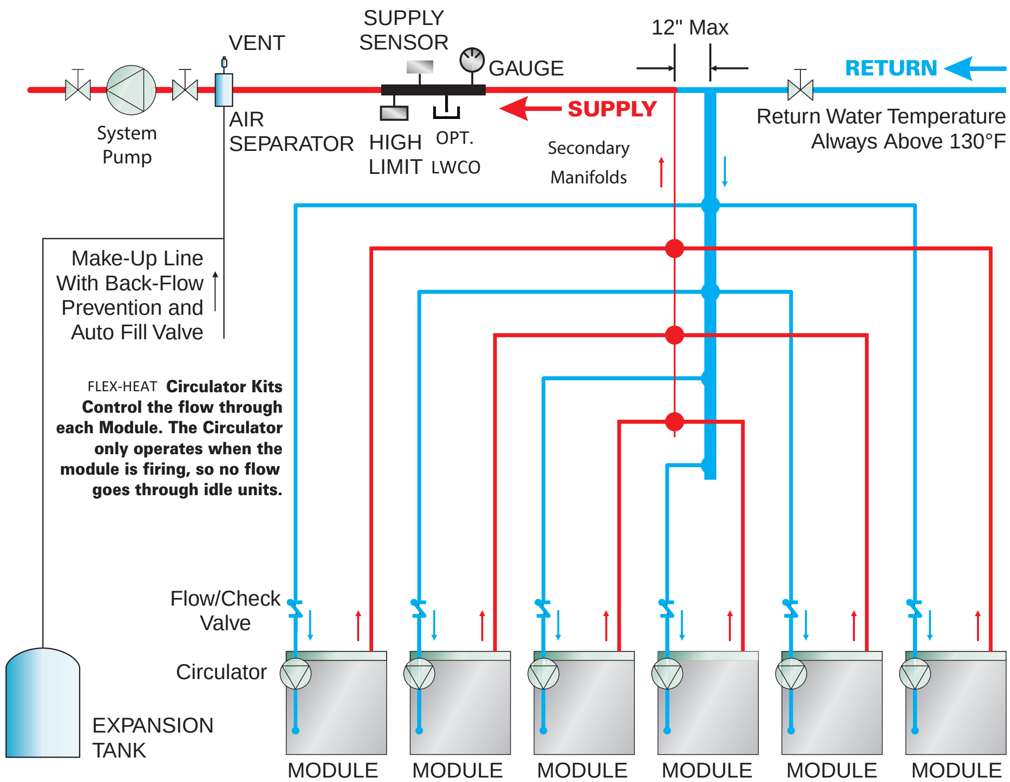


Figure 5.6: Primary-Secondary Pumping, Systems That Have Return Water Always Above 130° F

f) Locate the fill valve connection at the same point as the expansion tank. Never pipe the fill valve to the pump suction side if the pump discharge side is at the expansion tank connection. This would cause the fill valve to overfill the system because the pump would lower the pressure when it comes on.

3. Plain Steel Compression Tank (see Section H for sizing)

a) For air tanks (no diaphragm), always use a tank fitting into the bottom of the tank. The tank fitting is a tube which fits up into the tank and prevents the tank water from gravity circulating back into the system. If gravity circulation from the tank occurs, air is pulled down into the system again and the tank can become waterlogged.

b) Never use an automatic air vent on a system equipped with an air (no diaphragm) compression tank. The air will vent from the air vent and cause the tank to waterlog.

c) Be careful if you drain a system with an air tank. You must open the air vent valve on the tank to allow air to flow in as the water leaves the system. Otherwise, a vacuum would develop. The vacuum could be high enough to collapse the tank from external pressure.

4. Diaphragm Expansion Tanks (see Section H for sizing)

a) Always charge diaphragm or bladder expansion tanks to the cold fill pressure with the tank disconnected from the system to set and check the charge pressure. If the cold fill pressure is higher than the charge pressure, the usable volume in the tank is reduced and the system may over pressurize, causing weeping of the relief valve and excessive makeup.

C. PREVENTING CONDENSATION

1. Natural gas flue products condense at about 130° F. When return water to the boilers drops below this temperature condensation will begin on the fire side surfaces. Continued operation with flue gas condensation in the modules will damage the heat exchangers and the burners. Condensation must be prevented.

2. When system return water temperature will be below 130° F, pipe the boiler with a bypass arrangement to blend the system return water with hot boiler water to obtain at least 130° F entering the boiler.

3. The return water to the modules can only be heated by mixing hot supply water with the return water. This requires a pump in the boiler module circuit. So in order to control the return water temperature there are two options for the piping to the modules:

a) Parallel piped modules with a fixed bypass piped from the discharge side of the circulator to the return piping (not shown). This design only uses one pump for the entire system. – or –

b) Primary/Secondary piping using individual pumps on the modules, such as FLEX-HEAT® Circulator Kits.

4. Constant Low Temperature Commercial Systems – Use FIXED BY-PASS

a) On systems with a constant or nearly constant operating temperature (such as heat pump systems), the return water temperature to the boiler can be controlled by piping with a fixed-flow bypass loop. Set the balancing valves such that the return water to the boiler is at least 130° F (Figures 5.7 and 5.8).

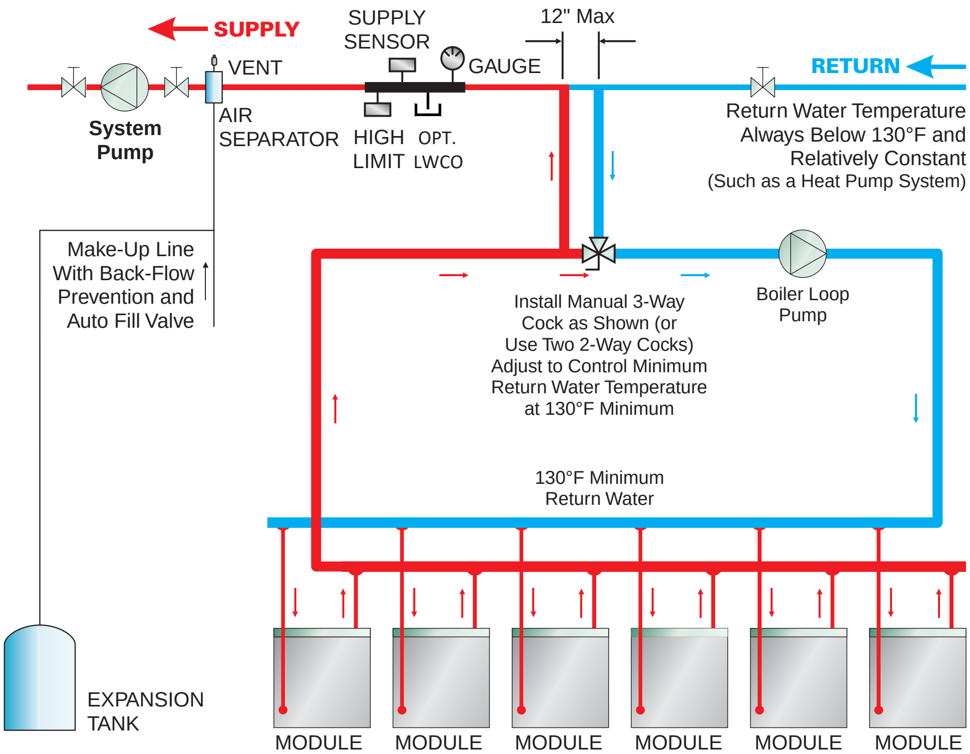


Figure 5.7: Parallel Pumping Fixed Bypass

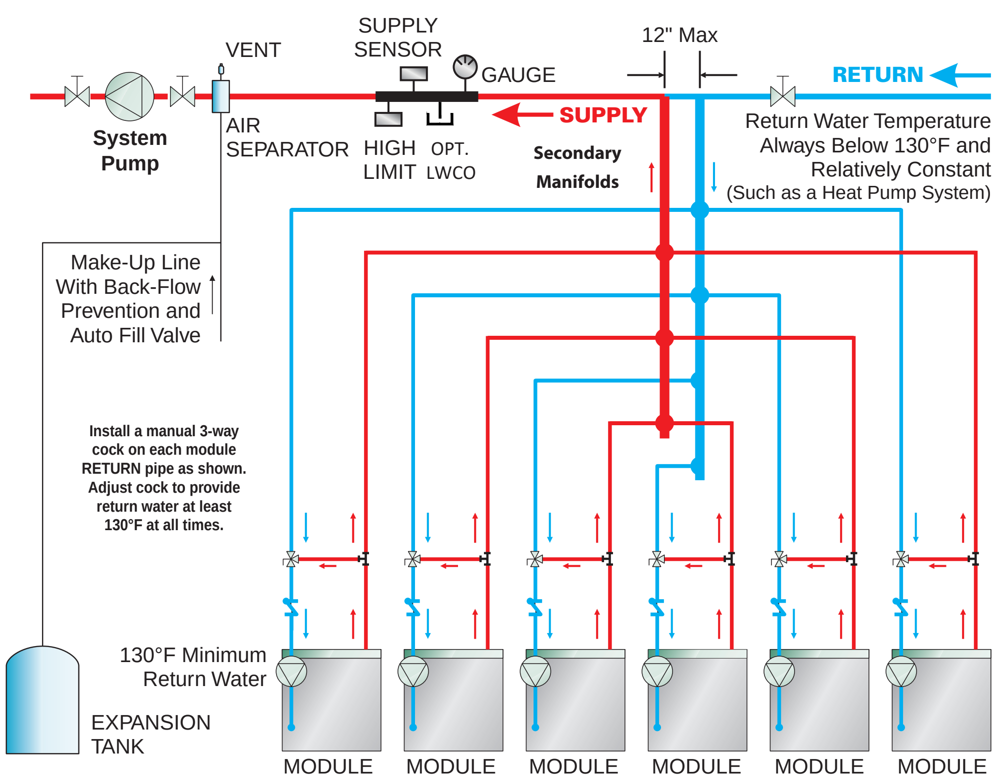


Figure 5.8: Primary-Secondary Pumping Fixed Bypass

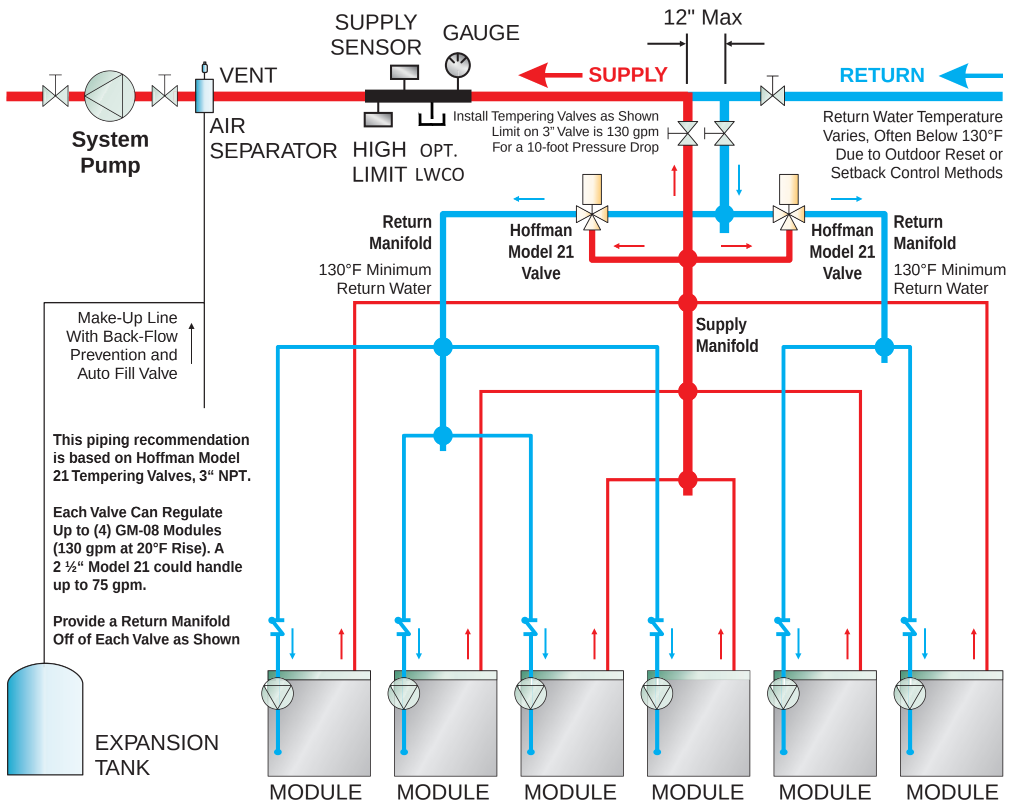


Figure 5.9: Primary-Secondary Pumping, Variable Bypass Using 3-Way Valve

5. Variable Low Temperature Systems – Use Tempering Valve(s) for VARIABLE BY-PASS

   a) Systems operated with an outdoor reset control or energy management controls (night or weekend setback, for example) will have return temperatures below 130° F.

      1. Outdoor reset controls lower supply temperature as outdoor temperature rises. Unless specially designed outdoor reset controls will regulate supply water to as low as 70° F. Return water would be even lower.

      2. After regulation to night or weekend setback the entire system is relatively cold. So, while the boiler modules heat the system the return water is below 130° F and condensation occurs in the modules.

   b) One solution on outdoor reset systems to prevent condensation is to regulate the supply water temperature always above 140° F. This is an option with FLEX-HEAT® Sequencers.

      1. Outdoor reset, however, should be allowed to lower the system supply temperature to as low as 70° F to 90° F in mild weather in order to achieve the benefits of reset in energy savings and comfort control.

   c) A fixed bypass arrangement at the boiler modules will not work with variable low temperature systems.

      1. When a fixed flow bypass is set, it causes a fixed temperature rise through the boiler loop. The temperature rise must be high when the system temperature is low.

      2. If this same high temperature rise through the boiler loop were maintained when the system temperature is hotter, the boilers would cycle on the limit control frequently.

   d) To allow the boiler loop temperature rise to adjust to system temperature, use tempering valve(s) in the module piping (Figure 5.9).

   e) This variable flow bypass arrangement provides automatic control of boiler return water while allowing the system return temperature to range as low or as high as needed for best operation of the heating system.

D. COMMERCIAL SYSTEM TYPES

1. Two-Pipe System (Figures 5.10-5.12)

   a) Most commercial hydronic systems are piped with two-pipe loops.

   b) Reverse return systems are easier to balance since the loss in the system piping to each loop is approximately the same. Even with reverse return, the system will be difficult to balance if the individual loop pressure drops are not similar.

   c) When piping modules in parallel use reverse return piping (when possible) of the modules to balance the flow. Direct return piping will cause higher flow in some modules than in others.

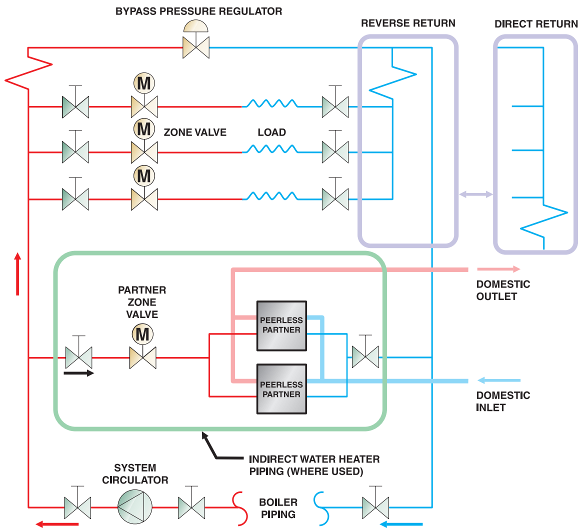


Figure 5.10: Two-Pipe System with Zone Valves

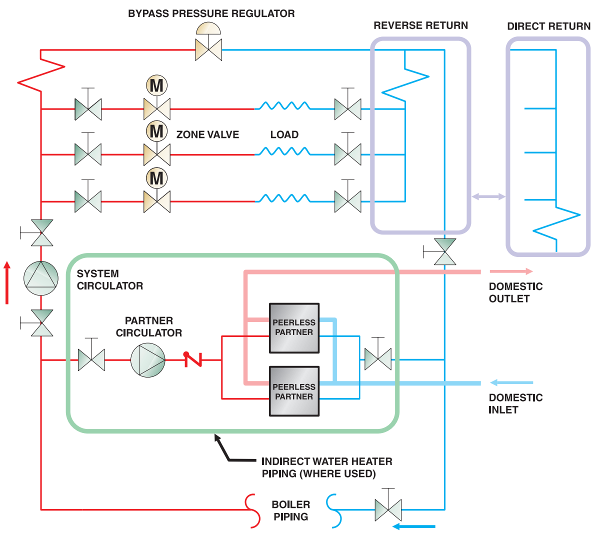


Figure 5.12: Two-Pipe System with Zone Valves for Space Heating/Zone Circulator for DHW

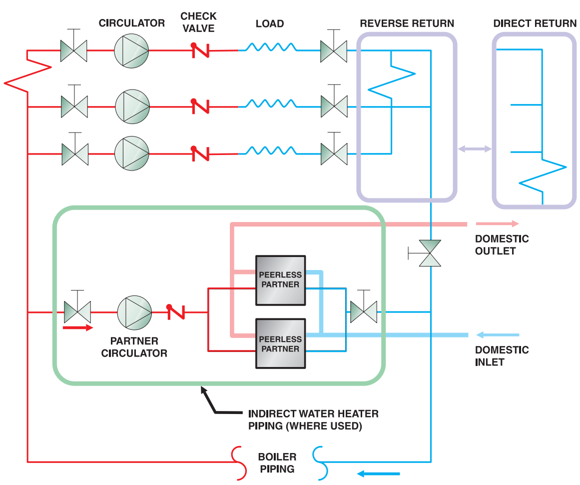


Figure 5.11: Two-Pipe System with Zone Circulators

d) Note the use of a by-pass pressure regulator in these systems. Because the pump head increases with decreased flow, some circuits may encounter too much flow as control valves in other circuits close off. The regulator limits the head, preventing excess flow and lifting of spring-loaded valve seats due to too much pressure.

e) The pressure drop on the risers (common piping) of a direct return system should be less than 5% of the circuit pressure drop.

f) With either direct return or reverse return systems the pressure loss through the system piping depends on the amount of flow through each circuit. As control valves modulate closed, the pressure loss through the system changes.

2. Primary/Secondary Piping (Figures 5.13 and 5.14)

a) Another, more versatile, piping design for commer-cial systems is the primary/secondary system. The primary loop is the loop containing the system pump. The boilers can either be directly in the primary loop or piped in secondary circuits (preferred method).

b) Primary/secondary systems are easily balanced since the pressure drop for each secondary loop is handled by its own pump and the primary pump always sees the same flow conditions. The primary pump only pumps water around the primary loop. The primary loop pressure drop is constant regardless of control valve movement in the secondary loops.

c) The secondary loops can either be piped off the main loop in series, as in Figure 5.14, or off of parallel crossover bridges as in Figure 5.13. The crossover bridge design is much more versatile since all of the secondary loops see the same supply water temperature. In the series system the supply temperature drops as the water proceeds around the main loop since hot water is being taken by the loops and cooler water is returned into the main loop flow.

1. The greatest advantage of the crossover bridge design is that the primary loop temperature drop can be greater than any of the secondary loops if desired. This allows lower flow rates and smaller piping in the primary loop.

d) Always pipe the secondary loop connections to the crossover bridge or main loop between 6 and 24 inches apart, as close as practical for the pipe size used. This is necessary to make the pressure drop through the common piping as small as possible, avoiding forced flow and loss of control in the secondary circuit.

e) Use two flow control valves when a control valve is not used in a secondary loop. This will prevent gravity circulation in the circuit or in the individual pipes.

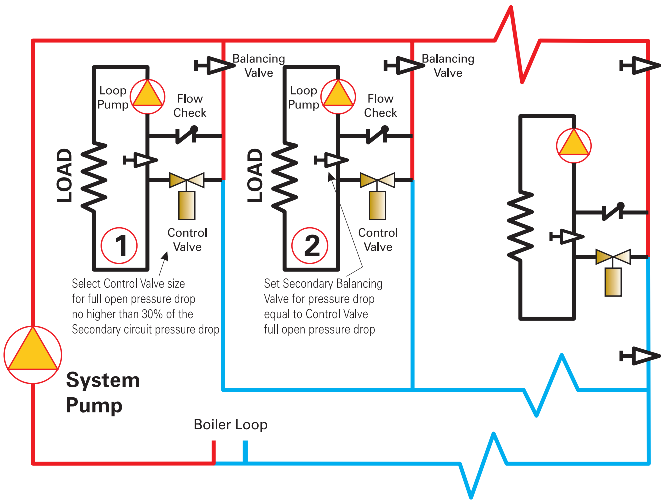


Figure 5.13: Primary/Secondary Piping Cross-over Design

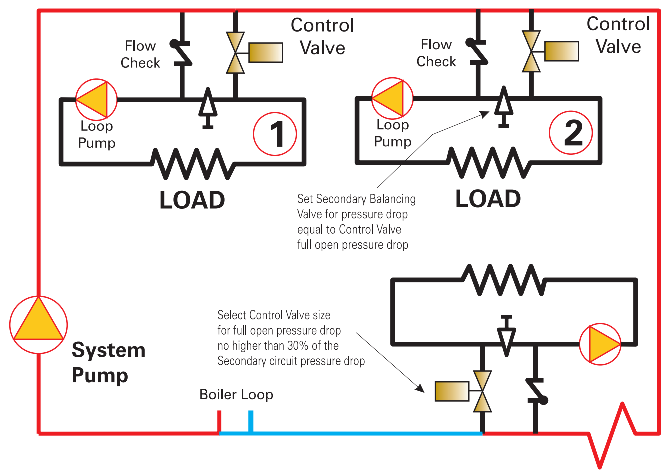


Figure 5.14: Primary/Secondary Piping Series Loop (One-Pipe)

E. DETERMINING PRESSURE DROP

1. The pressure drop through a single Series GM™ boiler is 9" W.C. @ 32.7 gpm (design flow for GM08 @ 20°F drop). For other flow rates:

   Pressure Drop (" W.C.) = 0.00842 *gpm^2

2. The pressure drop through the FLEX-HEAT® manifolds and boilers when piped according to Figure 5.2 is shown in Figure 5.15. Do not exceed 10 boilers piped to one FLEX-HEAT® manifold system.
3. Determine the piping head loss in feet by first figuring the Total Equivalent Length (TEL) for each circuit. The TEL is the number of feet of piping plus the allowance in equivalent feet for each fitting.
4. The equivalent length in feet for a fitting depends on the pipe size. Begin by estimating the TEL as 50% longer than the actual length of piping. For small systems this estimate is generally adequate without doing an actual calculation of equivalent lengths for the fittings. For calculating equivalent length see Table 5.1.
5. Select a trial pipe size from Table 5.1 based on the design flow rate in gpm.
   a) The maximum flow rates (based on a maximum of 4 feet per hundred feet loss) are intended to prevent flow generated noise.
   b) The minimum flow rates are set for adequate movement of air through the system (based on a minimum 0.75 feet per hundred feet head loss).
6. Table 5.1 provides an easy means of calculating the loss in the pipe in feet per hundred feet of pipe. This data closely (within 3%) matches the ASHRAE Fundamen-tals, 1993, pressure loss charts developed from the Moody friction factor curves in the range up to 10 feet per hundred feet.
7. To calculate a pressure drop for any given flow rate, gpm (U. S. Gallons per minute), find a and b from the table and solve as:

   $\Delta H = a \times (gpm)^b$ feet per hundred feet

$$\text{Total Head Loss} = \left(\frac{TEL}{100}\right) \times \Delta H \text{ feet}$$

8. You may find this calculation easier than using the ASHRAE log/log pressure drop curves, and the formulas can be easily programmed into a spreadsheet or calculator.
9. If the pressure drop for the trial pipe size and TEL is acceptable, determine the actual TEL for the system by totaling the fitting and valve equivalent lengths given in Table 5.1 Then recalculate total head loss (in feet) as:

$$\text{Total Head Loss} = \left(\frac{TEL}{100}\right) \times a \times (gpm)^b$$

10. For systems which will be filled with 50% glycol, calculate the pressure drops and flows for a water only system. Then apply the correction factors in the section following on glycol applications.

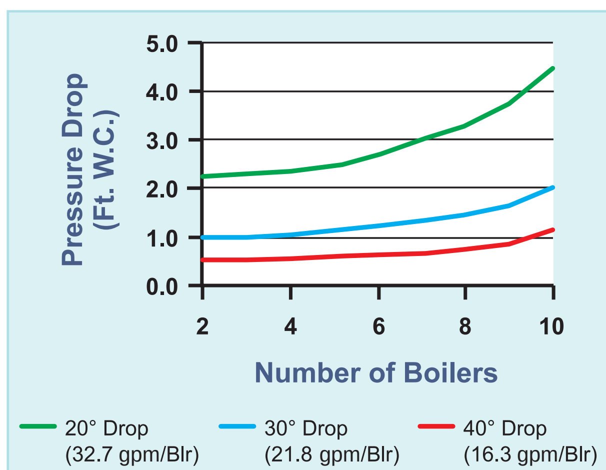


Figure 5.15: Pressure Drop thru Flex-Heat® Manifolds and Boiler Modules

Table 5.1: Calculating Pressure Drops for Steel and Copper Pipe, Head Loss = (TEL/100) x a x (gpm)^b

Size	Minimum Flow, gpm .75 ft/100 ft	Maximum Flow, gpm 4 ft/100 ft	a	b	Velocity @ Minimum fps	Velocity @ Maximum fps	Pipe ID
1/2	0.7	1.75	1.44E+00	1.827	0.7	1.8	0.622
3/4	1.5	3.8	3.61E-01	1.801	0.9	2.3	0.824
1	2.8	7.2	1.21E-01	1.772	1.0	2.7	1.049
1 1/4	6.2	15.1	2.43E-02	1.881	1.3	3.2	1.380
1 1/2	9.3	23	1.22E-02	1.849	1.5	3.6	1.610
2	18	44	3.34E-03	1.873	1.7	4.2	2.067
2 1/2	29.5	72	1.31E-03	1.876	2.0	4.8	2.469
3	53	133	5.47E-04	1.819	2.3	5.8	3.068
4	108	272	1.55E-04	1.812	2.7	6.9	4.026
5	197	495	5.09E-05	1.817	3.2	7.9	5.045
6	320	800	1.99E-05	1.827	3.6	8.9	6.065
8	660	1630	4.51E-06	1.852	4.2	10.5	7.981
10	1180	2930	1.66E-06	1.841	4.8	11.9	10.020
12	1910	4700	5.96E-07	1.859	5.4	13.3	12.000
Copper Tubing, Type L							
Size	Minimum Flow, gpm .75 ft/100 ft	Maximum Flow, gpm 4 ft/100 ft	a	b	Velocity @ Minimum fps	Velocity @ Maximum fps	Pipe ID
1/2	0.495	1.23	2.73E+00	1.839	0.7	1.7	0.545
3/4	1.37	3.37	4.18E-01	1.860	0.9	2.2	0.785
1	2.96	7.3	1.00E-01	1.854	1.2	2.8	1.025
1 1/4	5.1	12.7	3.77E-02	1.835	1.3	3.2	1.265
1 1/2	8.2	20.15	1.49E-02	1.862	1.5	3.6	1.505
2	17.4	43	3.80E-03	1.850	1.8	4.5	1.985
2 1/2	31.2	78	1.40E-03	1.827	2.1	5.2	2.465
3	49	123	6.32E-04	1.819	2.3	5.8	2.945
4	110	270	1.17E-04	1.864	2.9	7.2	3.905
5	190	485	6.38E-05	1.786	3.3	8.3	4.875
6	320	780	1.47E-05	1.879	3.8	9.3	5.845

The "a" values above are in engineering notation. For example, 5.96E-07 means move the decimal point 7 places; i.e. .000000596

Table 5.2: Equivalent Lengths for Typical Pipe Fittings, Feet

Equivalent Length for Pipe Fittings, Feet

Nominal Pipe Size	Gate Valve Full Open	Globe Valve Full Open	Butterfly Valve	Angle Valve Full Open	Swing Check Valve Full Open	90 Degree Elbow	Long Radius 90 & 45 Std Elbow	Close Return Bend	Standard Tee		Mitre Bend	
									Through Flow	Branch Flow	45 deg.	90 deg.
1/2	0.41	17.6		7.78	5.18	1.55	0.83	2.59	1.0	3.1		
3/4	0.55	23.3		10.3	6.86	2.06	1.1	3.43	1.4	4.1		
1	0.70	29.7		13.1	8.74	2.62	1.4	4.37	1.8	5.3		
1 1/4	0.92	39.1		17.3	11.5	3.45	1.84	5.75	2.3	6.9		
1 1/2	1.07	45.6		20.1	13.4	4.03	2.15	6.71	2.7	8.1		
2	1.38	58.6	7.75	25.8	17.2	5.17	2.76	8.61	3.5	10.3	2.6	10.3
2 1/2	1.65	70	9.26	30.9	20.6	6.17	3.29	10.3	4.1	12.3	3.1	12.3
3	2.04	86.9	11.5	38.4	25.5	7.67	4.09	12.8	5.1	15.3	3.8	15.3
3 1/2	2.43	103.8	13.74	45.9	30.4	9.17	4.89	15.3	6.1	18.3	4.5	18.3
5	3.36	143	18.9	63.1	42.1	12.6	6.73	21	8.4	25.2	6.3	25.2
6	4.04	172	22.7	75.8	50.5	15.2	8.09	25.3	10.1	30.3	7.6	30.3
8	5.32	226	29.9	99.8	33.3	20	10.6	33.3	13.3	39.9	10.0	39.9
10	6.68	284	29.2	125	41.8	25.1	13.4	41.8	16.7	50.1	12.5	50.1
12	7.96	338	34.8	149	49.7	29.8	15.9	49.7	19.9	59.7	14.9	59.7

SELECTING THE PUMP

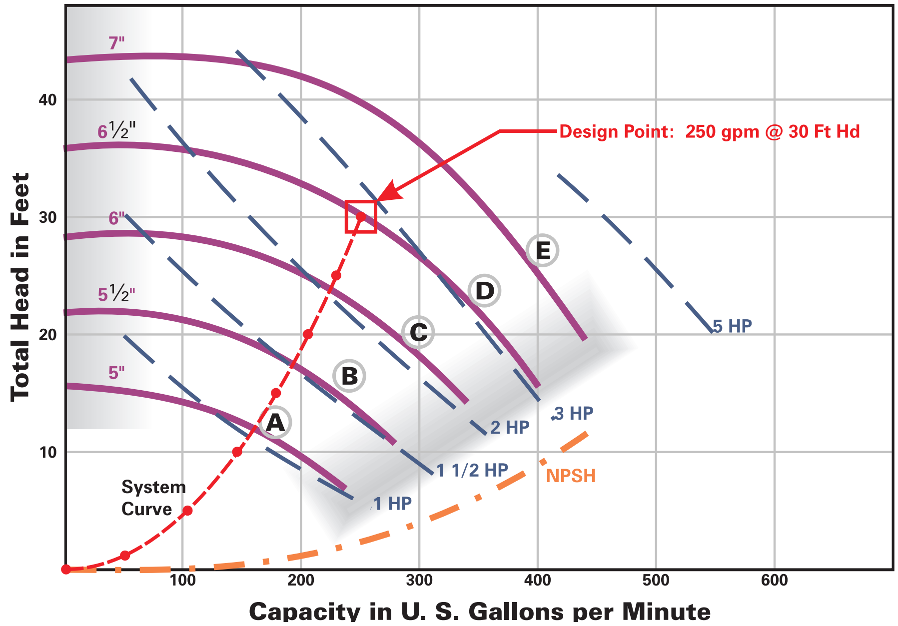


Figure 5.16: Typical Pump Curve

F. PUMP SELECTION

1. You can select a pump by using only the system design point (maximum flow and pressure drop). However, you should always select a pump which can operate at plus or minus 25% from the selection point. This allows for drift to account for system pressure drop actually lower than anticipated (moving to right on the pump curve) or higher (as control valves close off).
2. Do not select the pump either near the shut-off head or on the flat portion of the curve near the left side. Also avoid the right side of the pump curve. At the end of the pump curve on end-suction pumps, the pump can easily cavitate, causing noise and severe damage to the impeller. These areas are shown in gray in Figure 5.16.
3. If the design point does not fall directly on one of the impeller diameter curves for an end-suction pump, the pump manufacturer can trim the impeller to a diameter which will match the actual load. Pump curves for diameters between those shown can be plotted by splitting the distance between the curves shown and drawing a parallel curve for the new diameter.
4. Draw a System Curve
   a) Your pump selection will be improved by drawing a system curve for your system on the pump curves. Do this by plotting the design point on the curve. Then either use a heating slide rule (like the B & G System Syzer), apply the formula from Table 5.1 or apply the square law approximation:

$$\text{Head}_2 = \text{Head}_1 \times \left(\frac{\text{gpm}_2}{\text{gpm}_1}\right)^2$$

   b) Plot enough points to draw in a system curve above and below the design point.
      1. The design point may not fall directly on a pump curve.
      2. By extending the system curve, you can find the actual operating point where the system curve intersects the pump curve.
      3. See Figure 5.16 for a typical system curve sketched onto the pump curves.
   c) Avoid oversizing pumps.
      1. Oversizing will cause higher pressure and flow through the system.
      2. Noise and control valve problems will occur and electrical power usage will be unnecessarily high.
   d) Where possible, select a pump with a relatively flat curve to prevent excessive pressure on closed or modulating control valves.
      1. Most control valves should operate with no higher than a 20 foot pressure drop.
      2. Use a differential pressure valve (by-pass pressure regulator) to trim off excess pump pressure in the system and prevent dead-heading the pump in low flow conditions.

G. FREEZE PROTECTION ISSUES

1. Use only inhibited propylene glycol solutions up to 50% by volume with water.
   a) Have the system mixture checked annually to make sure the inhibitor level is adequate.
   b) Glycol without the inhibitor is very corrosive.
2. Do not use ethylene glycol since it will attack gaskets and seals used in boilers and hydronic systems.
3. Compression/Expansion Tank Sizing
   a) Consult tank manufacturer.
   b) General rule is to increase the tank size by 20% for 50/50 glycol compared to water only.
4. Glycol/water has a higher viscosity, lower heat content and lower heat transfer effects than water alone. Therefore, all system components need to be evaluated for use with this solution.
5. Heat exchangers need additional heating surface to do the same job with glycol/water. The approximate increase in shell length for a shell and tube heat exchanger ranges from a 10% increase at 240° F (check degree symbols) to a 53% increase at 120° F. Consult the manufacturer's literature for actual requirements.
6. To achieve generally the same heat transfer as water, increase the design flow for 50/50 glycol water as given in Table 5.3.
7. Centrifugal pump curves are not affected by the glycol/ water solution. The pump HP is affected by the fluid density, though.

Table 5.3

APPROXIMATE FLOW INCREASE FOR SAME HEAT TRANSFER WITH 50/50 GLYCOL VS WATER ONLY	
Average Water Temperature, °F	**Multiply Water-Only Flow Rate by:**
40	1.22
100	1.16
140	1.15
180	1.14
220	1.14

Table 5.4

APPROXIMATE PRESSURE DROP OF 50/50 GLYCOL VS WATER ONLY	
Average Water Temperature, °F	**Multiply Water-Only Flow Rate by:**
40	1.48
100	1.10
140	1.00
180	0.94
220	0.90

8. To determine pressure drop at the new flow rate, determine the pressure drop for water only at the new rate. Then multiply the pressure drop by the factor in Table 5.4.
9. This data is taken from ITT Bell & Gossett Bulletin No. TEH-176, Hydronic Systems Anti-Freeze Design.
10. Tips for glycol applications:
    a) Do not use galvanized pipe in the system. The coating reacts with glycol.
    b) Clean the system thoroughly with trisodium phosphate or other chemical cleaner before filling.
    c) You will probably want to use a manual fill system instead of an automatic fill valve. If the valve adds water to the system, the glycol will be diluted. With manual fill a drop in system pressure will indicate a leak problem. With automatic fill, you will not be warned of the problem.
    d) Do not use chromate water treatment. The chromate reacts with glycol.
    e) Use pumps with mechanical seals – not packing glands. Glycol leaks easier than water and may seep through the glands.

H. EXPANSION TANK SIZING

1. The following pages give guidelines for sizing compression tanks (air/water interface style) and diaphragm tanks. The equations are taken from the ASHRAE Systems Handbook, 1992.

Table 5.5: Diaphragm Expansion Tank

DIAPHRAGM EXPANSION TANK

NEVER EXCEED THE MAXIMUM ACCEPTANCE VOLUME SPECIFIED BY THE TANK MANUFACTURER

CALCULATE SYSTEM VOLUME INCLUDING PIPING AND ALL COMPONENTS

Pipe Size	Steel Pipe ID	Steel Gallons Per Foot	Copper Pipe ID	Copper Gallons Per Foot
1/2	0.622	0.016	0.545	0.012
3/4	0.824	0.028	0.785	0.025
1	1.049	0.045	1.025	0.043
1 1/4	1.380	0.078	1.265	0.065
1 1/2	1.610	0.106	1.505	0.092
2	2.067	0.174	1.985	0.161
2 1/2	2.469	0.249	2.465	0.248
3	3.068	0.384	2.945	0.354
4	4.026	0.661	3.905	0.622
5	5.047	1.04	4.875	0.970
6	6.065	1.50	5.845	1.394
8	7.981	2.60		
10	10.020	4.10		
12	12.000	5.88		

HEATING UNIT VOLUME ESTIMATES

	TYPE	RULE OF THUMB
Cast Iron Radiation	Columnar	0.114 Gallons per Square Foot EDR
	Thin Tube	0.056 Gallons per Square Foot EDR
	Convectors	1.5 Gallons per 10,000 Btuh (@200°F)
	Baseboard	4.7 Gallons per 10,000 Btuh (@200°F)
Copper Radiation	Convectors	0.64 Gallons per 10,000 Btuh (@200°F)
	Baseboard (3/4")	0.37 Gallons per 10,000 Btuh (@200°F)
Fan Coil Unit Heater	Default	0.2 Gallons per 10,000 Btuh (@180oF)
GM Modules	GM-05	6.15 Gallons per Module
	GM-06	7.20 Gallons per Module
	GM-07	8.25 Gallons per Module
	GM-08	9.30 Gallons per Module

CALCULATE REQUIRED TANK VOLUME (DATA FOR SEA LEVEL)

$$V_t = V_s \frac{\left[\left(\nu_2/\nu_1\right)-1\right] - 3\alpha\Delta t}{1-\left(P_1/P_2\right)}$$

The numerator and denominator are given in the tables below for sea level, P_a = 14.7 psia

$$V_t = V_s \frac{N}{D}$$ (see tables below for **N & D**)

- V_t = volume of expansion tank, gallons
- V_s = volume of system, gallons
- t_1 = fill temperature
- t_2 = maximum temperature for system
- P_a = atmospheric pressure (absolute), psia
- P_1 = fill pressure (absolute), psia
- P_2 = maximum allowable pressure (less than relief valve)
- ν_1 = specific volume of water at fill temperature, ft^3/lb
- ν_2 = specific volume of water at max. temperature, ft^3/lb
- α = linear coefficient of thermal expansion for pipe
  - = 6.5×10^{-6} in/in-°F for steel (used for data below)
  - = 9.5×10^{-6} in/in-°F for copper
- Δt = $(t_2 - t_1)$, °F

$$P_1 = \frac{\text{System Height - Height to Tank}}{144 \times \nu_1} + \text{Min Pressure at Top}$$ (5 or 10 psig usually)

N

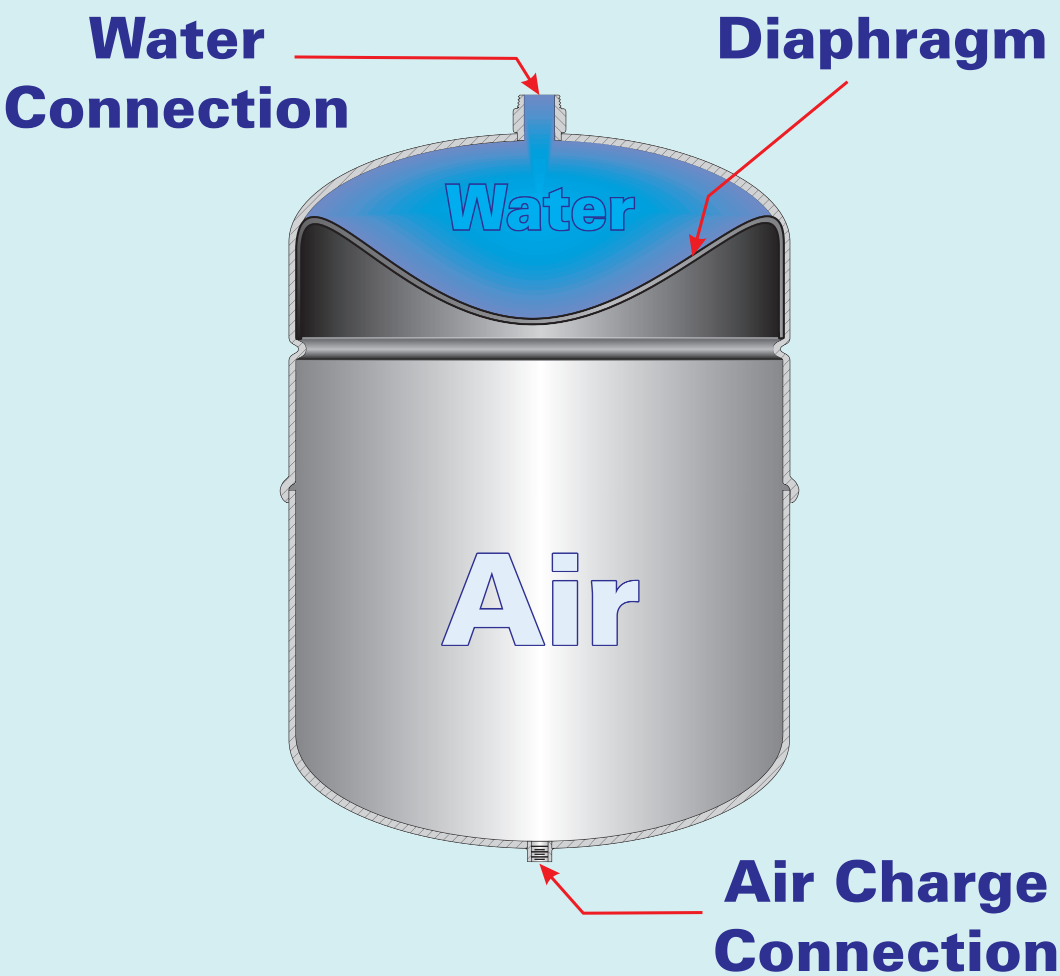
Max Temp	Fill Temp 40	Fill Temp 50	Fill Temp 60
100°F	0.00575	0.00569	0.00520
110°F	0.00771	0.00765	0.00716
120°F	0.0100	0.0099	0.0095
130°F	0.0124	0.0123	0.0118
140°F	0.0150	0.0149	0.0145
150°F	0.0179	0.0178	0.0173
160°F	0.0209	0.0208	0.0204
170°F	0.0242	0.0241	0.0236
180°F	0.0276	0.0275	0.0271
190°F	0.0313	0.0312	0.0307
200°F	0.0351	0.0350	0.0346
210°F	0.0391	0.0390	0.0386
220°F	0.0434	0.0433	0.0428
230°F	0.0476	0.0475	0.0471
240°F	0.0522	0.0521	0.0517

D

Max. Oper. Pressure (psig)	Fill Pressure (psig) 5	10	12	15	20	30	40	50	60	70	80
27	0.527	0.408	0.360	0.288	0.168	—	—	—	—	—	—
30	0.560	0.447	0.403	0.336	0.224	—	—	—	—	—	—
35	0.604	0.503	0.463	0.403	0.302	0.101	—	—	—	—	—
40	0.640	0.548	0.512	0.457	0.366	0.183	—	—	—	—	—
45	0.670	0.586	0.553	0.503	0.419	0.251	0.084	—	—	—	—
50	0.696	0.618	0.587	0.541	0.464	0.309	0.155	—	—	—	—
55	0.717	0.646	0.617	0.574	0.502	0.359	0.215	0.072	—	—	—
60	0.736	0.669	0.643	0.602	0.536	0.402	0.268	0.134	—	—	—
65	0.753	0.690	0.665	0.627	0.565	0.439	0.314	0.188	0.062	—	—
70	0.767	0.708	0.685	0.649	0.590	0.472	0.354	0.236	0.118	—	—
75	0.780	0.725	0.702	0.669	0.613	0.502	0.390	0.279	0.167	0.056	—
80	0.792	0.739	0.718	0.686	0.634	0.528	0.422	0.317	0.211	0.106	—
90	0.812	0.764	0.745	0.716	0.669	0.573	0.478	0.382	0.287	0.191	0.096
100	0.828	0.785	0.767	0.741	0.698	0.610	0.523	0.436	0.347	0.261	0.174

Note: For 50/50 Propylene Glycol multiply Expansion Factor X 3

DIAPHRAGM EXPANSION TANK



TIPS:

Always install with water connection up – this assures the diaphragm or bladder will always be wetted.

Always charge the tank air pressure to the required fill pressure with the tank disconnected from the system.

Figure 5.17: Typical Diaphragm Tank

Table 5.6: Compression Tank

COMPRESSION TANK

(WITH AIR/WATER INTERFACE)

CALCULATE SYSTEM VOLUME INCLUDING PIPING AND ALL COMPONENTS

Pipe Size	Steel Pipe ID	Steel Gallons Per Foot	Copper Pipe ID	Copper Gallons Per Foot
1/2	0.622	0.016	0.545	0.012
3/4	0.824	0.028	0.785	0.025
1	1.049	0.045	1.025	0.043
1 1/4	1.380	0.078	1.265	0.065
1 1/2	1.610	0.106	1.505	0.092
2	2.067	0.174	1.985	0.161
2 1/2	2.469	0.249	2.465	0.248
3	3.068	0.384	2.945	0.354
4	4.026	0.661	3.905	0.622
5	5.047	1.04	4.875	0.970
6	6.065	1.50	5.845	1.394
8	7.981	2.60		
10	10.020	4.10		
12	12.000	5.88		

HEATING UNIT VOLUME ESTIMATES

TYPE		RULE OF THUMB
Cast Iron Radiation	Columnar	0.114 Gallons per Sqare Foot EDR
	Thin Tube	0.056 Gallons per Square Foot EDR
	Convectors	1.5 Gallons per 10,000 Btuh (@200°F)
	Baseboard	4.7 Gallons per 10,000 Btuh (@200°F)
Copper Radiation	Convectors	0.64 Gallons per 10,000 Btuh (@200°F)
	Baseboard (3/4")	0.37 Gallons per 10,000 Btuh (@200°F)
Fan Coil Unit Heater	Default	0.2 Gallons per 10,000 Btuh (@180oF)
GM Modules	GM-05	6.15 Gallons per Module
	GM-06	7.20 Gallons per Module
	GM-07	8.25 Gallons per Module
	GM-08	9.30 Gallons per Module

CALCULATE REQUIRED TANK VOLUME (DATA FOR SEA LEVEL)

$$V_t = V_s \frac{\left[(\nu_2/\nu_1) - 1\right] - 3\alpha\Delta t}{(P_a/P_1) - (P_a/P_2)}$$

V_t = volume of expansion tank, gallons
V_s = volume of system, gallons
t_1 = fill temperature
t_2 = maximum temperature for system
P_a = atmospheric pressure (absolute), psia
P_1 = fill pressure (absolute), psia
P_2 = maximum allowable pressure (less than relief valve)
ν_1 = specific volume of water at fill temperature, ft^3/lb
ν_2 = specific volume of water at max. temperature, ft^3/lb
α = linear coefficient of thermal expansion for pipe
= 6.5×10^{-6} in/in-°F for steel (used for data below)
= 9.5×10^{-6} in/in-°F for copper

The numerator and denominator are given in the tables below for sea level, P_a = 14.7 psia

$$V_t = V_s \frac{N}{D}$$ (see tables below for **N & D**)

$$P_1 = \frac{\text{System Height - Height to Tank}}{144 \times \nu_1} + \text{Min Pressure at Top (5 or 10 psig usually)}$$

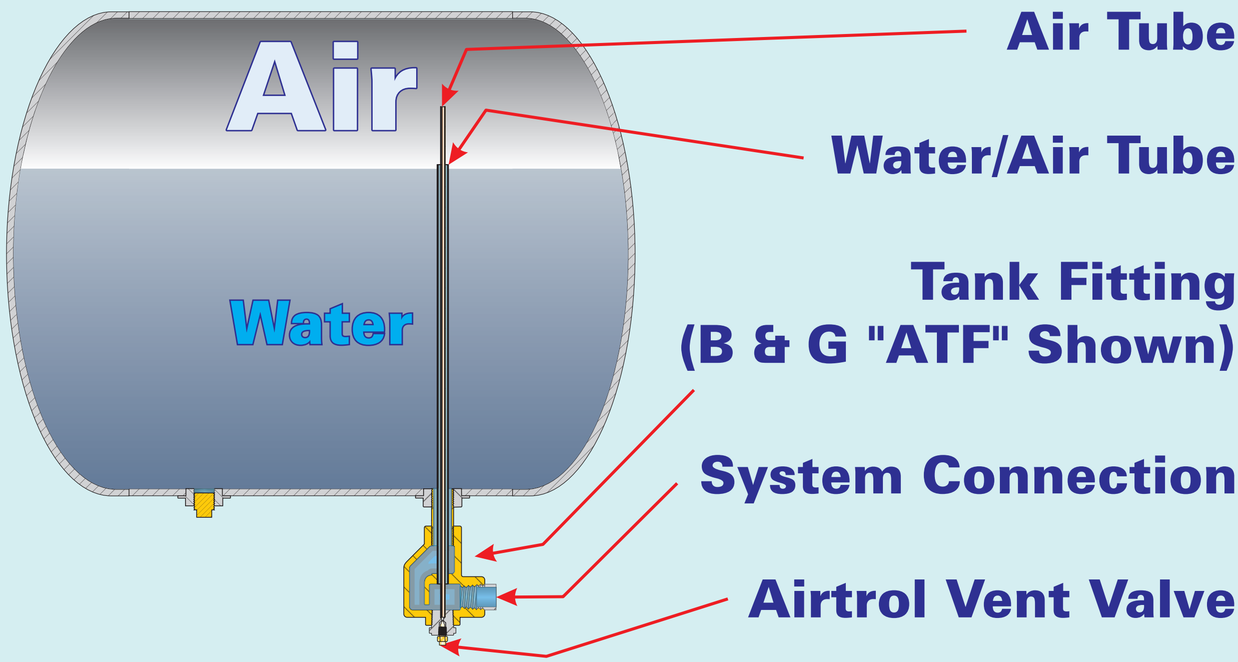
N

Max Temp	Fill Temp 40	Fill Temp 50	Fill Temp 60
100	0.00570	0.00589	0.00483
110	0.00800	0.00819	0.00713
120	0.00968	0.00987	0.00881
130	0.0126	0.0128	0.0117
140	0.0149	0.0151	0.0140
150	0.0178	0.0180	0.0169
160	0.0208	0.0210	0.0199
170	0.0243	0.0245	0.0234
180	0.0279	0.0281	0.0270
190	0.0314	0.0316	0.0305
200	0.0350	0.0352	0.0341
210	0.0391	0.0393	0.0382
220	0.0433	0.0435	0.0424
230	0.0475	0.0477	0.0466
240	0.0523	0.0525	0.0514

D

Fill Pressure	Allowable Pressure Rise 6	8	10	12	15	20	25	30	40	50
8	0.135	0.169	0.198	0.224	0.258	0.303	0.339	0.369	0.413	0.445
10	0.116	0.146	0.172	0.195	0.225	0.266	0.299	0.326	0.368	0.398
12	0.101	0.127	0.150	0.171	0.198	0.236	0.266	0.291	0.330	0.359
16	0.0783	0.0990	0.118	0.135	0.157	0.189	0.215	0.237	0.271	0.297
20	0.0625	0.0794	0.095	0.109	0.128	0.155	0.177	0.196	0.227	0.250
25	0.0486	0.0621	0.0745	0.0859	0.102	0.124	0.143	0.159	0.186	0.206
30	0.0389	0.0499	0.0601	0.0696	0.0826	0.102	0.118	0.132	0.155	0.174
40	0.0266	0.0343	0.0415	0.0483	0.0578	0.0720	0.0843	0.0952	0.114	0.128
50	0.0193	0.0250	0.0304	0.0355	0.0428	0.0536	0.0633	0.0720	0.0868	0.0990
60	0.0146	0.0190	0.0232	0.0272	0.0329	0.0416	0.0493	0.0564	0.0686	0.0789
70	0.0115	0.0150	0.0183	0.0215	0.0261	0.0332	0.0396	0.0454	0.0557	0.0644
80	0.0092	0.0121	0.0148	0.0175	0.0212	0.0271	0.0324	0.0373	0.0461	0.0536

COMPRESSION TANK



TIPS:

- ❑ Always use a tank fitting (such as the B&G ATF Fitting Shown).
- ❑ Never install automatic air vents in the heating system when using compression tanks – they will cause the tank to waterlog.
- ❑ The initial (cold) fill should raise the water level to 2/3 of the tank diameter. The insertion length of a tank fitting is set to accomplish this.
- ❑ Connect the system to the compression tank with no smaller than ¾" pipe – to allow room for air to move up the pipe to the tank.

Figure 5.18: Typical Compression Tank – Note Use of Tank Fitting – See Table for Sizing

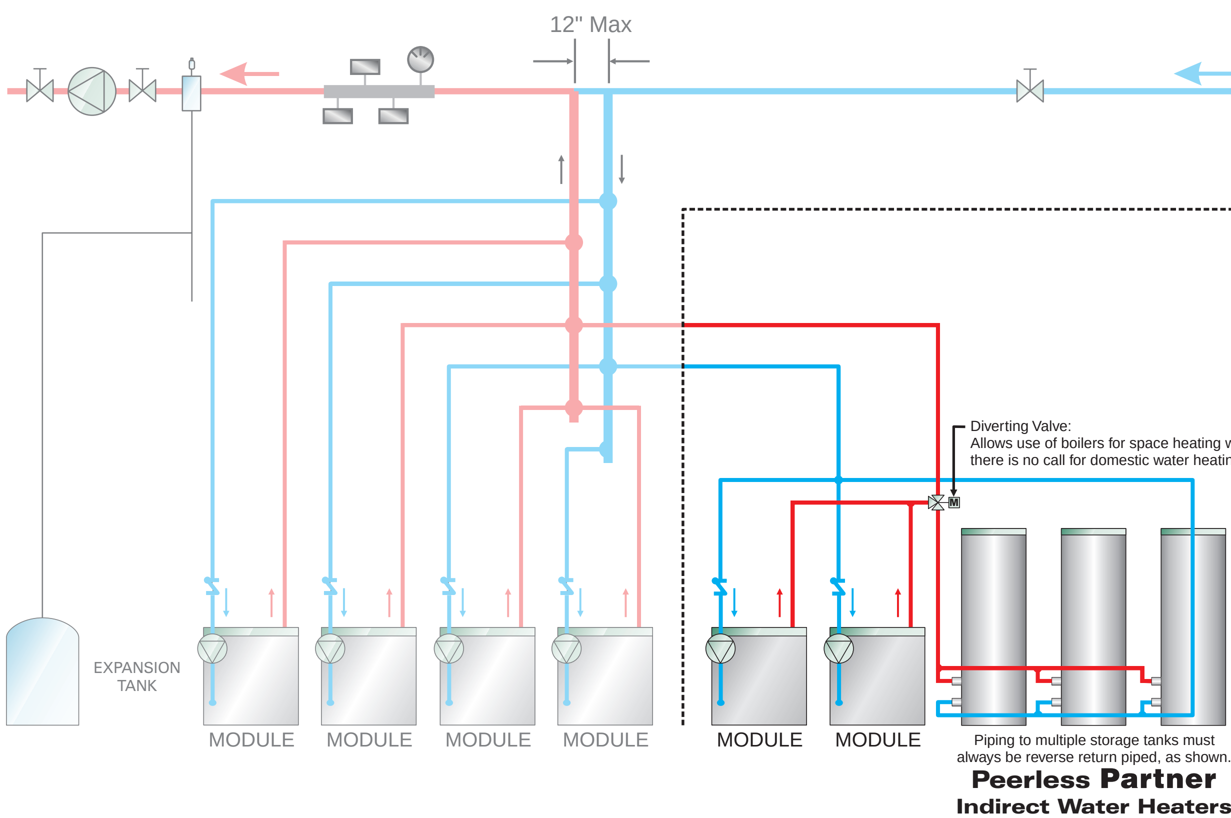
6. PEERLESS® PARTNER® DHW SYSTEMS

A. MODELS

1. Peerless® Partner® indirect-fired water heaters are available in five sizes, from 30 gallons to 119 gallons (Figure 2.6 in Section 2).
2. All models use a low pressure drop coil to reduce the circulator requirements for boiler water circulation and provide high output from the water heater.

B. PIPING

1. See Figures 6.1 and 6.2 for piping of typical domestic water systems using Series GM™ Modular Boilers and Peerless® Partner® Indirect-Fired Water Heaters.
   a) Figure 6.2 shows a typical system with a modular boiler dedicated to domestic water heating and a separate modular boiler for space heating.
   b) Figure 6.1 shows a typical system using combined space heating and water heating. In this example a diverting valve is used to prioritize the heat from some of the modules for domestic water heating. When domestic needs are satisfied these modules may be used for space heating.
   c) Peerless® Partner® domestic water systems may also be piped as an additional heating zone. See system piping section and consider Peerless® Partner® as one "load" in the system
2. Select a circulator(s) that will supply the flow rate required for the needed first hour capacity. See Figure 2.6 in Section 2 for the first hour ratings of the Peerless® Partner® indirect-fired water heaters.
   a) The flow rate through the Peerless® Partner® indirect-fired water heaters will be the combined flow from the circulators. Only the amount of flow and heat needed for the domestic water load will be activated with this arrangement.



INDIRECT-FIRED WATER HEATER PIPING

Figure 6.1: Dedicated Boiler Modules for Combined DHW and Space Heating – Primary-Secondary Boiler Piping Using FLEX-HEAT® Circulators Return Water Temperatures Above 130°F

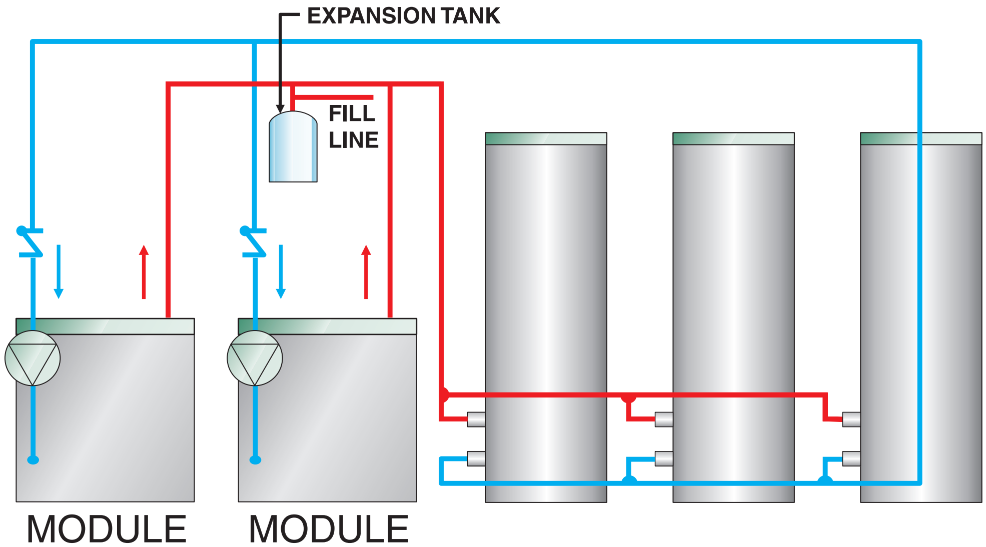


Figure 6.2: **Boiler Modules Dedicated to DHW Heating Only – Primary-Secondary Piping Using FLEX-HEAT® Circulators DHW Return Water Temperatures Above 130°F**

7. GAS PIPING

A. CODES & STANDARDS

1. Size and install the piping in accordance with the National Fuel Gas Code, ANSI Z223.1, NFPA 54 and all applicable local and state codes.
2. The sizing information and guidelines given in this Guide are based on the National Fuel Gas Code, 1996.

B. INSTALLATION GUIDELINES

1. Use only pipe joint compounds listed by Underwriters Laboratories for use with propane gas. This is necessary because most natural gas includes some propane content.
2. Maximum Pressure:
   a) The gas valves on Series GM™ Modular Boilers are rated for maximum 1/2 psig gas pressure. If the supply pressure can at any time exceed this pressure install a main gas pressure regulator of the lock-up type which will reduce and control the pressure to be less than 1/2 psig at all times.
   b) Isolate the boiler gas control train from the system during pressure tests. If the test pressure is less than 1/2 psig close the boiler gas valve manual shut-off knob. If the test pressure is over 1/2 psig, close the service valve ahead of each module if the valve pressure rating is adequate. Otherwise, disconnect the gas supply piping from the modules.
   c) Any pressure in excess of 1/2 psig at the modules will pose the risk of nuisance problems (failure to open) or serious hazard as indicated below:

WARNING	Do not expose the Gas Control Train to excess pressure (over 1/2 psig). The gas valves could be damaged. This could result in severe personal injury or death. Do not test gas supply piping with an open flame. Use a soap suds mixture brushed onto the pipe joints to test for leaks.

3. Minimum Pressure:
   a) The minimum natural gas supply pressure at the modules is 4.5 - 5.5" water column depending on model (see module rating plates). Make sure the system regulator and the piping are sized and adjusted properly to provide the pressure required to all modules under all flow conditions.

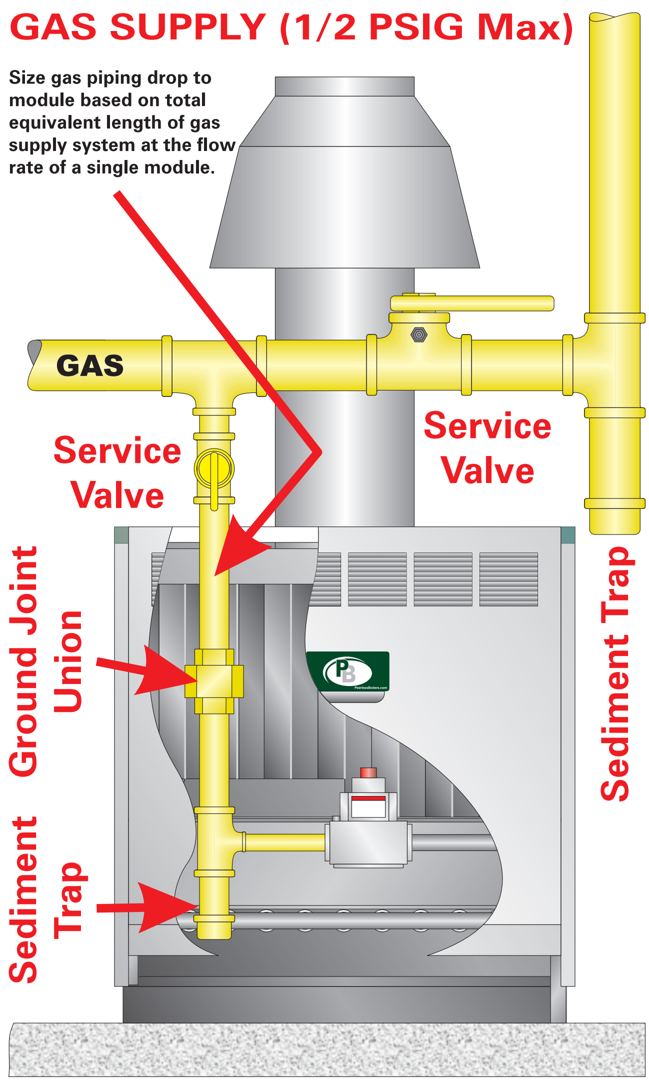


Figure 7.1: Gas Piping Sediment Trap, Detail

   b) The minimum LP gas supply pressure at the modules is 11.0" water column.

4. Install service valves and sediment traps at the supply connection to each module and ahead of the combined gas piping feeding the modular system. Install a ground joint union in the gas piping connection at each Module (Figures 3.3, 3.4 and 7.1).

C. SUPPORT THE GAS PIPING

1. Follow the National Fuel Gas Code and local requirements for support of the gas piping.
2. Refer to Table 7.1 below for NFGC requirements for support of piping.

Table 7.1

NATIONAL FUEL GAS CODE REQUIREMENTS FOR SUPPORT OF GAS PIPING	
Steel Pipe Nominal Size (Inches)	**Spacing of Supports (Feet)**
1/2″	6′
3/4″ or 1″	8′
1-1/4″ or Larger, Horizontal	10′
1-1/4″ or Larger, Vertical	Every Floor Level

D. GAS PIPE SIZING

1. Determine Equivalent Length of Pipe
   a) Table 7.3 gives the equivalent length in feet of pipe for common gas train piping components.
   b) Begin by determining the measured length of piping (in feet) from the main regulator to the furthest module.
   c) For a first estimate of gas train size, use a trial equivalent length of 1.5 times the measured length.
2. Select a gas train size from the Capacity Table capable of carrying the total connected gas load using this trial length (see below for flow requirements per module).
   a) Using this gas train size calculate the actual equivalent length for the gas piping system. With this new, actual length, check the gas train size for the capacity. Refine the size if needed and repeat the process.
   b) You can select graduated sizing for the gas supply by using the total equivalent length for all sections of the piping but select pipe size based on the gas flow going through that piping segment.
3. Gas Piping Drop to Modules
   a) Select the size of the piping drop to the modules from the Capacity Table as well.
   b) **Do not size the drop the same as the module gas valve connection size.**
   c) Select a pipe size for the drop to the modules from the Capacity Table **based on the flow rate to the individual modules but with the equivalent length for the entire gas system.**
4. Gas Flow Requirements
   a) See Table 7.2 below for gas train size and flow of natural gas for Series GM™ Modules.

Table 7.2

GM SERIES MODULAR BOILERS GAS FLOW REQUIREMENTS			
Model	**Natural Gas Cubic Feet Per Hour (1000 Btu/Ft^3)**	**LP Gas Cubic Feet Per Hour (2500 Btu/Ft^3)**	**Gas Valve Pipe Size (Inches)***
GM-e-05	214.5	86	3/4” NPT
GM-e-06	268	107	3/4” NPT
GM-07	342	137	3/4” NPT
GM-08	399	160	3/4” NPT

* Do not size the gas piping drop to the module gas valves the same size as the gas valve connection. Size it based on the flow to the module with an equivalent length of flow equal to the ENTIRE SYSTEM EQUIVALENT LENGTH. This will usually result in a gas supply pipe size of 1” to 2” NPT.

   b) See Table 7.3 for sizing the gas train for natural gas with specific gravity of 0.60.
   c) For other specific gravity gas multiply the capacities in Table 7.4 by the correction factors in Table 7.5.
   d) The sizing table is based on gas supply pressure 1/2 psig or less with a pressure drop of 0.3 inch water column. For other conditions, refer to the National Fuel Gas Code, ANSI Z223.1.

Table 7.3: Equivalent Length (feet) for Common Gas Train Components

Pipe Size (In.)	Pipe I.D. (In.)	L = equivalent length in feet of Schedule 40 (standard weight) straight pipe								
		Screwed fittings[2]				90° welding elbows and smooth bends[1]	Valves (screwed, flanged, or welded)			
		45° ell	90° ell	180° close return bends	Tee		Gate	Globe	Angle	Swing check
1/2	0.622	0.73	1.55	3.47	3.1	0.83	0.36	17.3	8.65	4.32
3/4	0.824	0.96	2.06	4.6	4.12	1.1	0.48	22.9	11.4	5.72
1	1.049	1.22	2.62	5.82	5.24	1.4	0.61	29.1	14.6	7.27
1 1/4	1.380	1.61	3.45	7.66	6.9	1.84	0.81	38.3	19.1	9.58
1 1/2	1.610	1.88	4.02	8.95	8.04	2.14	0.94	44.7	22.4	11.2
2	2.067	2.41	5.17	11.5	10.3	2.76	1.21	57.4	28.7	14.4
2 1/2	2.469	2.88	6.16	13.7	12.3	3.29	1.44	68.5	34.3	17.1
3	3.068	3.58	7.67	17.1	15.3	4.09	1.79	85.2	42.6	21.3
4	4.026	4.7	10.1	22.4	20.2	5.37	2.35	112	56	28
5	5.047	5.88	12.6	28	25.2	6.72	2.94	140	70	35
6	6.065	7.07	15.2	33.8	30.4	8.09	3.54	168	84.1	42.1

1. Values for welded fittings are for conditions where bore is not obstructed by weld spatter or backing rings. If appreciably obstructed, use values for "Screwed Fittings."
2. Flanged fittings have three-fourths the resistance of screwed elbows and tees.

Table 7.4: Pipe Capacity for Natural Gas, Specific Gravity 0.60

Maximum Capacity of Pipe in Cubic Feet of Gas per Hour for Gas Pressures of 0.5 psig or Less and a Pressure Drop of 0.3 Inch Water Column

(Based on a 0.60 Specific Gravity Gas)

Pipe Size (In.)	Pipe I.D. (In.)	Length of Pipe, Feet													
		10	20	30	40	50	60	70	80	90	100	125	150	175	200
1/2	0.622	132	92	73	63	56	50	46	43	40	38	34	31	28	26
3/4	0.824	278	190	152	130	115	105	96	90	84	79	72	64	59	55
1	1.049	520	350	285	245	215	195	180	170	160	150	130	120	110	100
1 1/4	1.38	1,050	730	590	500	440	400	370	350	320	305	275	250	225	210
1 1/2	1.61	1,600	1,100	890	760	670	610	560	530	490	460	410	380	350	320
2	2.067	3,050	2,100	1,650	1,450	1,270	1,150	1,050	990	930	870	780	710	650	610
2 1/2	2.469	4,800	3,300	2,700	2,300	2,000	1,850	1,700	1,600	1,500	1,400	1,250	1,130	1,050	980
3	3.068	8,500	5,900	4,700	4,100	3,600	3,250	3,000	2,800	2,600	2,500	2,200	2,000	1,850	1,700
4	4.026	17,500	12,000	9,700	8,300	7,400	6,800	6,200	5,800	5,400	5,100	4,500	4,100	3,800	3,500

Table 7.5: Correction Factors for Specific Gravity Other Than 0.60

Multiply Piping Capacities by the Following Multiplier for Specific Gravity of Gas Other Than 0.60

Specific Gravity	Multipler	Specific Gravity	Multiplier	Specific Gravity	Multipler	Specific Gravity	Multiplier
.35	1.31	.65	.96	1.00	.78	1.60	.61
.40	1.23	.70	.93	1.10	.74	1.70	.59
.45	1.16	.75	.90	1.20	.71	1.80	.58
.50	1.10	.80	.87	1.30	.68	1.90	.56
.55	1.04	.85	.84	1.40	.66	2.00	.55
.60	1.00	.90	.82	1.50	.63	2.10	.54

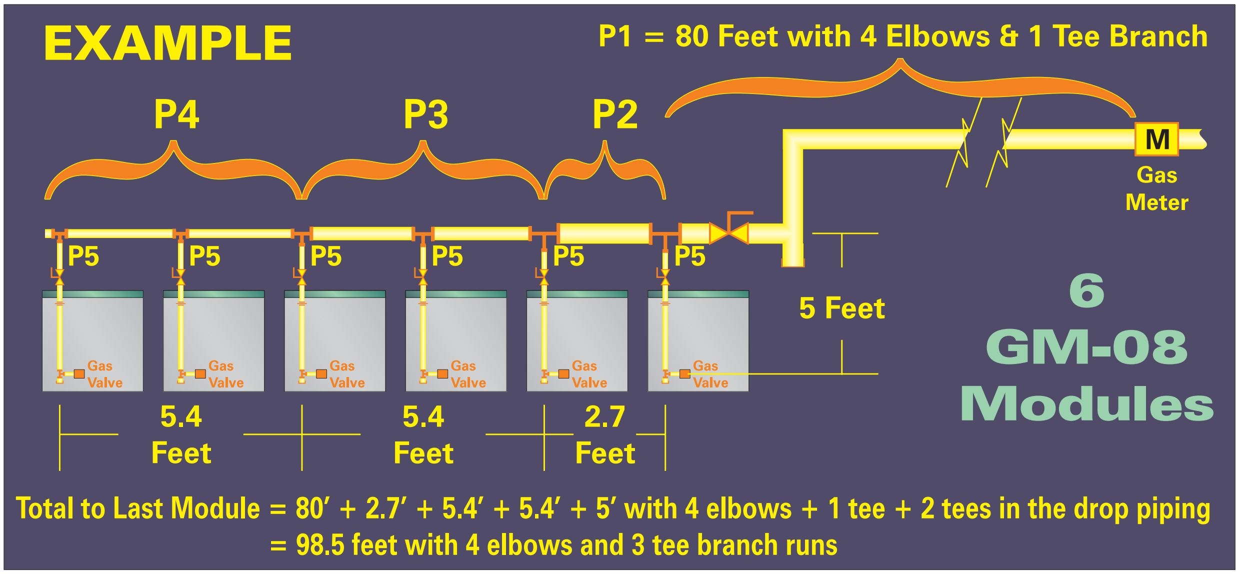


Figure 7.2: Gas Pipe Sizing Example

E. GAS PIPE SIZING EXAMPLE

1. Figure 7.2 is a schematic piping diagram of (6) Natural Gas GM-08 modules on 32” centers as shown. The example will be for natural gas at 0.60 specific gravity.
   a) P1 = piping from gas meter to first module, consisting of 80 feet of pipe with four 90 degree elbows; it carries gas to all 6 modules, or 6 times 399 ft^3 = 2394 scfh.
   b) Piping P2 carries gas to module 2 through 6, or 5 times 399 ft^3 = 1995 scfh.
   c) Piping P3 carries gas to modules 3 through 6, or 4 times 399 ft^3 = 1596 scfh.
   d) Piping P4 carries gas to modules 5 through 6, or 2 times 399 ft^3 = 798 scfh.
   e) Piping P5 is the gas line drop to each module, the flow being 399 scfh in each P5.
   f) The total piping feeding module 6 is, as shown, 98.5 feet of pipe with 4 elbows & 3 tees.

2. Use the Tables to Size Piping.
   a) Estimate TEL (total equivalent length) as 1.5 times the running length, so TEL=1.5 x 98.5 =147.8 feet.
   b) For 2394 scfh gas through a TEL of 147.8 feet the gas line would have to be 4” (from the 150 foot column of Table 7.4).
   c) From Table 7.3 the equivalent length of a 90 degree elbow for 4” pipe is 10.1 feet. Each tee (branch) would be 20.2 feet. The TEL for 4” pipe would, then, be: TEL=98.5 + 4 x 10.1 + 3 x 20.2=199.5 feet.
   d) Check Table 7.4 for 2394 scfh at 199.5 feet TEL (200 foot column).
   e) See that a 4” pipe will work for P1.
   f) For P2, TEL = 199.5, flow = 1995; P2 will also have to be 4”.
   g) For P3, TEL = 199.5, flow = 1596; select 3” gas piping from Table 7.4; For P4, select 2-1/2” for a flow of 798 scfh.
   h) Select 2” pipe for P5 to carry 399 scfh.

8. ELECTRICAL WIRING & CONTROLS

A. CODES & STANDARDS

1. Wire according to the National Electrical Code and local code requirements.

B. GENERAL GUIDELINES

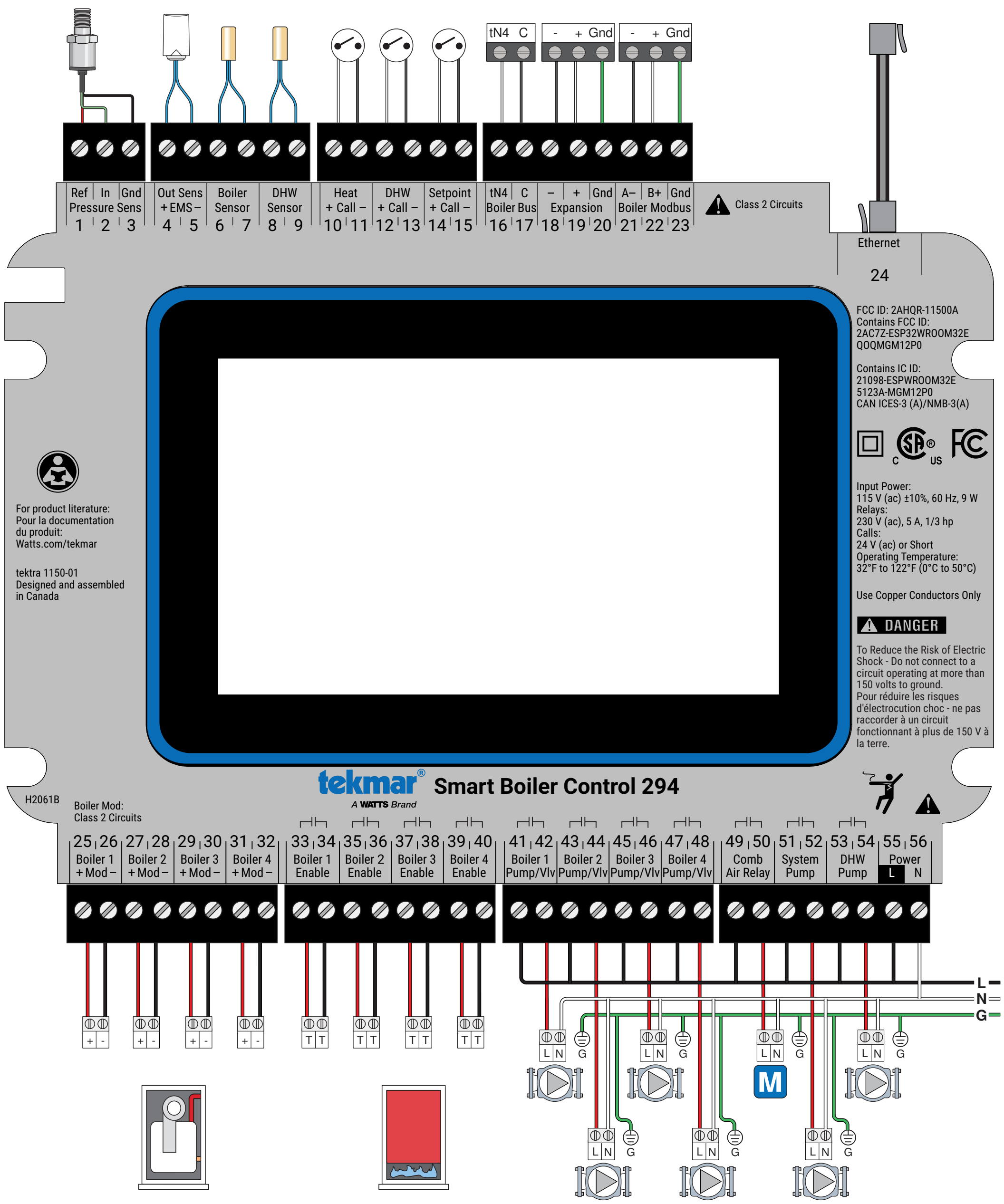
1. The tekmar® 294 series control operates the boilers to maintain system water temperatures according to outdoor temperature and/or heatpoint demand as shown in Figure 8.1. The 294EXP expansion control, as shown in Figure 8.2, allows for boiler expansion up to 16 total boilers. For more detailed information regarding the tekmar® controls, refer to instructions packed with the controls.

   Note that the tekmar® controls are boiler controllers. For information on zone controllers, contact tekmar® regarding their 300 series controls.

2. For optimum domestic water control, tekmar® recommends inserting the tekmar® DWH sensor in the Peerless® Partner® limit well. Mount the Honeywell limit in the domestic water outlet piping as close to the Peerless® Partner® as possible and with no intervening valves.

tekmar® 294 Control

The 294 control allows for the control of four boilers based on outdoor air temperature, control for indirect Domestic Hot Water (DHW) generation and a Setpoint load.

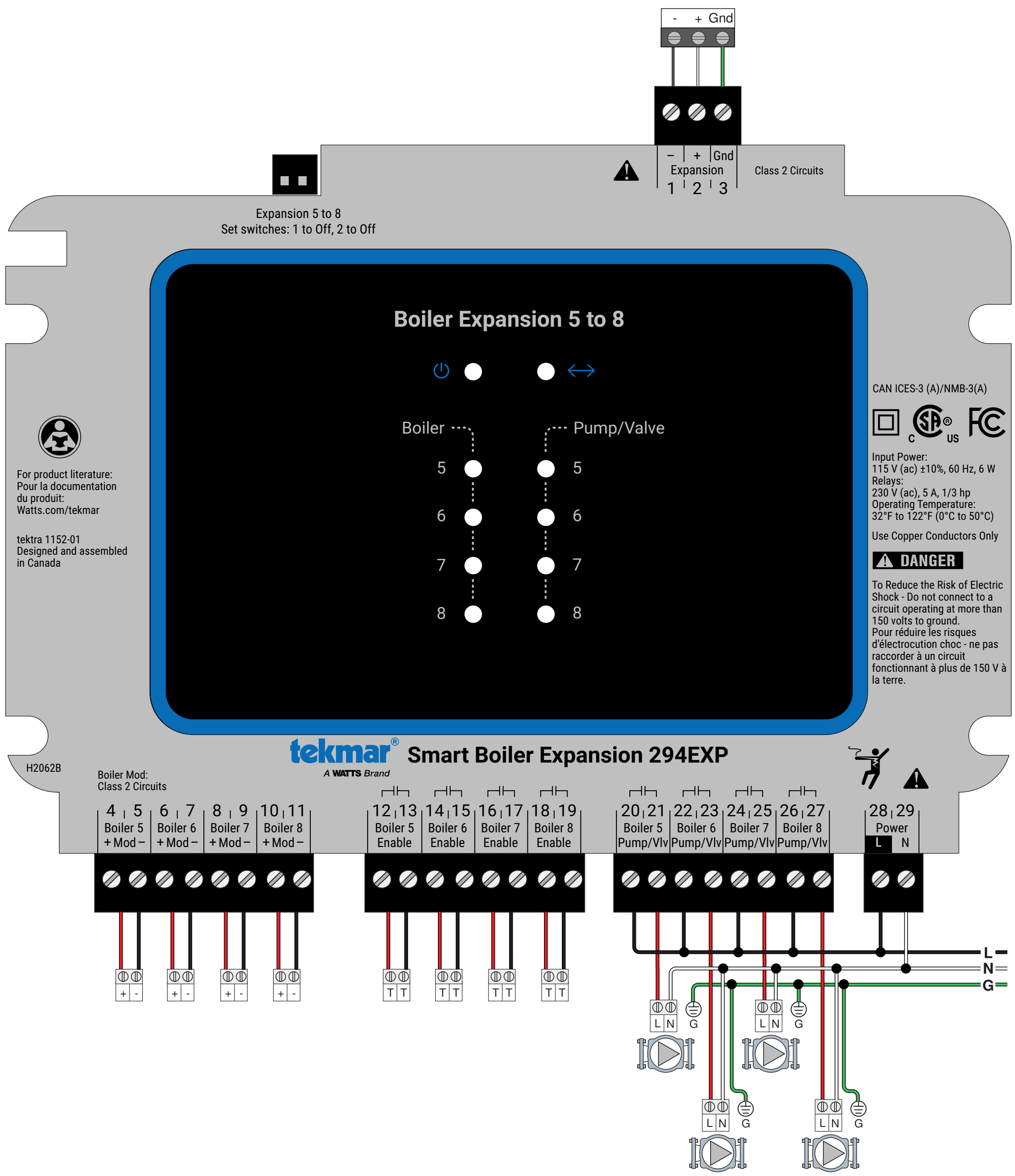


For more detailed information, please refer to tekmar® Data Brochure Number D263.

Figure 8.1: Model 294 Control – To 4 Stages for Boiler Sequencing & DHW Priority Options

tekmar® 294EXP Control

The 294EXP control allows for the control of four expansion boilers, up to 16 total, based on outdoor air temperature, control for indirect Domestic Hot Water (DHW) generation and a Setpoint load.



For more detailed information, please refer to tekmar® Data Brochure Number D274.

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Figure 8.2: Model 294EXP Control

Series GM™

Gas Boilers

FLEX-HEAT®
HYDRONIC COMFORT SYSTEM

Design & Application Guide

PeerlessBoilers.com

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