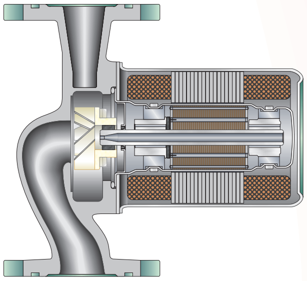
FULL-COLOR TRAINING GUIDE SERIES

PeerlessBoilers.com

The COLOR of Water



PIPING & DESIGNING HYDRONIC SYSTEMS

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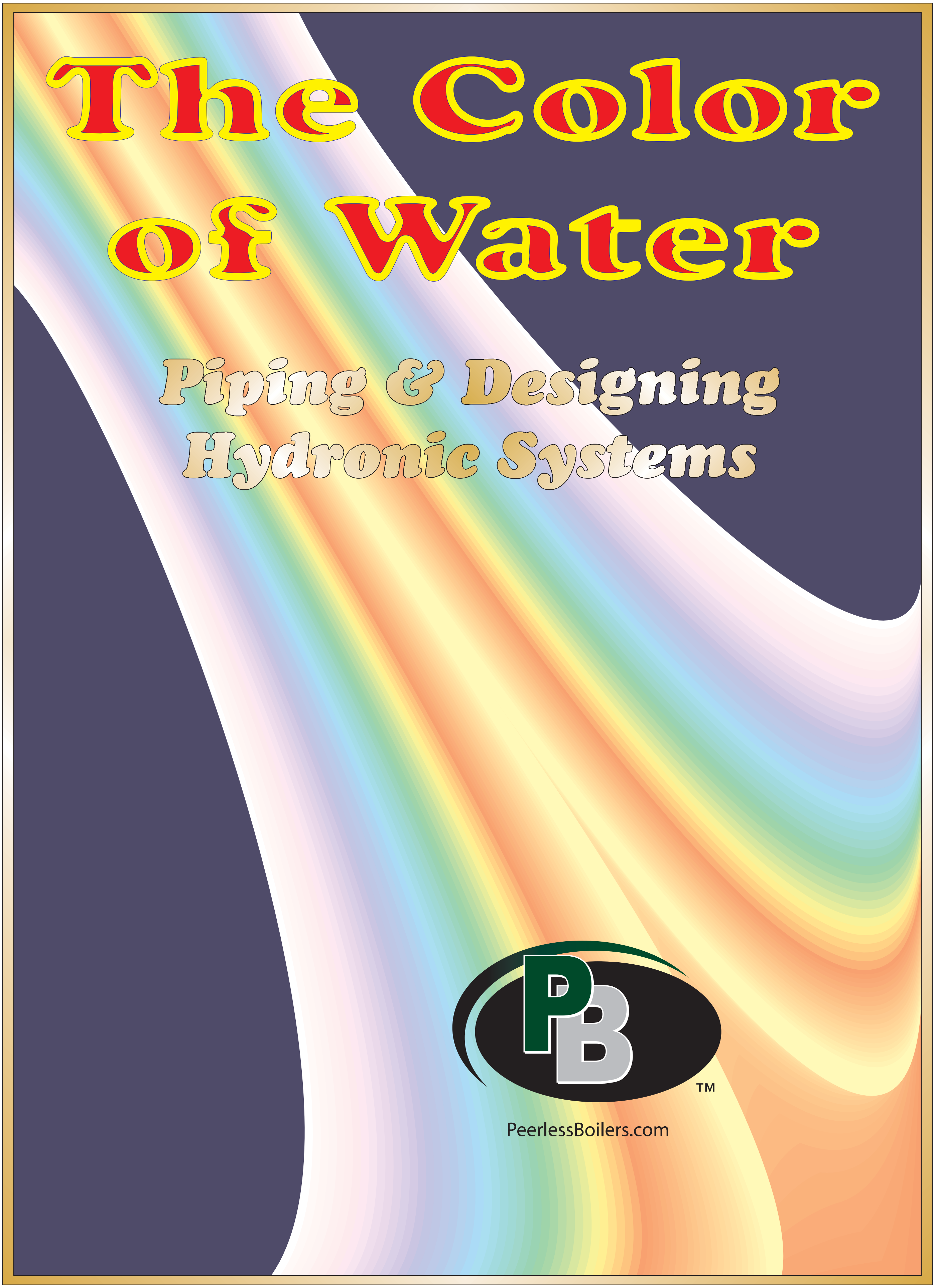
Installation and Training Information



The Color of Water

Piping & Designing Hydronic Systems

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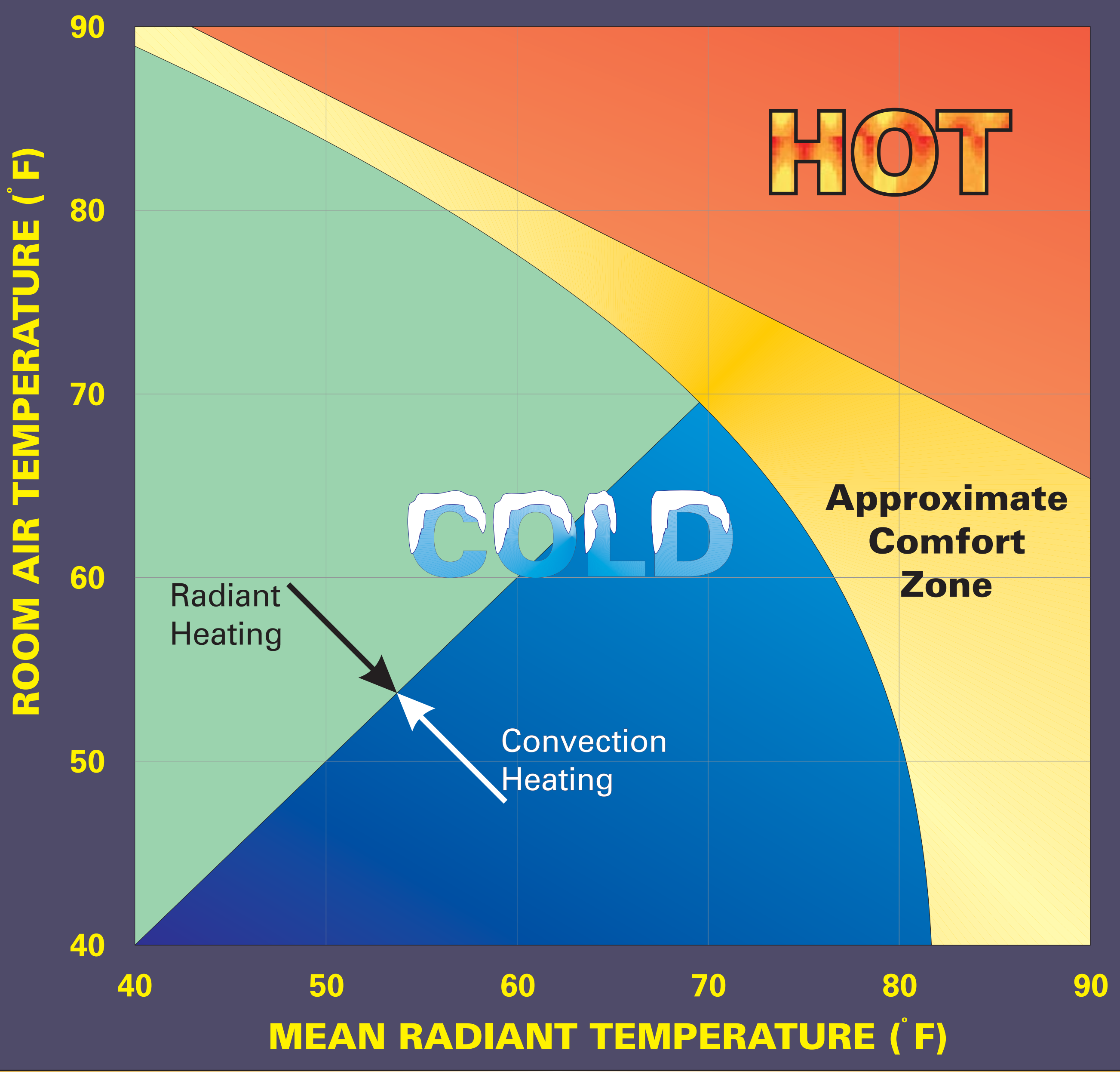
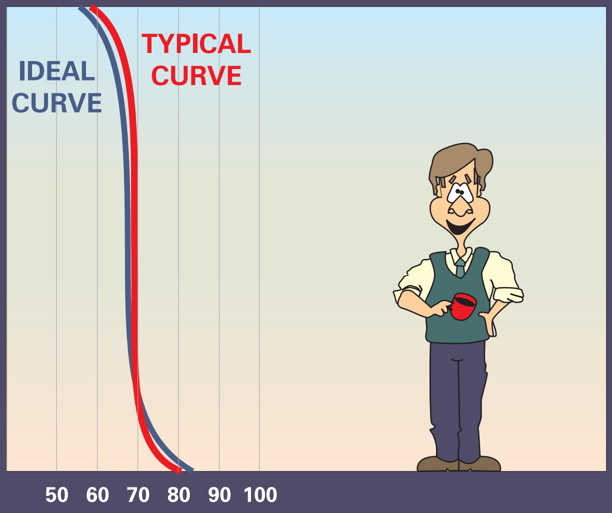
The Color of Water

COMFORT ZONE VS MEAN RADIANT TEMPERATURE

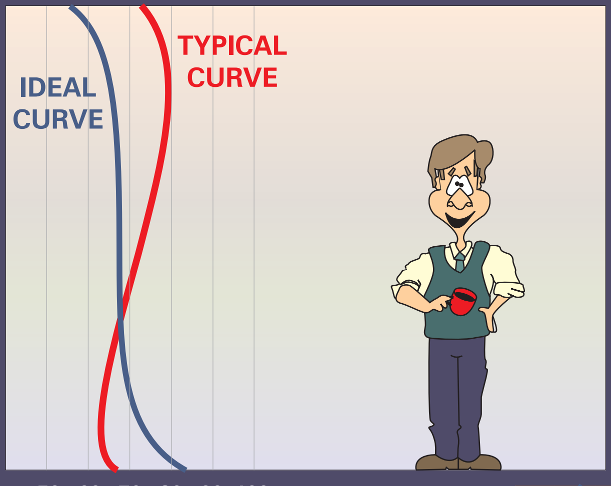


Hydronic systems heat the outside walls. Radiant floor systems heat all of the room contents. This raises the mean radiant temperature in the room – the average temperature of all surfaces. So the range of comfort is much wider for a hydronic system than a warm air system.

HYDRONIC COMFORT

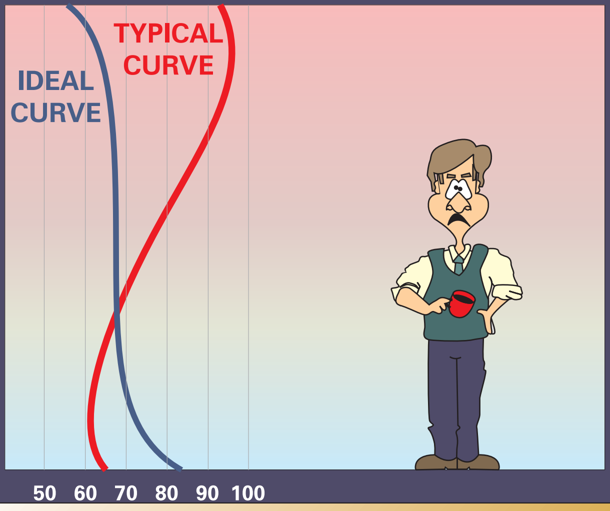


RADIANT FLOOR SYSTEMS (Typical Temperature Map)



HYDRONIC BASEBOARD SYSTEMS (Typical Temperature Map)

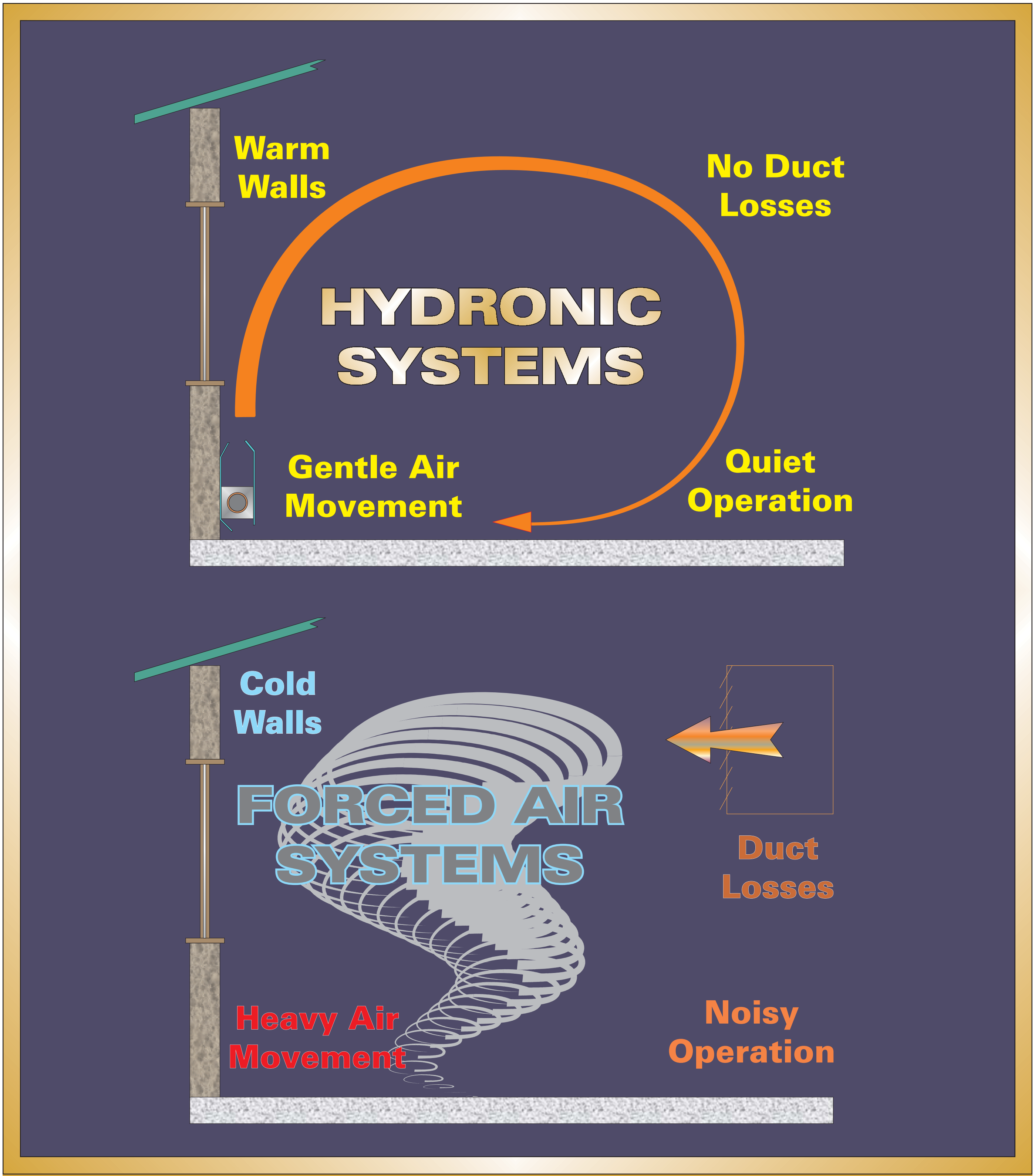
FORCED AIR SYSTEMS (Typical Temperature Map)



Hydronic systems provide a better temperature distribution in the room.

The Ideal is warm feet and cool head.

Radiant floor systems provide the best results. The temperature map almost exactly matches the Ideal Heating Curve.



Hydronic heating is comfortable, quiet and efficient.

Warm air heating cannot equal the performance of a hydronic system.

HYDRONIC COMFORT

WARM WALLS

Baseboard radiation heats the wall with the warm air currents rising upward. Radiant floor systems heat the walls by radiation. Warm walls make us more comfortable since we don't radiate heat to them.

GENTLE AIR MOVEMENT

The heat circulates gently and radiates in a room with hydronic heating. Contrast this to the high velocity air blown all around the house in a forced air system. This causes dust, dirt and germs to spread.

NO DUCT LOSSES

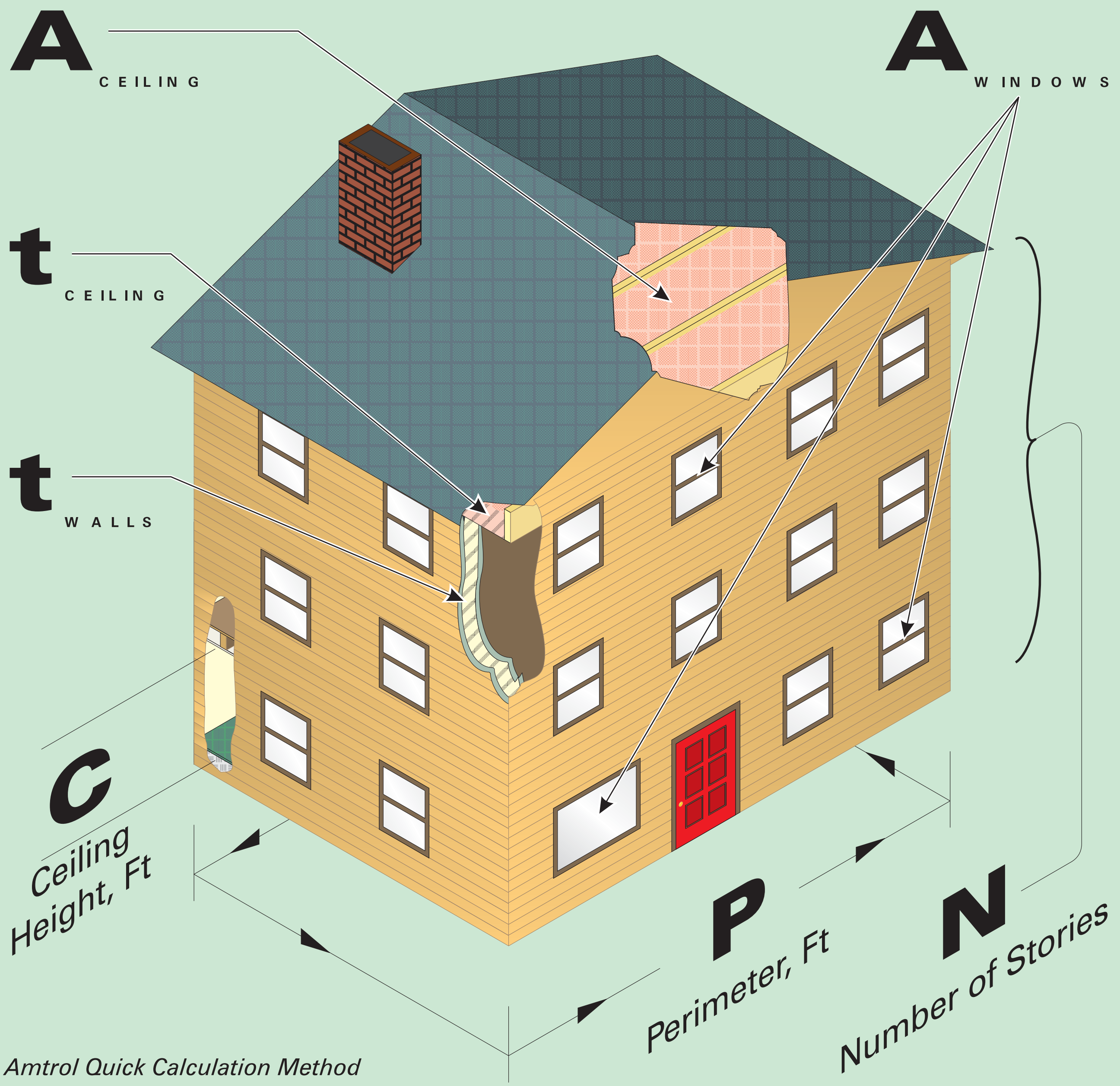
Heat is distributed to the radiation in small pipes in a hydronic system. Little energy is wasted. But forced air systems lose energy through heat loss and air leakage from the ducts to unheated spaces. So hydronic systems provide higher whole house efficiency.

QUIET OPERATION

Hydronic heating is quiet. There is no noise from air movement in ducts, no blower and no large motors to run the system. And boilers run quieter as well. They are designed to run as quietly as possible – matched to the system.

Hydronic heating is the best choice for comfort and efficiency.

HEAT LOAD CALCULATIONS



Amtrol Quick Calculation Method

This heat load calculation is courtesy of Amtrol, developed by their training group.

The advantage of this approach is that you don't have to reference any additional charts and graphs to do it.

WHAT YOU NEED TO KNOW

$A_{WINDOWS}$, Ft^2 _______________

$A_{CEILING}$, Ft^2 _______________

$t_{CEILING}$, Inches _______________

t_{WALLS}, Inches _______________

N Number of Stories _______________

C Ceiling Height, Ft _______________

P Perimeter, Ft _______________

U Window Heat Loss Factor _______________

Single Pane U = 1.15
Single Pane w/ Storms U = 0.65
Double Pane U = 0.53

F Infiltration Factor _______________

Loose Construction (1 1/2 air changes per hour) F = 0.027
Average Construction (1 air change per hour) F = 0.018
Tight Construction (2/3 air change per hour) F = 0.012

Take measurements on the house and fill in the blanks.

The thicknesses, $t_{CEILING}$ and t_{WALLS}, above are thickness of the insulation only.

AREAS AND VOLUMES

A_{WALL}, Ft^2 = Total Wall Area, Ft^2

$$\underset{P}{\boxed{}} \times \underset{C}{\boxed{}} \times \underset{N}{\boxed{}} = \underset{A_{WALL},\ Ft^2}{\boxed{}}$$

$A_{NETWALL}$, Ft^2 = Net Wall Area, Ft^2

$$\underset{A_{WALL}}{\boxed{}} - \underset{A_{WINDOWS}}{\boxed{}} = \underset{A_{NETWALL},\ Ft^2}{\boxed{}}$$

V_{HOUSE}, Ft^3 = Volume of House, Ft^3

$$\underset{A_{CEILING}}{\boxed{}} \times \underset{C}{\boxed{}} \times \underset{N}{\boxed{}} = \underset{V_{HOUSE},\ Ft^3}{\boxed{}}$$

R FACTORS

R_{WALL}

$$\boxed{4} + \left(\boxed{3} \times \underset{t_{WALL}}{\boxed{}}\right) = \underset{R_{WALL}}{\boxed{}}$$

$R_{CEILING}$

$$\boxed{4} + \left(\boxed{3} \times \underset{t_{CEILING}}{\boxed{}}\right) = \underset{R_{CEILING}}{\boxed{}}$$

Calculate the Areas, Volume and R Factors and write in the numbers above.

HEAT LOSSES

T_{DIFF} = Design Temperature Difference

H_{WALLS}, Btuh = Heat Loss Through Walls

	x		÷		=	
A_{WALLS}		T_{DIFF}		R_{WALLS}		H_{WALL}, Btuh

$H_{CEILING}$, Btuh = Heat Loss Through Ceiling

	x		÷		=	
$A_{CEILING}$		T_{DIFF}		$R_{CEILING}$		$H_{CEILING}$, Btuh

$H_{WINDOWS}$, Btuh = Heat Loss Through Windows

	x		x		=	
$A_{WINDOWS}$		U		T_{DIFF}		$H_{WINDOWS}$, Btuh

H_{INFILT}, Btuh = Heat Loss Through Infiltration

	x		x		=	
V_{HOUSE}		F		T_{DIFF}		H_{INFILT}, Btuh

H_{TOTAL}, Btuh = TOTAL HEAT LOSS FOR HOUSE

	+		+		+		=	
H_{WALLS}		$H_{CEILING}$		$H_{WINDOWS}$		H_{INFILT}		H_{TOTAL}, Btuh

Calculate the heat losses and write in the numbers above.

SIZING REPLACEMENT BOILERS

Rule of Thumb

COPPER BASEBOARD SYSTEM

- *Calculate the building heat loss - or -*
- *Measure the installed length of baseboard and multiply the number of feet times: 600 Btuh for standard baseboard or 800 Btuh for high output baseboard*
- *Add for domestic water load if necessary*
- *Select a boiler with a Net I=B=R rating at least equal to the load*

Rule of Thumb

RADIANT PANEL SYSTEM

- *Calculate the building heat loss*
- *Increase the calculated heat loss by 10% to 15% for extra piping and pick-up losses*
- *Add for domestic water load if necessary*
- *Select a boiler with a Net I=B=R rating at least equal to the load*

Apply these guidelines for baseboard systems and radiant panel systems.

SIZING REPLACEMENT BOILERS

Rule of Thumb

CONVERTED GRAVITY SYSTEM - or - LARGE WATER CONTENT SYSTEM

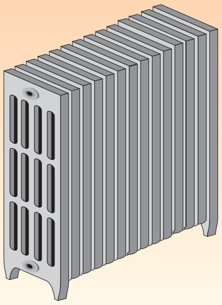
- *Calculate the installed square feet of radiation. You can use the cast iron radiation table in this book or other references for radiation types not shown.*
- *Increase the load by 15% to 25% for additional piping and pick-up losses.*
- *Change the calculated load in square feet of radiation to Btuh by multiplying by 150 for average water temperature of 170 °F.*
- *Add for domestic water load if necessary*
- *Select a boiler with a Net I=B=R rating at least equal to the load*

Use these rules of thumb for high volume systems and gravity return systems.

CAST IRON RADIATORS

Rule of Thumb

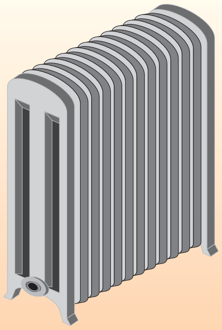
One square foot of radiation will put out 150 Btuh when the average water temperature is 170 °F.



TUBULAR RADIATION

RATING - Square Feet per Section

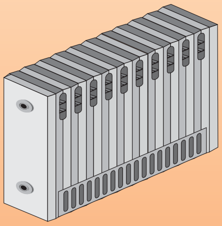
Height	3 Tube	4 Tube	5 Tube	6 Tube	7 Tube
14"					2.67
17"					3.25
20"	1.75	2.25	2.67	3.00	3.67
23"	2.00	2.50	3.00	3.50	
26"	2.33	2.75	3.50	4.00	4.75
32"	3.00	3.50	4.33	5.00	5.50
38"	3.50	4.25	5.00	6.00	6.75



COLUMN RADIATION

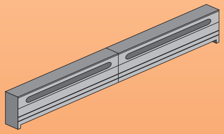
RATING - Square Feet per Section

Height	1 Column	2 Column	3 Column	4 Column	5 Column
14"					4.00
17"					4.00
18"			2.25	3.00	5.00
20"	1.50	2.00			5.00
22"			3.00	4.00	6.00
23"	1.67	2.33			
26"	2.00	2.67	3.75	5.00	
32"	2.50	3.33	4.50	6.50	
38"	3.00	4.00	5.00	8.00	
44"				10.00	
45"		5.00	6.00		



RADIANT CONVECTOR

Width	Height	Square Feet Per Section
5"	20"	2.25
7 1/2"	20"	3.40



CAST IRON BASEBOARD

Width	Height	Square Feet Per Linear Foot
2 1/2"	10"	3.40

Use these charts to figure the total heating surface of all cast iron radiation in the home.

The output from the radiation will be 150 Btuh per square foot when the average water temperature in the radiation is 170° F.

BASEBOARD HEATING RULES OF THUMB

$$\text{Flow Rate} = \text{MBH} \div 10$$

For Temperature Change of 20 °F

PUMP HEAD = .06 times the length in feet of the longest run of pipe in the system

COPPER PIPE MAXIMUM FLOW AND HEAT CAPACITY

Pipe Size (Copper)	Maximum Flow Rate (gpm)	Heat Capacity @ 20°F ΔT
1/2"	1.4	14 MBH
3/4"	3.9	39 MBH
1"	8.0	80 MBH
1 1/4"	14.2	142 MBH

COPPER PIPE MAXIMUM FEET OF BASEBOARD

Baseboard Size (Copper)	Btuh per Foot	Baseboard Capacity (Feet)
1/2"	600	24
3/4"	600	65
1"	770	104
1 1/4"	790	180

These rules of thumb provide a quick way of sizing the piping and the circulator.

TOTAL EQUIVALENT LENGTH OF PIPING

TEL = **Total Equivalent Length (of Piping)**
= **Total Length of Piping + Equivalent Lengths of Fittings**

For trial calculations and for most residential and small systems, figure the TEL as 1.5 times the measured length of piping.

Equivalent Length, Feet for Threaded Pipe Fittings and Valves

Pipe Size	Elbow 90° Std	Elbow 90° LR	Elbow 45°	Return Bend	Tee Through	Tee Branch	Globe Valve	Gate Valve	Angle Valve	Swing Check
1/2	3		0.6	3	1.3	3.5	20	0.5		7.8
3/4	3.6	2	0.8	3.6	2	4.5	21	0.6	13	7.9
1	4.5	2.4	1.1	4.5	2.7	5.4	27	0.8	13.7	8.9
1¼	5.7	2.9	1.5	5.7	3.9	7.4	37	1	15.6	11.7
1½	6.5	2.9	1.8	6.5	4.9	8.6	43	1.1	15.5	13.4
2	7.5	3.2	2.4	7.5	6.8	10.5	52	1.3	15.7	17.2
2½	8.1	3.4	2.9	8.1	8.5	12.3	62	1.6	15.1	21
3	10.1	3.9	3.7	10.1	11.3	15.1	75	1.8	16.4	27
4	12.6	4.3	5.1	12.6	16.1	19.7	102	2.2	17.9	36

Equivalent Length, Feet for Flanged Pipe Fittings and Valves

Pipe Size	Elbow 90° Std	Elbow 90° LR	Elbow 45°	Return Bend, Std	Return Bend, LR	Tee Through	Tee Branch	Globe Valve	Gate Valve	Angle Valve	Swing Check
1	1.3	1.3	0.7	1.3	1.3	0.8	3	39		14.3	6
1.25	1.8	1.7	1	1.8	1.7	1.1	4.2	52		16.1	8.7
1.5	2.2	1.9	1.2	2.2	1.9	1.3	4.9	54		16.1	10.7
2	2.9	2.3	1.5	2.9	2.3	1.5	6.3	67	2.6	18.7	15
2.5	3.4	2.7	1.8	3.4	2.6	1.7	7.5	76	2.6	21.7	18.9
3	4.3	3.2	2.3	4.3	3.2	2.2	9.6	88	2.8	28	25
4	5.6	4	3.3	5.6	4	2.7	12.6	116	2.9	38	36
5	7.2	4.8	4.1	7.2	4.8	3.2	14.9	143	2.4	50	48
6	8.8	5.5	5.2	8.8	5.5	3.7	18.2	172	2.8	64	61
8	11.7	7	7.4	11.7	6.5	4.4	25	247	3.5	91	87
10	14.6	8.2	9.3	14.6	8.2	5.3	31	331	3.5	122	116
12	17.3	9.4	11.5	15.1	9.4	5.8	36	409	3.6	151	144

For trial calculations and for rule of thumb (small systems only), multiply the longest run of piping times 1.5 to determine the Total Equivalent Length.

Use this chart to calculate the actual TEL for the system. Apply the TEL in the pressure drop formula to calculate the pressure drop.

PRESSURE DROP
(FEET PER HUNDRED FEET PIPING)

Total Pressure Drop, Feet

$$\text{Total Pressure Drop, Feet} = \frac{\text{Total Equivalent Length}}{100} \times a \times \text{GPM}^{b}$$

Schedule 40 Steel Pipe Pressure Drop Information
Head Loss, Feet per 100 Feet of Pipe, = a x GPM^b

Pipe Size Inches	Pipe OD Inches	Sch 40 Wall	Pipe ID Inches	Velocity = GPM x	Minimum Recomm. GPM	Minimum Velocity feet per sec	Maximum Recomm. GPM	Maximum Velocity feet per sec	a	b
1/2	0.840	0.109	0.622	1.05595	0.7	0.7	1.9	2.0	1.41393	1.775
3/4	1.050	0.113	0.824	0.60169	1.5	0.9	4.1	2.5	0.35528	1.795
1	1.315	0.133	1.049	0.37126	2.9	1.1	7.9	2.9	0.10682	1.811
1 1/4	1.660	0.140	1.380	0.21452	6.2	1.3	16	3.5	0.02685	1.828
1 1/2	1.900	0.145	1.610	0.15761	9.4	1.5	25	3.9	0.01228	1.837
2	2.375	0.154	2.067	0.09562	18.4	1.8	48	4.6	0.003421	1.851
2 1/2	2.875	0.203	2.469	0.06702	30	2.0	78	5.2	0.001371	1.860
3	3.500	0.216	3.068	0.04340	53	2.3	138	6.0	0.0004452	1.871
4	4.500	0.237	4.026	0.02520	110	2.8	284	7.2	0.0001081	1.883
5	5.563	0.259	5.045	0.01605	200	3.2	515	8.3	3.318E-05	1.893
6	6.625	0.280	6.065	0.01111	326	3.6	836	9.3	1.260E-05	1.900
8	8.625	0.322	7.981	0.006414	674	4.3	1721	11.0	2.962E-06	1.910
10	10.750	0.365	10.020	0.004069	1229	5.0	3126	12.7	8.886E-07	1.918
12	12.750	0.375	12.000	0.002837	1977	5.6	5013	14.2	3.415E-07	1.924

Type L Copper Pipe Pressure Drop Information
Head Loss, Feet per 100 Feet of Pipe, = a x GPM^b

Pipe Size Inches	Pipe OD Inches	Type L Wall	Pipe ID Inches	Velocity = GPM x	Minimum Recomm. GPM	Minimum Velocity feet per sec	Maximum Recomm. GPM	Maximum Velocity feet per sec	a	b
1/2	0.625	0.040	0.545	1.3754	0.5	0.7	1.4	2.0	2.4135	1.709
3/4	0.875	0.045	0.785	0.6630	1.4	0.9	3.9	2.6	0.4275	1.731
1	1.125	0.050	1.025	0.3888	2.9	1.1	8.0	3.1	0.1186	1.746
1 1/4	1.375	0.055	1.265	0.2553	5.1	1.3	14.2	3.6	0.04280	1.756
1 1/2	1.625	0.060	1.505	0.1804	8.2	1.5	22.6	4.1	0.01836	1.764
2	2.125	0.070	1.985	0.1037	17.3	1.8	47.6	4.9	0.004727	1.776
2 1/2	2.625	0.080	2.465	0.06723	31.1	2.1	84.9	5.7	0.001626	1.784
3	3.125	0.090	2.945	0.04710	50.2	2.4	137	6.4	6.742E-04	1.791
4	4.125	0.110	3.905	0.02679	107	2.9	290	7.8	1.660E-04	1.801

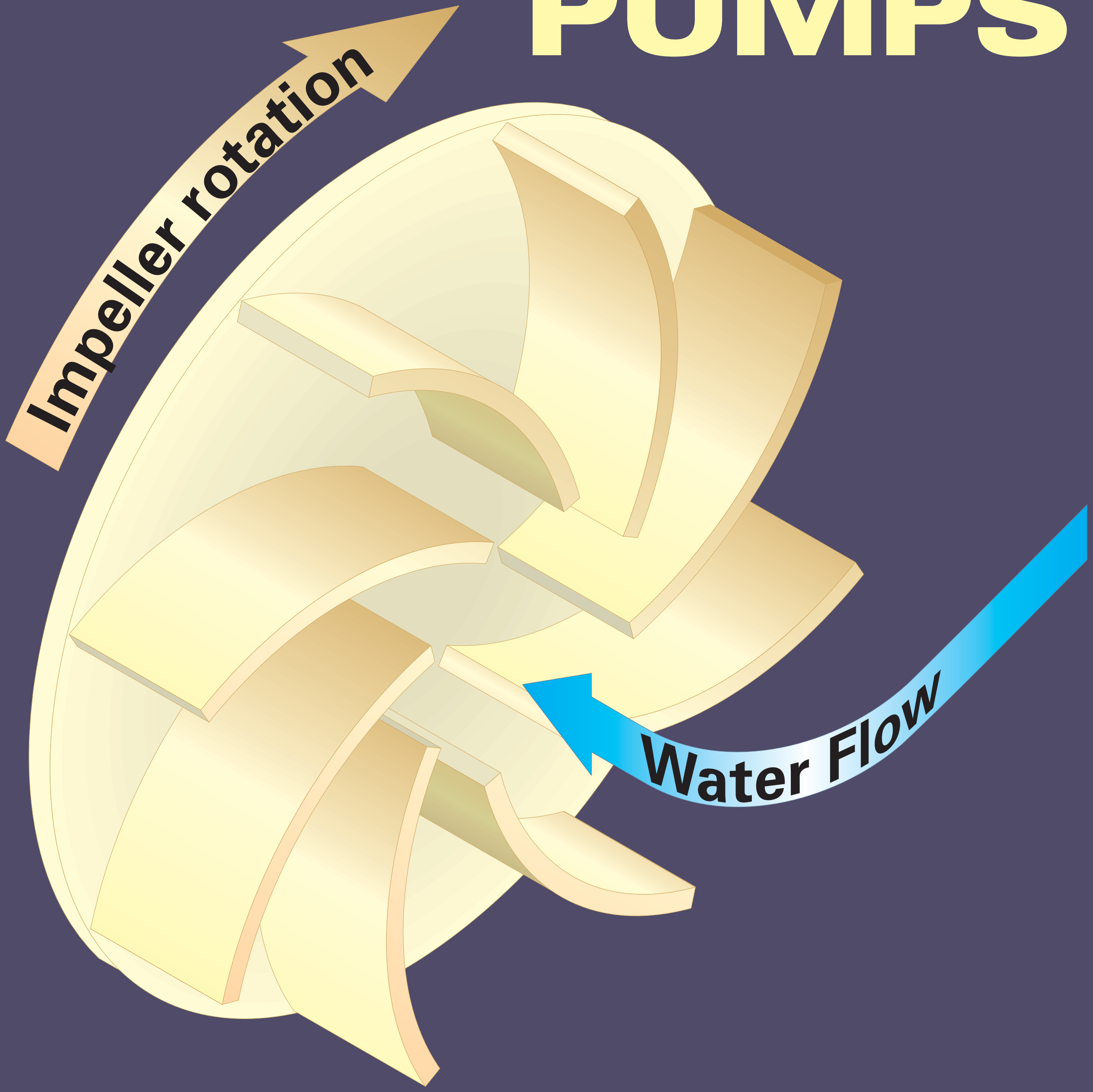
Note: Some "a" numbers above are in engineering notation. 3.415E-07 = .0000003415, for example

Select the pipe size.

Then read across the chart to find “a” and “b” for that pipe size.

Calculate the pressure drop with the formula at the top.

CENTRIFUGAL PUMPS

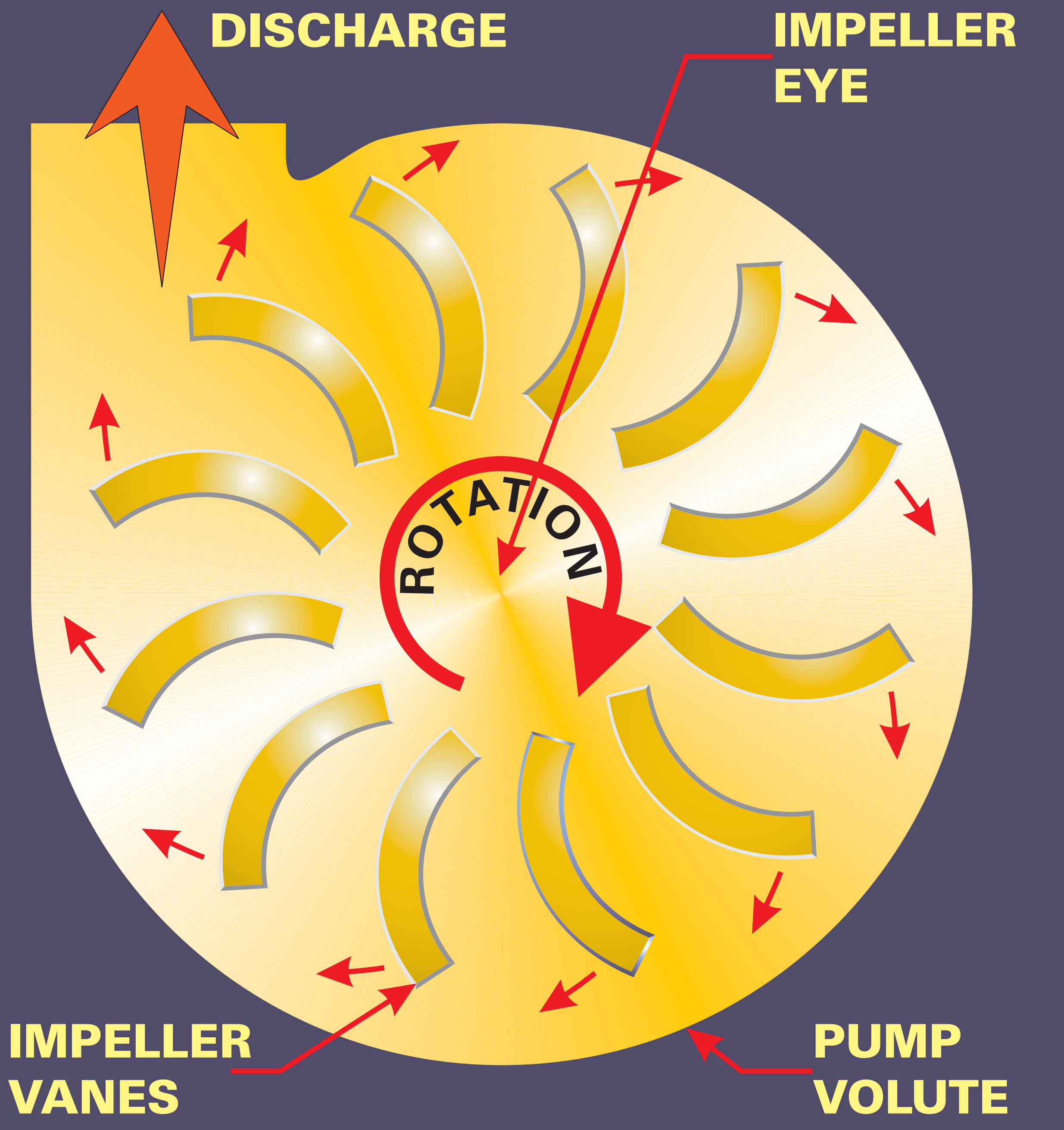


Centrifugal pumps rotate as shown above.

Water flows into the eye of the impeller.

The pump raises the pressure of the water as it moves from the impeller eye through the impeller vanes.

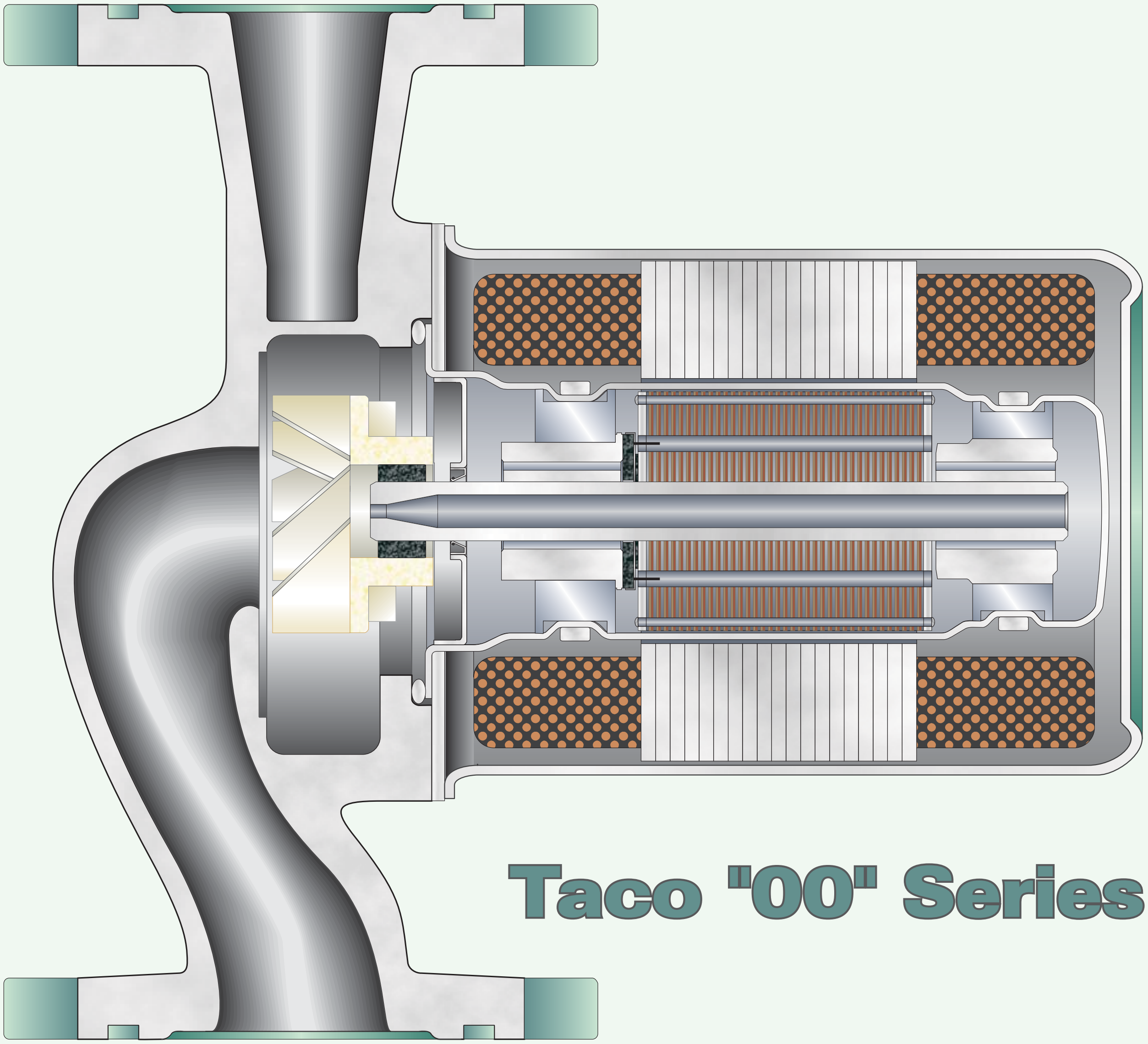
CENTRIFUGAL PUMPS



Water flows into the eye of the impeller.

The pump volute directs the flow of the water to the discharge.

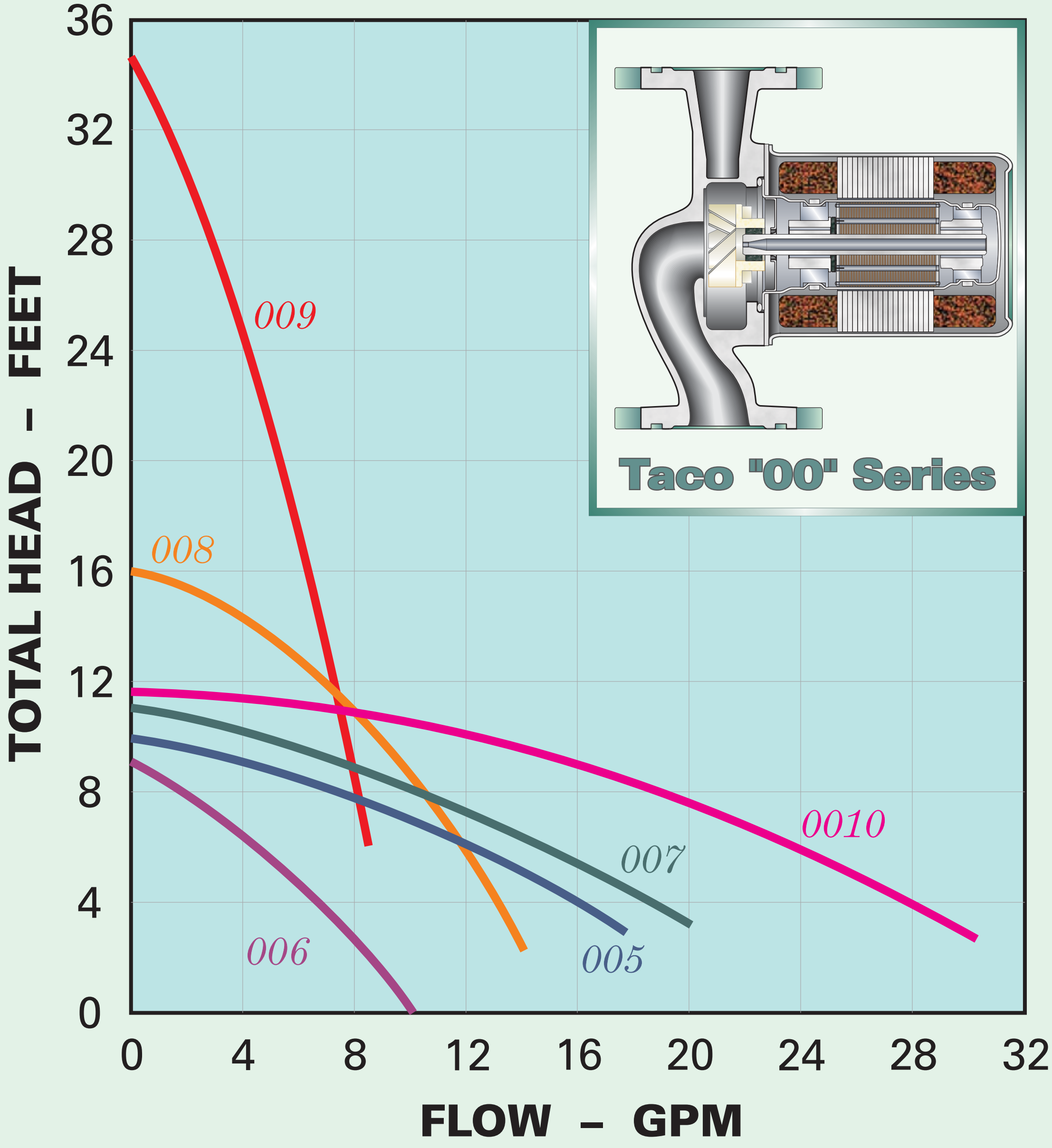
WATER LUBRICATED CIRCULATOR (Typical)



The Taco 007 is a typical water lubricated circulator.

System water actually flows through the shaft into the rotor chamber.

CIRCULATOR CURVES TACO "00" SERIES



These are the pump curves for the Taco 00 series circulators.

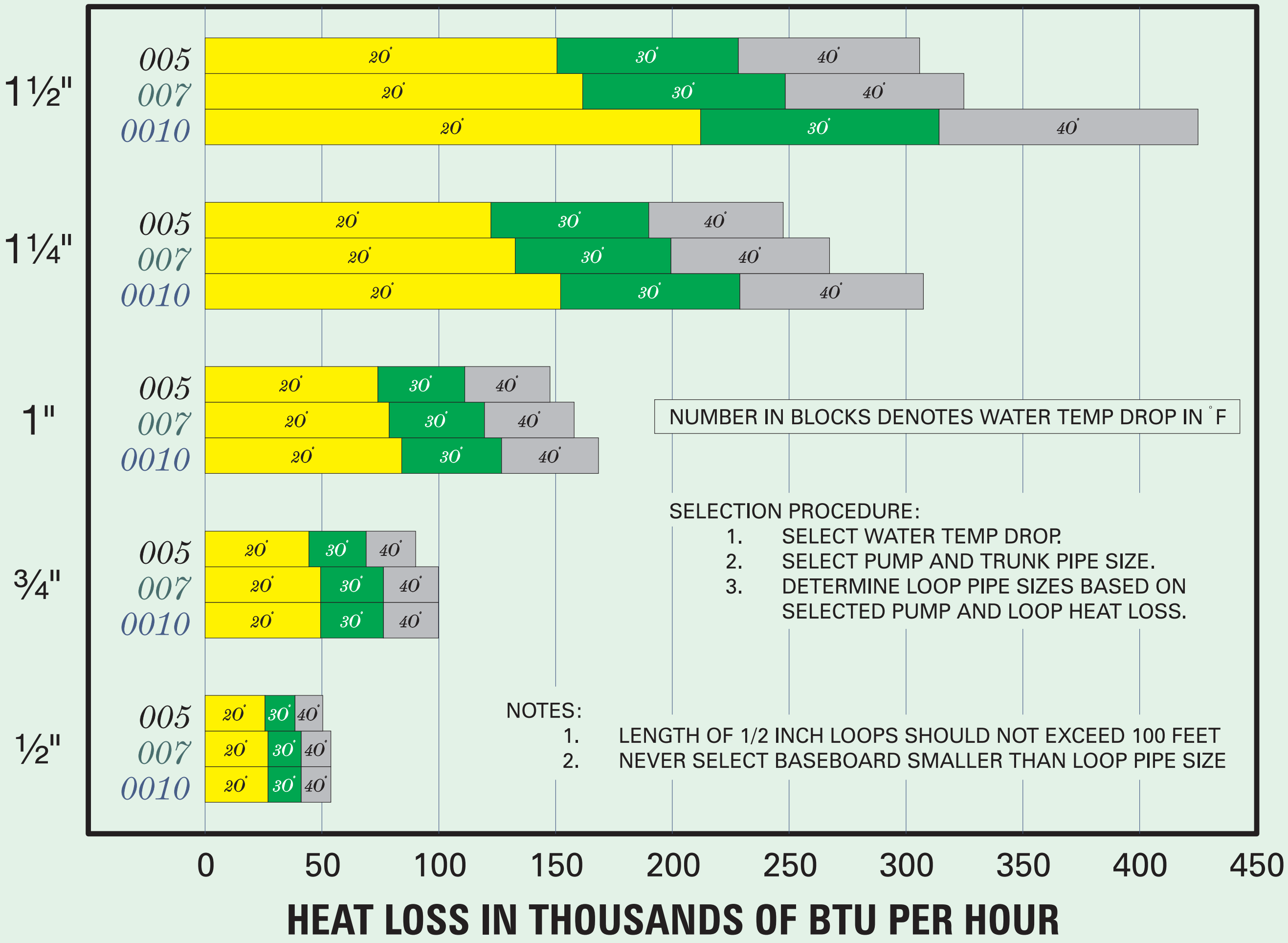
The curve layout is similar to that used by other circulator manufacturers for in-line pumps and circulators.

CIRCULATOR QUICK SELECTION

Rule of Thumb

Below is a typical quick selection method. This one is from Taco for their "00" Series Circulators

PUMP SELECTION FOR SERIES LOOP - HOT WATER HEATING SYSTEMS



NUMBER IN BLOCKS DENOTES WATER TEMP DROP IN °F

SELECTION PROCEDURE:

1. SELECT WATER TEMP DROP.
2. SELECT PUMP AND TRUNK PIPE SIZE.
3. DETERMINE LOOP PIPE SIZES BASED ON SELECTED PUMP AND LOOP HEAT LOSS.

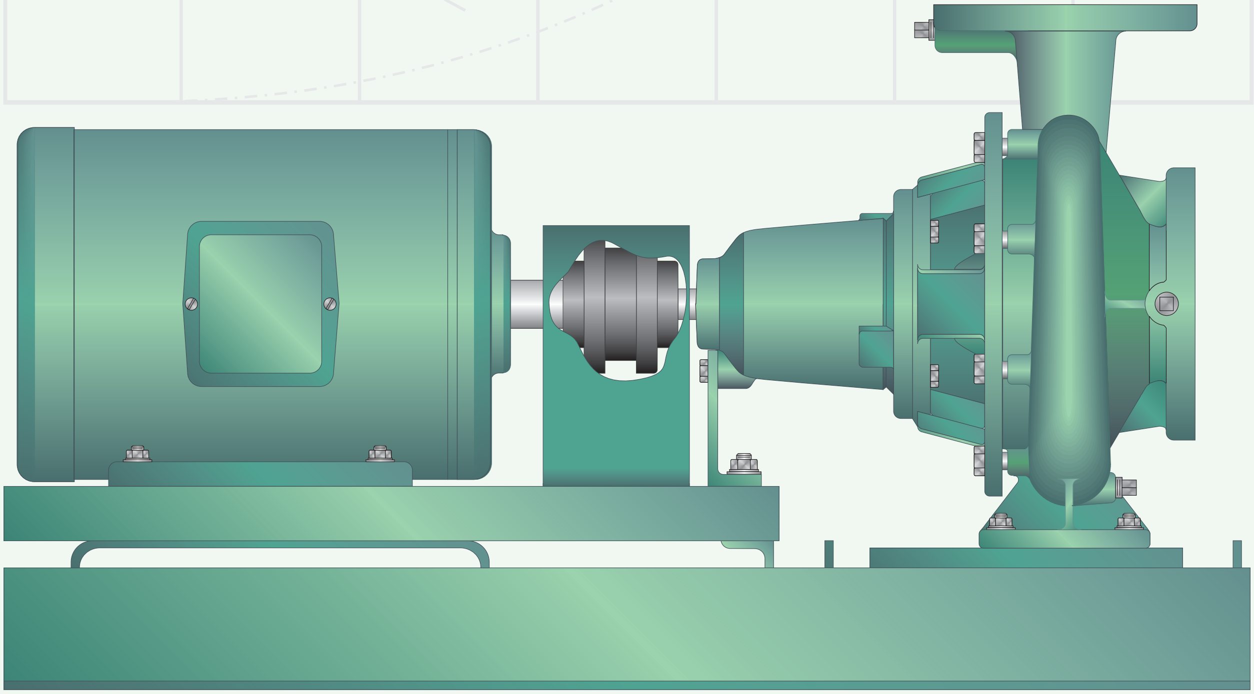
NOTES:

1. LENGTH OF 1/2 INCH LOOPS SHOULD NOT EXCEED 100 FEET
2. NEVER SELECT BASEBOARD SMALLER THAN LOOP PIPE SIZE

Use this chart to select the Taco circulator based on heat load and pipe size used.

Similar charts are available from other circulator manufacturers.

END SUCTION PUMP BASE MOUNTED TYPICAL



This is a typical base mounted end suction pump.

These pumps are also offered in direct-coupled configurations.

WORKING WITH PUMP CURVES

Pump curves are usually plotted as Head vs Flow. This is because Head doesn't depend on density or temperature of the fluid.

Density affects the Pump Motor Horsepower, but not flow. Multiply the horsepower on the curve by the specific gravity of the fluid to determine the corrected horsepower.

Curves plotted in PSIG vs Flow only apply for the temperature and density of the fluid shown.

In-Line Pumps and Circulators:

Pump curves for these pumps (typical curve shown in red) only show Head vs Flow.

Look in the manufacturer's charts for information on pump motor horsepower.

The motors for these pumps are sized to be non-overloading. They can carry the load for the entire pump curve.

End Suction Pumps:

These pump curves usually show the Head vs Flow for several impeller diameters. Specify that the impeller be machined to the diameter which provides the best fit for the application.

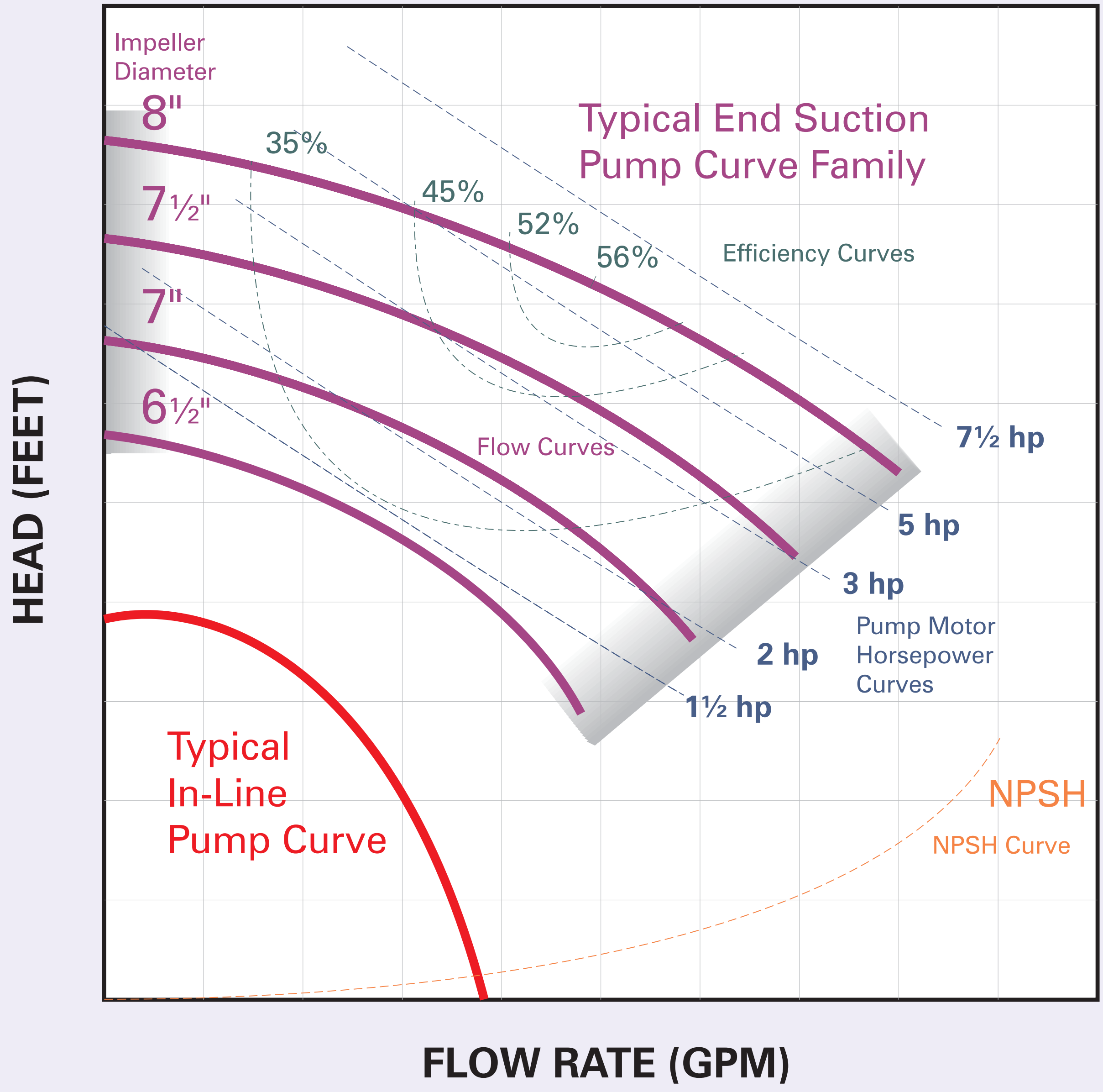
Pump Motor Horsepower: Select a motor which can carry the pump load through the entire expected range of operation.

Efficiency: The efficiency curves show the ratio of horsepower delivered to the water vs horsepower used by the pump.

NPSH: The NPSH curve shows the minimum NPSH required at the pump suction connection to prevent cavitation.

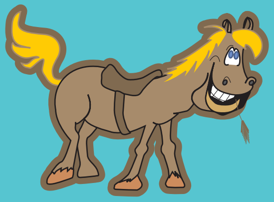
Pump curves are usually shown in Head (feet of water) vs Flow (GPM).

PUMP CURVES



This graph compares a typical in-line pump curve to a family of curves for an end-suction pump.

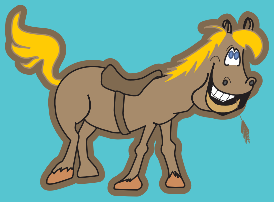
PUMP MOTOR HORSEPOWER



In-Line Pumps & Circulators

Find the motor horsepower in separate tables.

The pumps are usually equipped with a motor large enough to cover the entire pump curve. This is called a non-overloading motor.



End Suction Pumps

Determine the range of operation on the pump curve by laying out a system curve on the pump graph.

Select a motor horsepower curve which lies above the pump curve for the entire range of operation.

Consider the motor service factor if the decision is close.

Water Horsepower	$\frac{\text{GPM} \times \text{Head} \times \text{Specific Gravity}}{3960}$
Brake Horsepower	$\frac{\text{GPM} \times \text{Head} \times \text{Specific Gravity}}{3960 \times \text{Pump Efficiency}}$
Pump Efficiency	$\frac{\text{Water Horsepower}}{\text{Pump Horsepower}} \times 100\%$

Water Horsepower is the power delivered to the water.

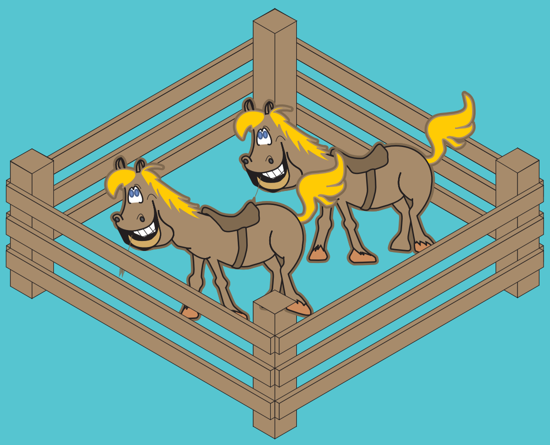
The Brake Horsepower required for the motor is higher because of the efficiency of the motor and the pump.

PUMP POWER CONSUMPTION

RUNNING TIME	OPERATING COST, DOLLARS PER BHP for 85% Efficient Motor				
	$ .04 per KWH	$ .08 per KWH	$ .12 per KWH	$ .16 per KWH	$ .20 per KWH
1 Hour	$ 0.04	$ 0.07	$ 0.11	$ 0.14	$ 0.18
24 Hours	$ 0.84	$ 1.69	$ 2.53	$ 3.37	$ 4.21
30 Days	$ 25.28	$ 50.55	$ 75.83	$ 101.10	$ 126.38
6 Months	$ 153.76	$ 307.53	$ 461.29	$ 615.06	$ 768.82
9 Months	$ 230.65	$ 461.29	$ 691.94	$ 922.58	$ 1153.23
1 Year	$ 307.53	$ 615.06	$ 922.58	$ 1230.11	$ 1537.64

$$\textbf{Electrical Power} = \frac{\textbf{Pump Brake Horsepower}}{\textbf{Motor Efficiency}}$$

Note: 1 BHP = .760 KW



The cost of operating a large pump can be high.

Consider parallel or series pumping and speed control options to reduce pump energy consumption.

NPSH

Net Positive Suction Head, or NPSH, is the pressure available to keep the water from vaporizing.

The pressure at the eye of the impeller is lower than at the pump suction connection. The higher the flow through the pump, the greater the pressure difference. This is why *NPSH required increases with increasing flow.*

The NPSH curve is the NPSH required by the pump to prevent cavitation (formation of vapor in the pump impeller). *For most hydronic heating systems, with cold fill pressure at least 12 psig and operating temperature at or below 240 °F, NPSH requirements are not likely to present a problem.*

Never install a strainer on the suction side of a pump. The pressure loss that develops across the strainer will cause a lower pressure in the pump suction and will cause cavitation. *Always install strainers on the pump discharge side.*

In high altitude applications, NPSH may be more of a factor. The available NPSH reduces 1/2 psig per 1000 feet of elevation. So *fill pressures must often be higher at altitude.*

If NPSH is a concern, consider a larger pump to operate more to the left on the pump curve where NPSH required is reduced.

NPSH is a measure of the pressure available to prevent water from flashing to steam in the pump.

NPSH

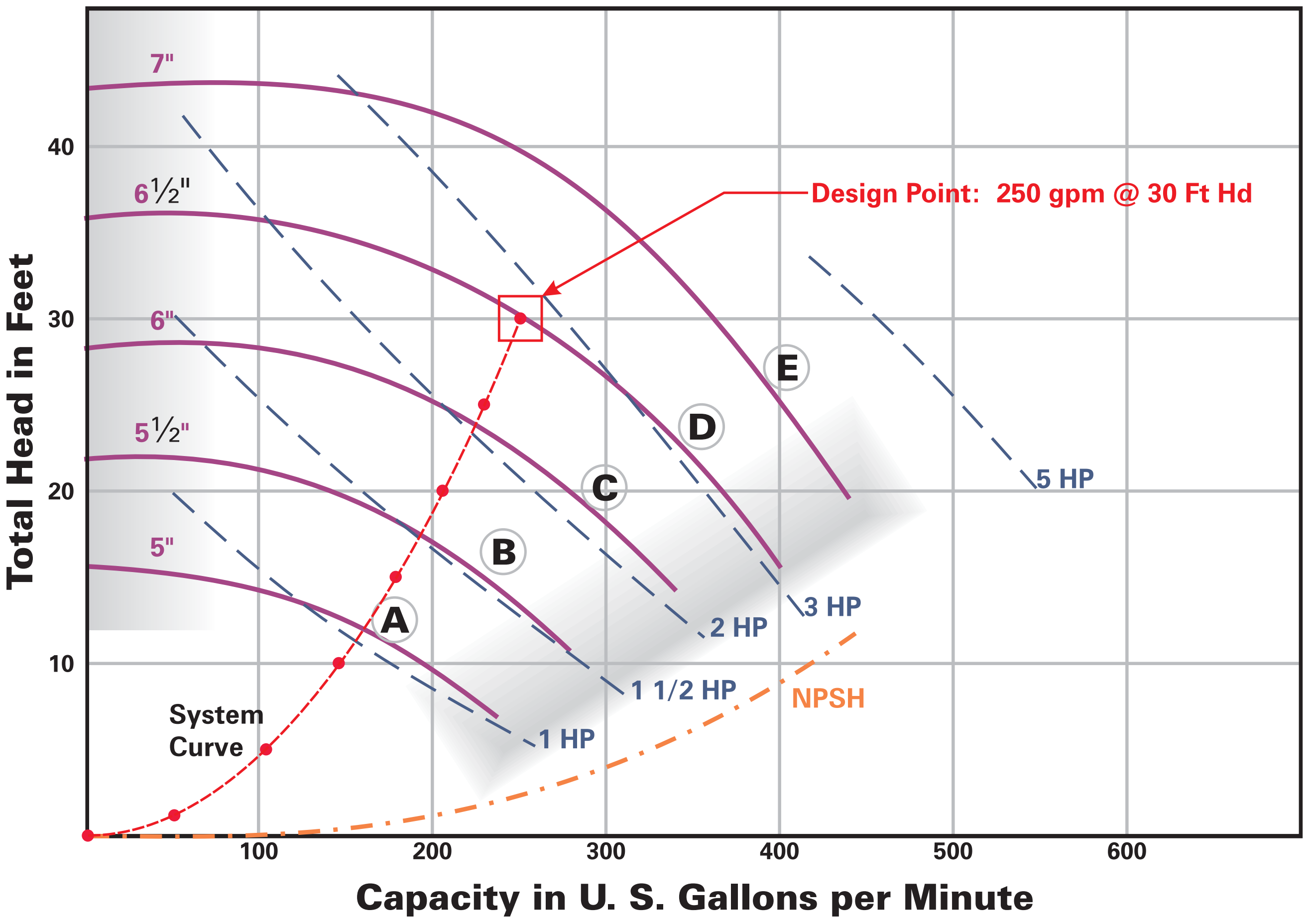
$$\text{NPSH}_{AVAILABLE} = \frac{v^2}{64.4} + (\text{Atm Pres - Vap Pres})_{FEET} + (\text{Pressure at Pump Inlet})_{FEET}$$

"v" is the velocity (feet per second) of the water entering the pump based on the pump inlet pipe diameter. This factor is usually not very large and can be ignored unless the calculation is close. Usually allow at least 2 feet water safety margin over the NPSH required.

Water Temp	Vapor Pressure	Sea Level Vapor Pressure	Density	Specific Gravity	Ft Water per PSI	Atm Pres Minus Vap Pres
°F	PSIA	PSIG	#/Ft3			Ft Water
60	**0.26**	-14.44	62.34	1.0000	2.310	**33.35**
100	**0.95**	-13.75	62.00	0.9944	2.323	**31.93**
110	**1.28**	-13.42	61.84	0.9920	2.328	**31.25**
120	**1.69**	-13.00	61.73	0.9901	2.333	**30.33**
130	**2.23**	-12.47	61.54	0.9871	2.340	**29.18**
140	**2.83**	-11.87	61.39	0.9847	2.346	**27.84**
150	**3.72**	-10.97	61.20	0.9816	2.353	**25.82**
160	**4.75**	-9.95	61.01	0.9786	2.360	**23.48**
170	**6.00**	-8.70	60.79	0.9751	2.369	**20.60**
180	**7.52**	-7.18	60.57	0.9715	2.377	**17.06**
190	**9.15**	-5.55	60.39	0.9686	2.385	**13.22**
200	**11.54**	-3.16	60.13	0.9645	2.395	**7.56**
210	**14.14**	-0.56	59.88	0.9605	2.405	**1.35**
220	**17.20**	2.51	59.63	0.9565	2.415	**-6.05**
230	**20.77**	6.07	59.38	0.9525	2.425	**-14.73**
240	**24.99**	10.29	59.10	0.9480	2.436	**-25.07**
250	**29.85**	15.15	58.82	0.9435	2.448	**-37.09**

Use this chart to determine whether the NPSH available is high enough to prevent cavitation.

SELECTING THE PUMP



This graph shows a family of pumps curves with a system curve drawn over it.

The system curve allows a correct pump selection for the system and is particularly helpful in determining the size to which the impeller should be machined for the best performance.

SELECTING THE PUMP

DO NOT select a pump which would operate either near the shut off head (left side of curve) or near the end of the curve on the right. Either of these conditions will cause cavitation and rapid damage to the pump.

Select a pump which can operate safely at ± 25% from the selection point. This allows for drift in operation or for pressure drops higher or lower than calculated.

If the design point doesn't fall directly on one of the pump curves shown, have the impeller trimmed so the curve would coincide

DRAW A SYSTEM CURVE ON THE PUMP GRAPH

When the design point does not fall directly on or very near a pump curve, draw a system curve.

Start by plotting the Design Point on the curve.

Then calculate the pressure drop for the system at other flow rates and plot these points to generate a curve. Calculate these other points using the square law, below, or by using a heating slide rule (such as the B & G System Syzer).

Don't oversize the pump. This will cause noise and control valve wear or damage due to excessive flow and will use more electrical power than required.

When possible, select a pump which will provide a relatively flat curve. This will avoid big changes in flow and pressure drop as control valves open and close.

SQUARE LAW: $$\text{Pressure Drop}_2 = \text{Pressure Drop}_1 \times \left(\frac{\text{Flow}_2}{\text{Flow}_1}\right)^2$$

Draw the design point on the pump graph.

Make a system curve by calculating pressure drops for other flow rates, using the square law or a system sizing aid or the pressure drop formula in this book.

PUMP OPERATING EQUATIONS

THE AFFINITY LAWS

What are these equations for?
To predict how the pump will act under different conditions.

FLOW RATE

$$GPM_2 = GPM_1 \times \left(\frac{DIAMETER_2}{DIAMETER_1} \right) \qquad GPM_2 = GPM_1 \times \left(\frac{SPEED_2}{SPEED_1} \right)$$

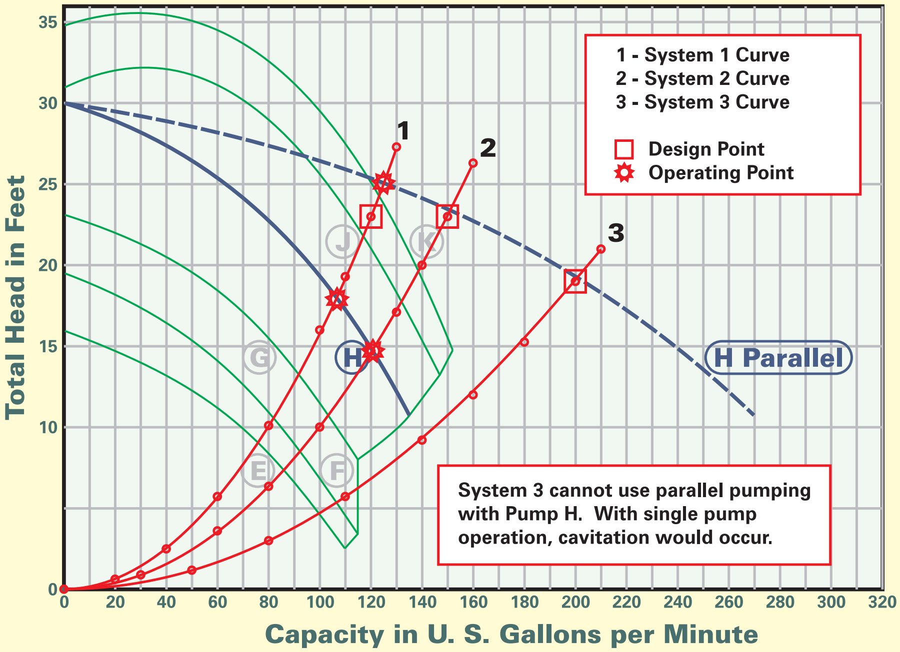
HEAD, FEET

$$HEAD_2 = HEAD_1 \times \left(\frac{DIAMETER_2}{DIAMETER_1} \right)^2 \qquad HEAD_2 = HEAD_1 \times \left(\frac{SPEED_2}{SPEED_1} \right)^2$$

POWER, BHP

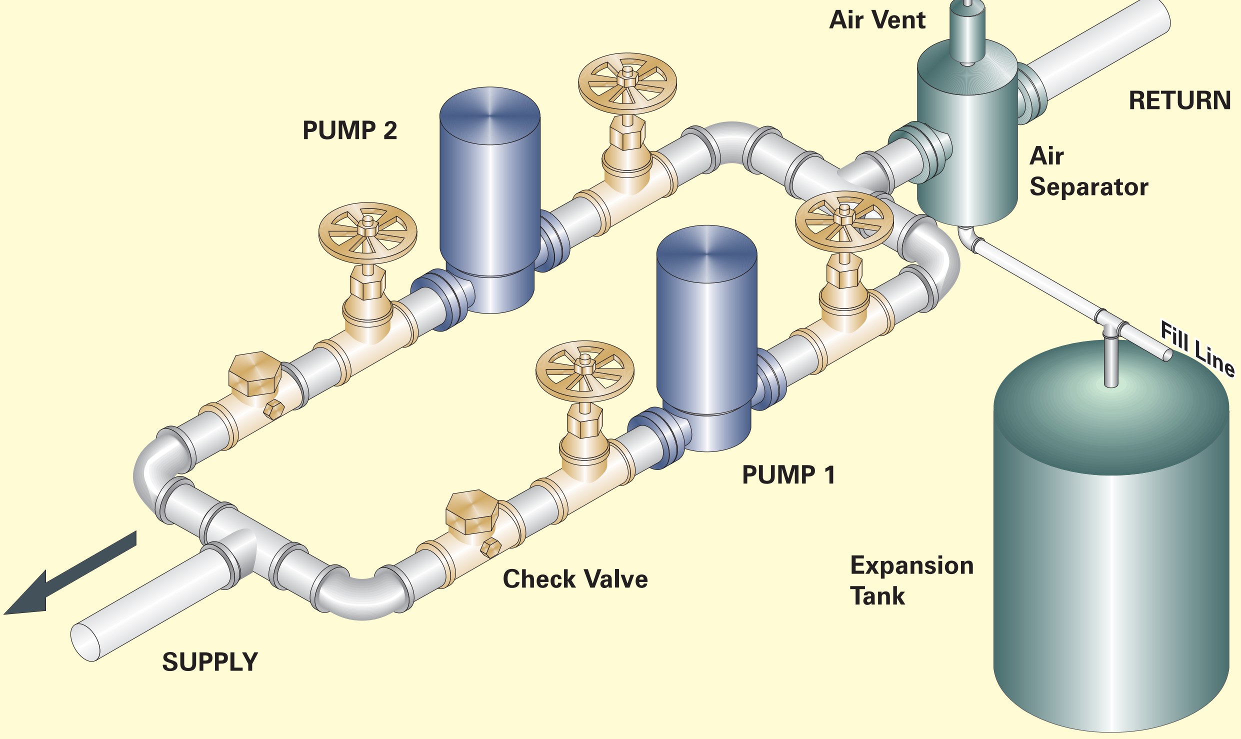
$$BHP_2 = BHP_1 \times \left(\frac{DIAMETER_2}{DIAMETER_1} \right)^3 \qquad BHP_2 = BHP_1 \times \left(\frac{SPEED_2}{SPEED_1} \right)^3$$

Use these equations to predict pump performance and power requirements at different conditions.



System 3 cannot use parallel pumping with Pump H. With single pump operation, cavitation would occur.

TYPICAL PARALLEL PUMPING CURVES



PARALLEL PUMPING

You can use standard in-line pumps instead of larger, special machined impeller end suction pumps by piping the pumps in parallel.

The flow at any pressure is twice the flow for a single pump at that pressure. Draw a parallel pump curve to select the correct pump.

PUMP LOCATION

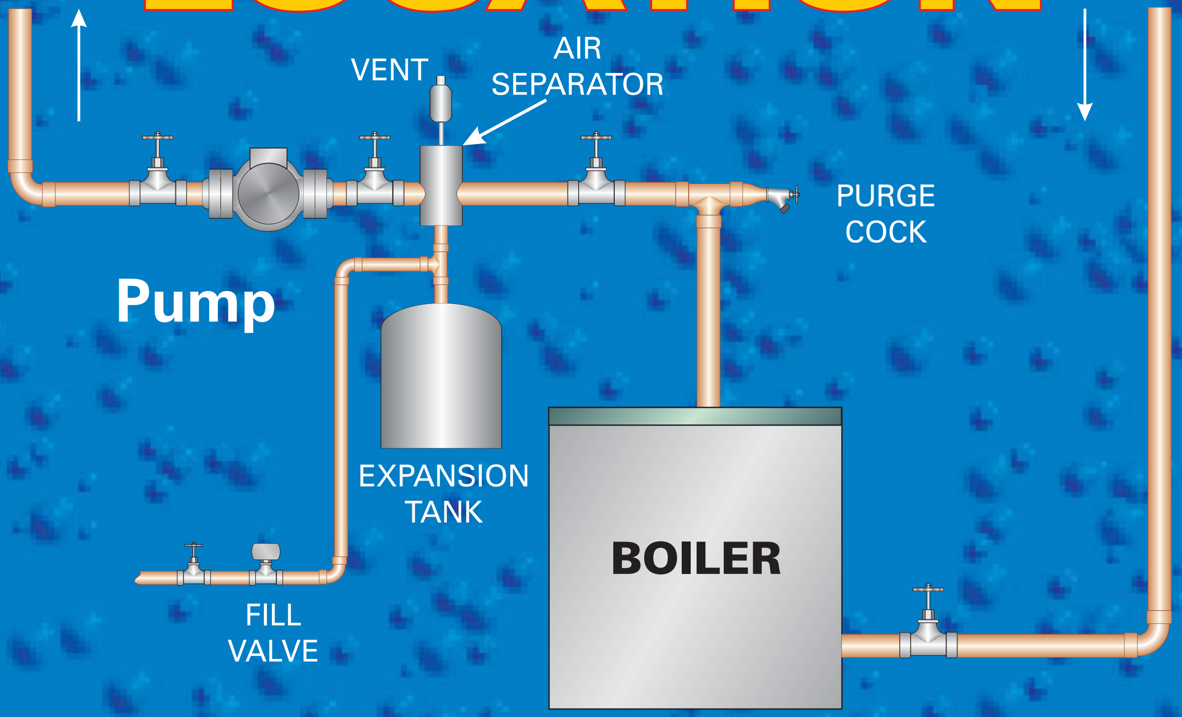
Water absorbs air. The higher the pressure and the lower the temperature, the more air it can hold.

To remove air from the water, locate the air vent or compression tank near the boiler supply connection - the point of highest temperature. Pipe the pump with its suction connection near the expansion tank.

To prevent air problems, make sure the highest pressure is at the top of the system when possible. So, the pump should pump toward the top of the system and away from the expansion or compression tank.

Placing the pump in the right position in the system will help air removal.

PUMP LOCATION



THE PRESSURE AT THE EXPANSION TANK STAYS THE SAME UNLESS:
You add or remove water from the system
The water temperature changes
You change the tank charge pressure

THE PUMP CANNOT AFFECT THE EXPANSION TANK PRESSURE.

THIS MEANS . . . .

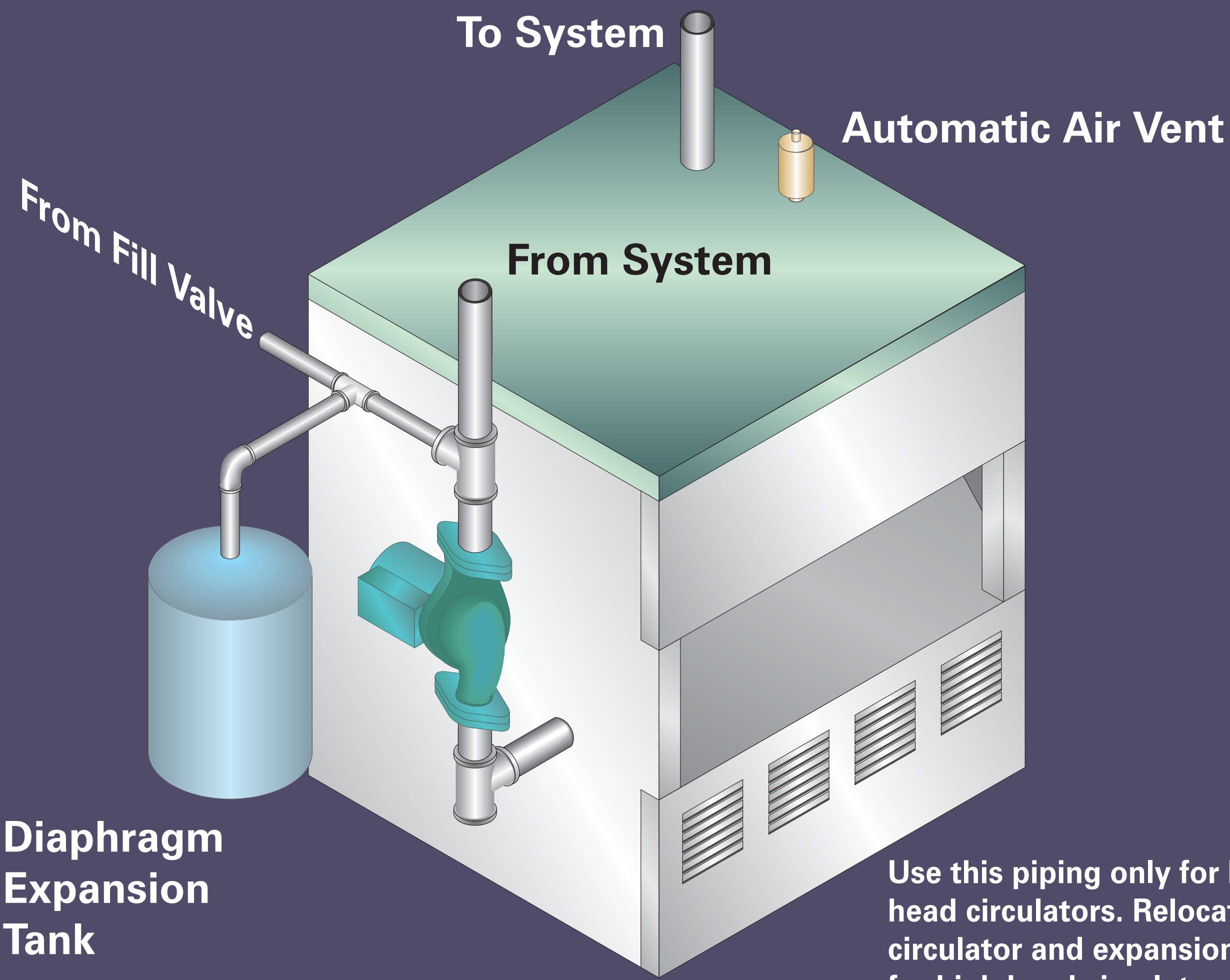
- If the pump pumps TOWARD the tank (wrong way), the pump head SUBTRACTS pressure from the system.
- If the pump pumps AWAY from the tank (right way), the pump head ADDS pressure to the system.

Packaged residential boilers will often be supplied with the pump installed on the return line. This is acceptable for low head circulators (though not as effective for air removal).

Always pipe high head circulators as shown, with the expansion tank at the pump suction side.

PACKAGED RESIDENTIAL BOILER PIPING

(Typical, Diaphragm Tank)



Use this piping only for low head circulators. Relocate circulator and expansion tank for high head circulators.

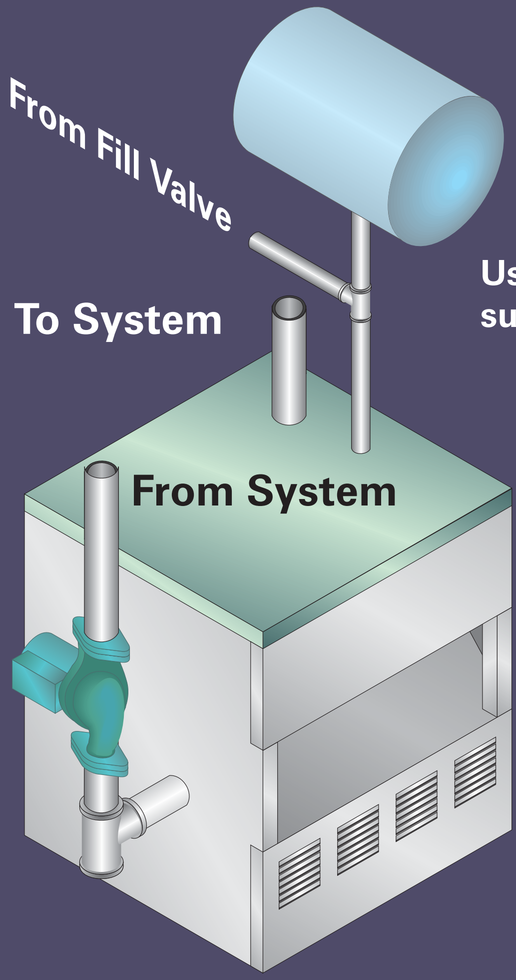
Locate the expansion tank and fill line at the pump suction side of a return line mounted circulator.

Pipe the automatic air vent at the top of the boiler or on a supply line mounted air separator.

Never pipe a high head circulator on the return line.

PACKAGED RESIDENTIAL BOILER PIPING

(Typical, Compression Tank)



Use a tank fitting at the tank connection, such as the B & G "ATF" fitting.

DO NOT USE Automatic Air Vents with a compression tank system.

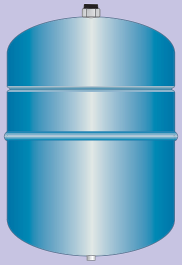
Use this piping only for low head circulators. Relocate circulator and expansion tank for high head circulators.

Pipe a compression tank off of the top of the boiler on packaged boilers with return line mounted circulators.

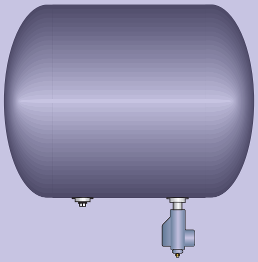
Never use automatic air vents on systems with compression tanks.

Never mount a high head circulator on the return line.

CONTROLLING WATER EXPANSION



Diaphragm
or
Bladder
Tank



Compression
Tank

Water expands 3.7% when heated from 60 °F to 200 °F.

Size the expansion tank or compression tank for the total volume of the system.

Never install automatic air vents on systems which use compression tanks.

Always use a tank fitting on compression tanks to prevent waterlogging.

Compression tanks should fill to 2/3 full at initial system fill.

Connect to the compression tank with no smaller than 3/4" pipe to allow room for air to move up the pipe.

The expansion tank or compression tank must be large enough to allow the water to expand without causing excessive pressure in the system.

ESTIMATE SYSTEM VOLUME

BOILER VOLUME

Consult the boiler literature, or use a default of 1 gallon for every 4300 Btuh Output for typical boilers.

HEATING UNIT VOLUME

Cast Iron Radiation: (Gallons per Square Foot Surface)
  Large Tube (Column): 0.114
  Thin Tube: 0.056
Cast Iron Radiation: (Gallons per 10,000 Btuh @ 200 °F)
  Convectors: 1.5
  Baseboard: 4.7
Non-Ferrous Radiation: (Gallons per 10,000 Btuh @ 200 °F)
  Convectors: 0.64
  Baseboard (3/4"): 0.37

Fan Coil & Unit Heater: (Gallons per 10,000 Btuh @ 180 °F)
  Default: 0.2

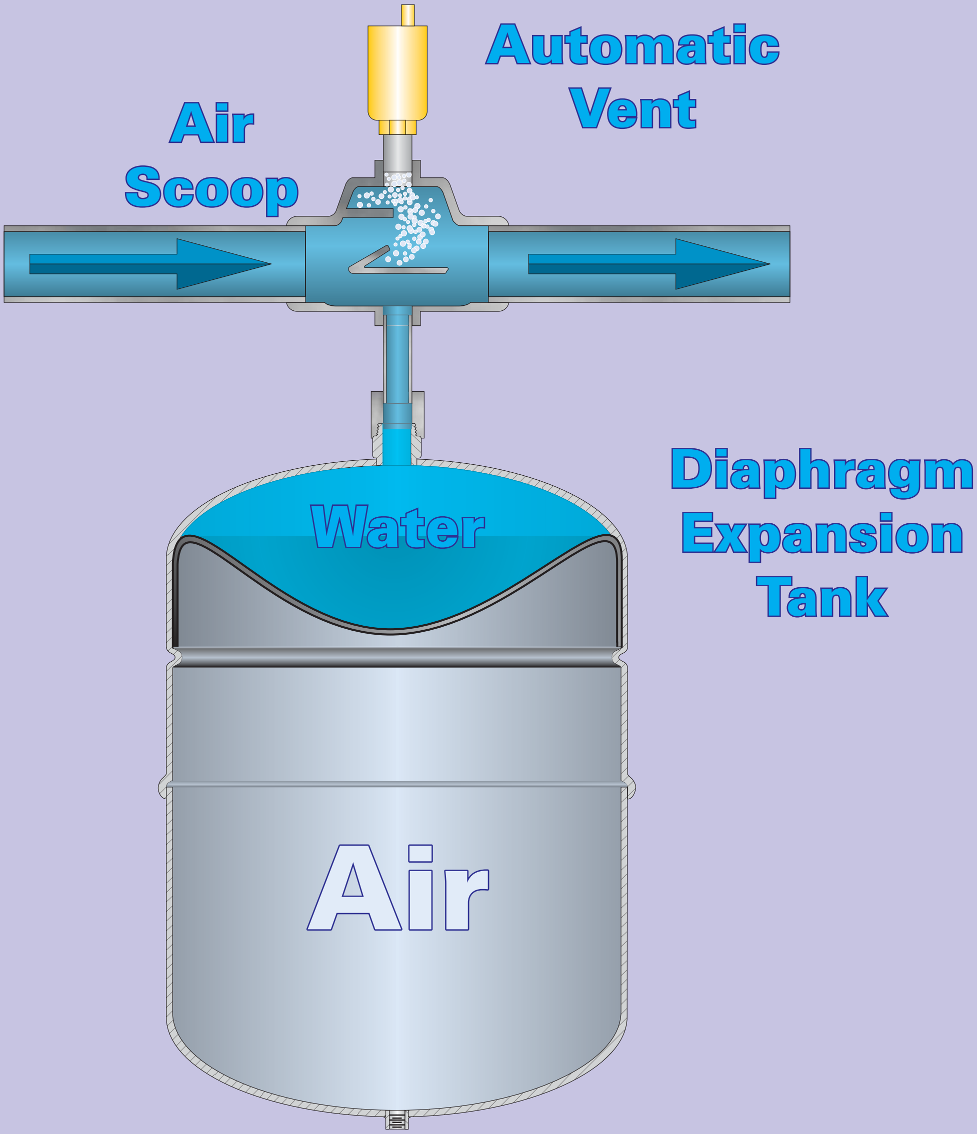
PIPING

Pipe Size, In.	Gallons per Foot	Pipe Size, In.	Gallons per Foot	Pipe Size, In.	Gallons per Foot	Pipe Size, In.	Gallons per Foot
½	0.016	1½	0.106	4	0.660	8	2.66
¾	0.028	2	0.170	5	1.04	10	4.20
1	0.045	2½	0.250	6	1.50	12	5.96
1¼	0.078	3	0.380				

Use these guidelines to calculate the system volume.

For firebox boilers or other large volume boilers, make sure to use the boiler manufacturer’s data for the volume instead of the rule of thumb given above.

AIR SEPARATOR OPERATION (Typical)



Install an in-line air separator in the supply line for best removal of the air.

EXPANSION TANK QUICK SELECTOR (Typical)

EXTROL SIZING TABLE

FILL PRESSURE 12 PSIG

RELIEF PRESSURE 30 PSIG

AVERAGE SYSTEM TEMPERATURE 200 °F

BOILER NET OUTPUT IN 1000's OF BTU/HR	TYPE OF RADIATION							
	Finned Tube Baseboard or Radiant Panel		Convectors or Unit Heaters		Radiators - Cast Iron		Baseboard - Cast Iron	
	SW	CS	SW	CS	SW	CS	SW	CS
25	15	15	15	15	15	15	15	15
50	15	15	15	15	15	30	15	30
75	15	30	15	30	30	30	30	60
100	15	30	15	30	30	60	30	60
125	15	30	30	60	30	60	30	90
150	30	30	30	60	30	90	60	90
175	30	60	30	60	60	SX-30	60	SX-30
200	30	60	60	60	60	SX-30	60	SX-30
250	30	60	60	90	60	SX-30	90	SX-40
300	60	90	60	SX-30	90	SX-30	90	SX-40
350	60	SX-30	60	SX-30	90	SX-40	SX-30	SX-60
400	60	SX-30	90	SX-40	SX-30	SX-40	SX-30	SX-60

SW Indicates Summer/Winter hook up where boiler is used for heating and supplying domestic hot water. Minimum boiler temp of 150 °F is required.

CS Indicates Cold Start hook up where the boiler is used for heating only.

Quick selector charts like this are an easy way of sizing expansion tanks and compression tanks.

DIAPHRAGM EXPANSION TANK SIZING

$$P_{fill} = \left(H_{system} - H_{tank}\right) \times \left(\frac{D_{cold}}{144}\right) + 5$$

$$V = V_{system} \times \left(\frac{D_{cold}}{D_{hot}} - 1\right) \times \left(\frac{P_{rel\ valve} + 9.7}{P_{rel\ valve} - P_{charge} - 5}\right)$$

V = Minimum Required Tank Volume

V_{system} = Volume of System, Gallons

D_{cold} = Density of System Water at Fill Temp

D_{hot} = Density of System Water at Op Temp

P_{fill} = Fill Pressure, psig

P_{charge} = Diaphragm Tank Chargel Pressure, psig

$P_{rel\ valve}$ = Relief Valve Pressure Setting, psig

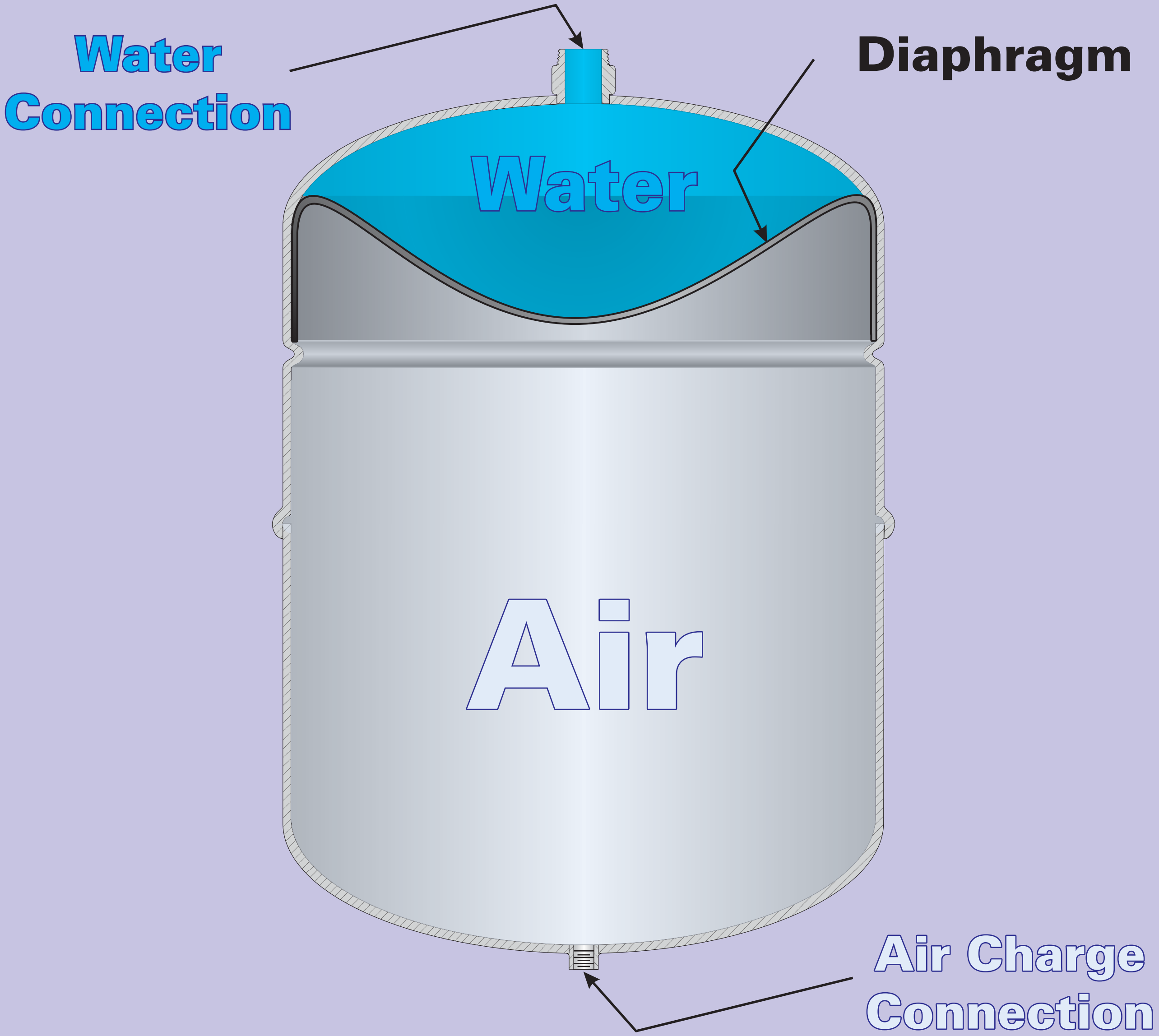
H_{system} = Height of Highest System Component

H_{tank} = Height of Compression Tank Inlet

This formula provides for a minimum pressure of 5 psig at the top of the system.

You can find the density of water at different temperatures in the NPSH table earlier in this book.

DIAPHRAGM EXPANSION TANK (Typical)



The water and air are separated by a rubber diaphragm in this type of tank.

Make sure to charge the tank (disconnected from system) to the desired fill pressure, usually 12 psig on residential systems.

COMPRESSION TANK SIZING

$$P_{fill} = \left(H_{system} - H_{tank}\right) x \left(\frac{D_{cold}}{144}\right) + 5$$

$$V = \frac{V_{system} \; x \left(\frac{D_{cold}}{D_{hot}} - 1\right)}{14.7 x \left(\frac{1}{(P_{fill} + 14.7)} - \frac{1}{(P_{rel\ valve} + 14.7)}\right)}$$

V = Minimum Required Tank Volume\

V_{system} = Volume of System, Gallons

D_{cold} = Density of System Water at Fill Temp

D_{hot} = Density of System Water at Op Temp

P_{fill} = Fill Pressure, psig

$P_{rel\ valve}$ = Relief Valve Pressure Setting, psig

H_{system} = Height of Highest System Component

H_{tank} = Height of Compression Tank Inlet

This formula provides a minimum of 5 psig at the top of the system.

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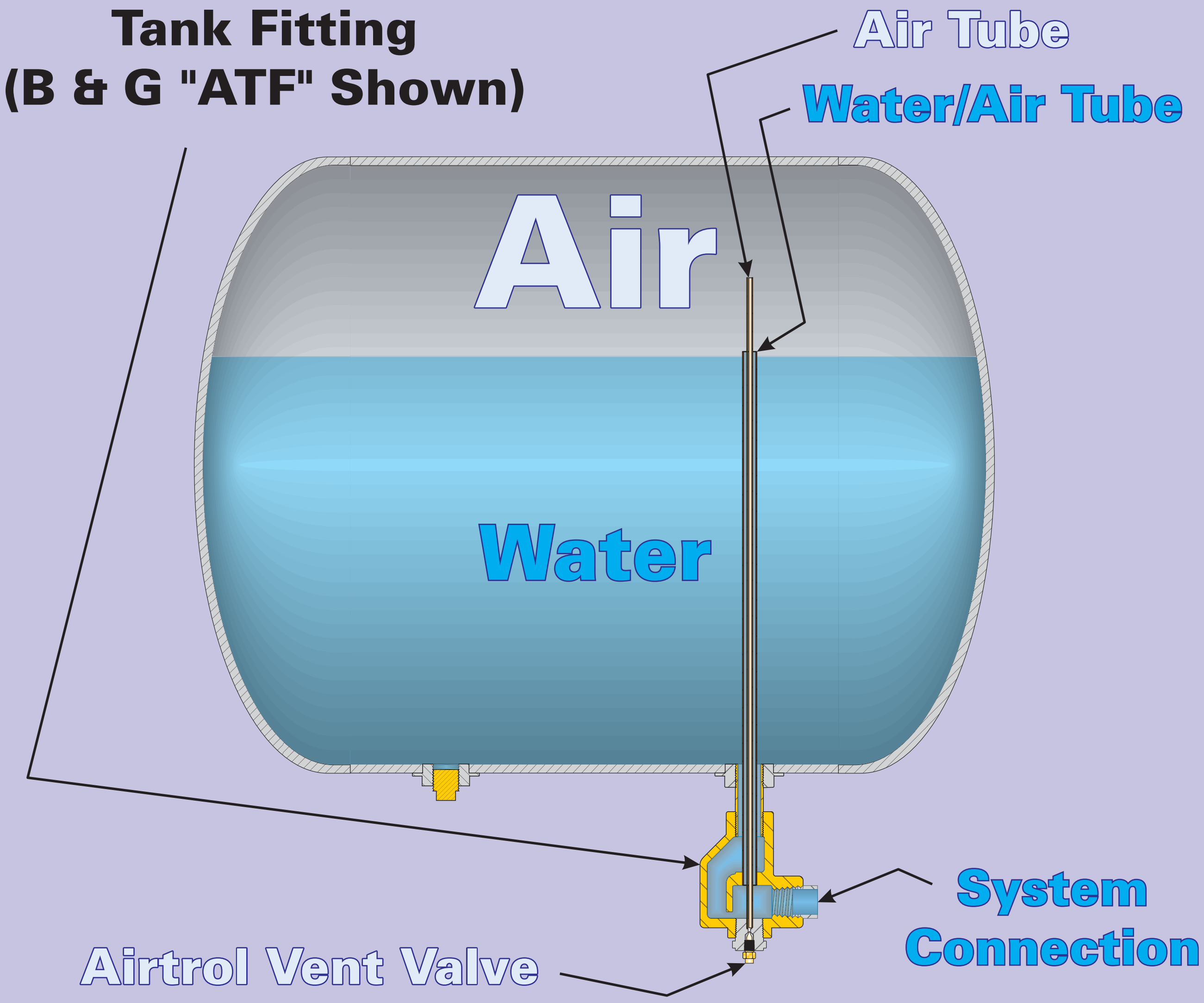
COMPRESSION TANK (Typical)

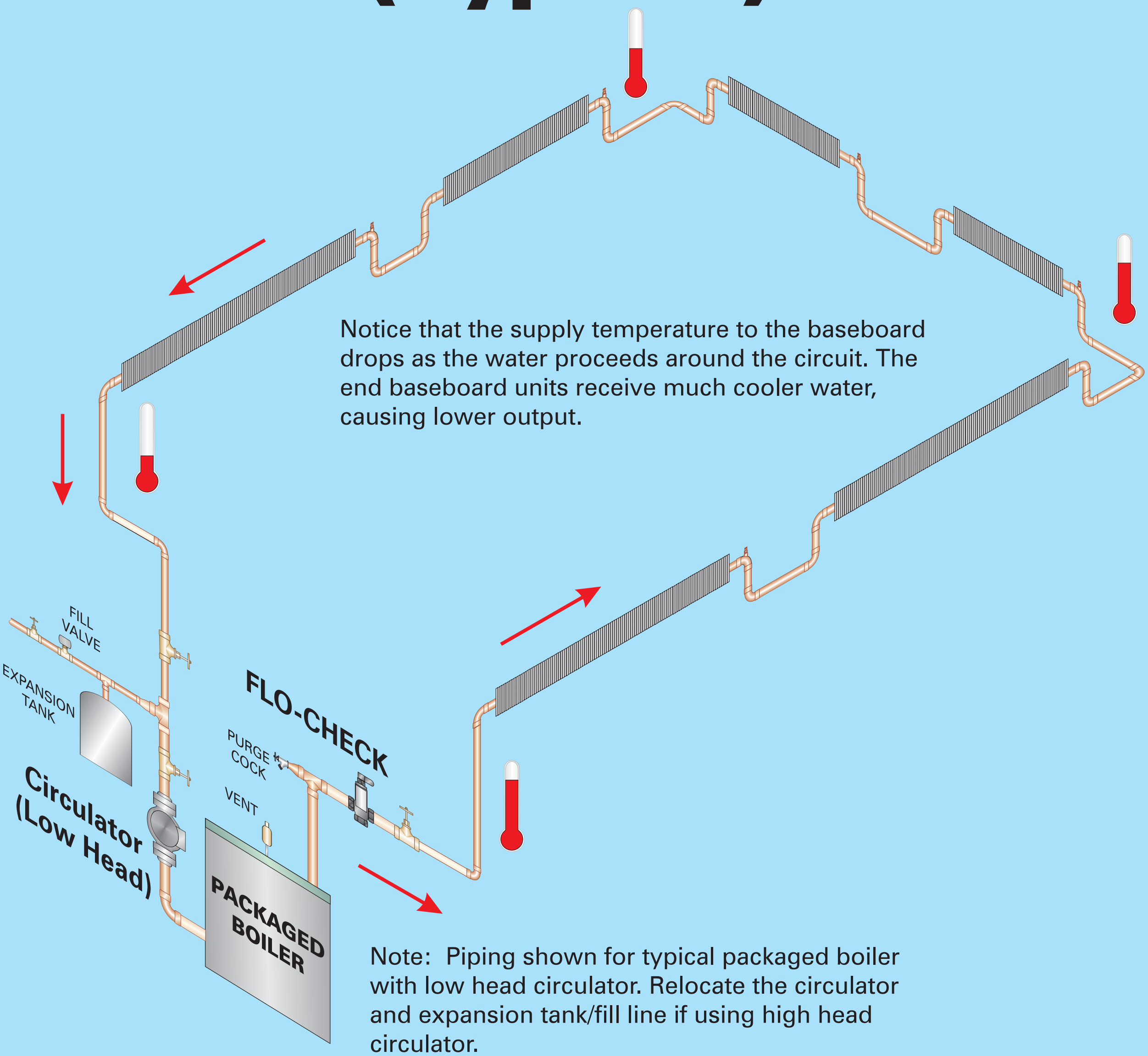


Always use a tank fitting, such as the B & G type shown, with compression tanks.

The tank fitting prevents gravity circulation of the water down to the piping. This would carry air down to the system.

Never use automatic air vents on systems with compression tanks.

SERIES LOOP SYSTEM RESIDENTIAL ONLY (Typical)

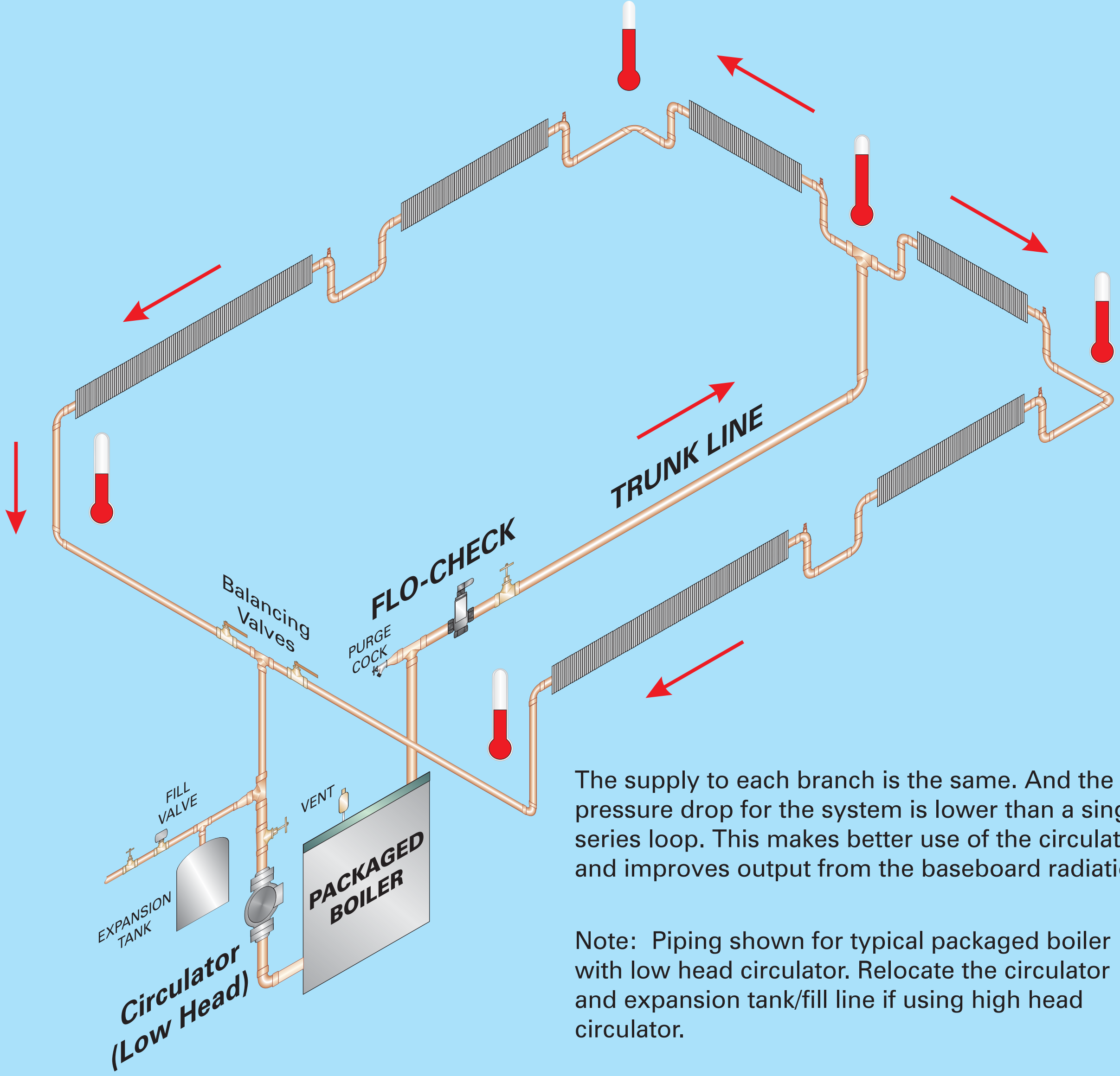


Notice that the supply temperature to the baseboard drops as the water proceeds around the circuit. The end baseboard units receive much cooler water, causing lower output.

Note: Piping shown for typical packaged boiler with low head circulator. Relocate the circulator and expansion tank/fill line if using high head circulator.

The supply temperature to baseboard units on series loops drops from unit to unit. This can cause heating problems if the later units are not sized for a lower average water temperature.

SERIES LOOP SYSTEM RESIDENTIAL ONLY (Typical)

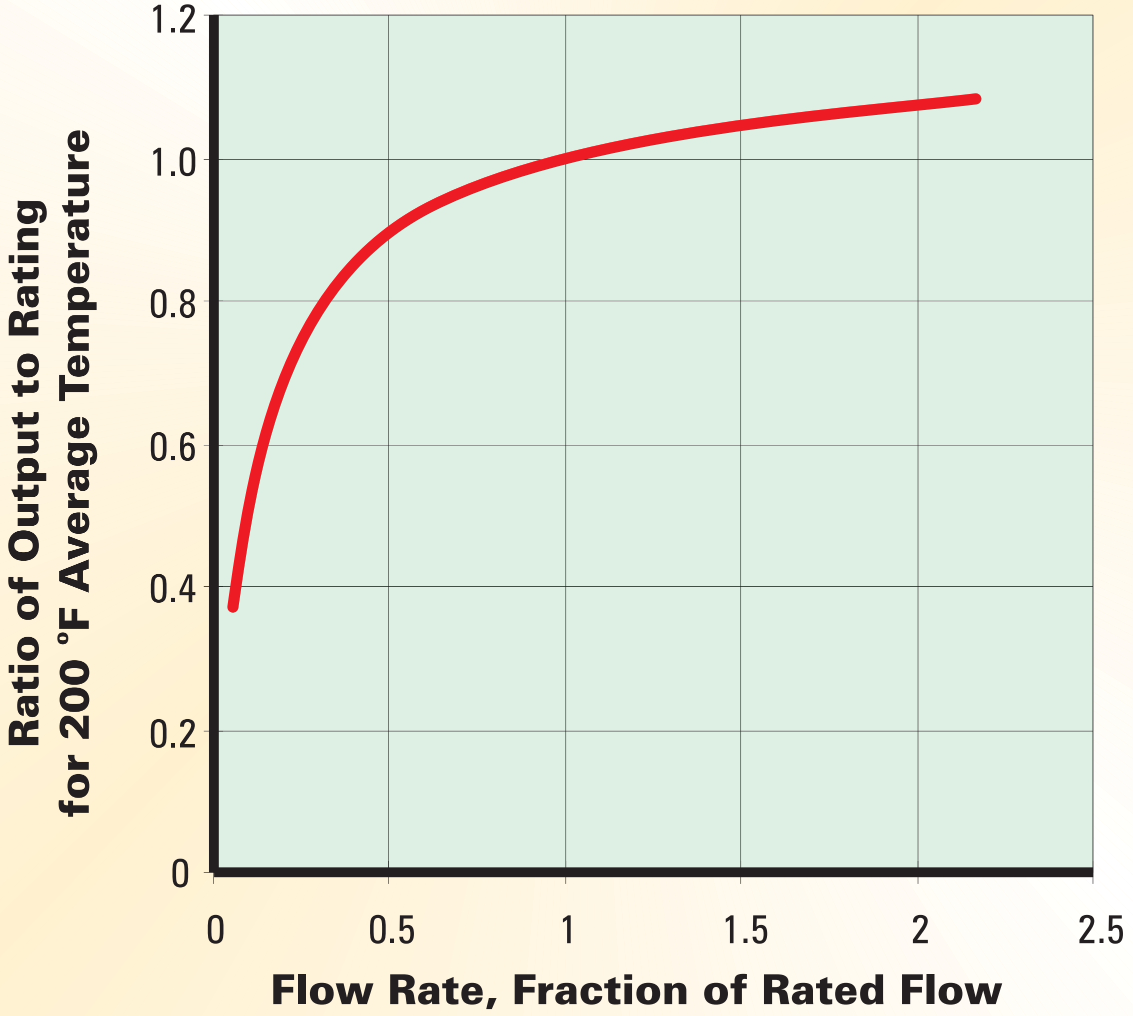


The supply to each branch is the same. And the pressure drop for the system is lower than a single series loop. This makes better use of the circulator and improves output from the baseboard radiation.

Note: Piping shown for typical packaged boiler with low head circulator. Relocate the circulator and expansion tank/fill line if using high head circulator.

Split loop systems are an improvement over series loop systems because the pressure drop is lower and the reduction in supply temperature to the baseboard units is not as severe.

CHANGE IN BASEBOARD OUTPUT with FLOW RATE

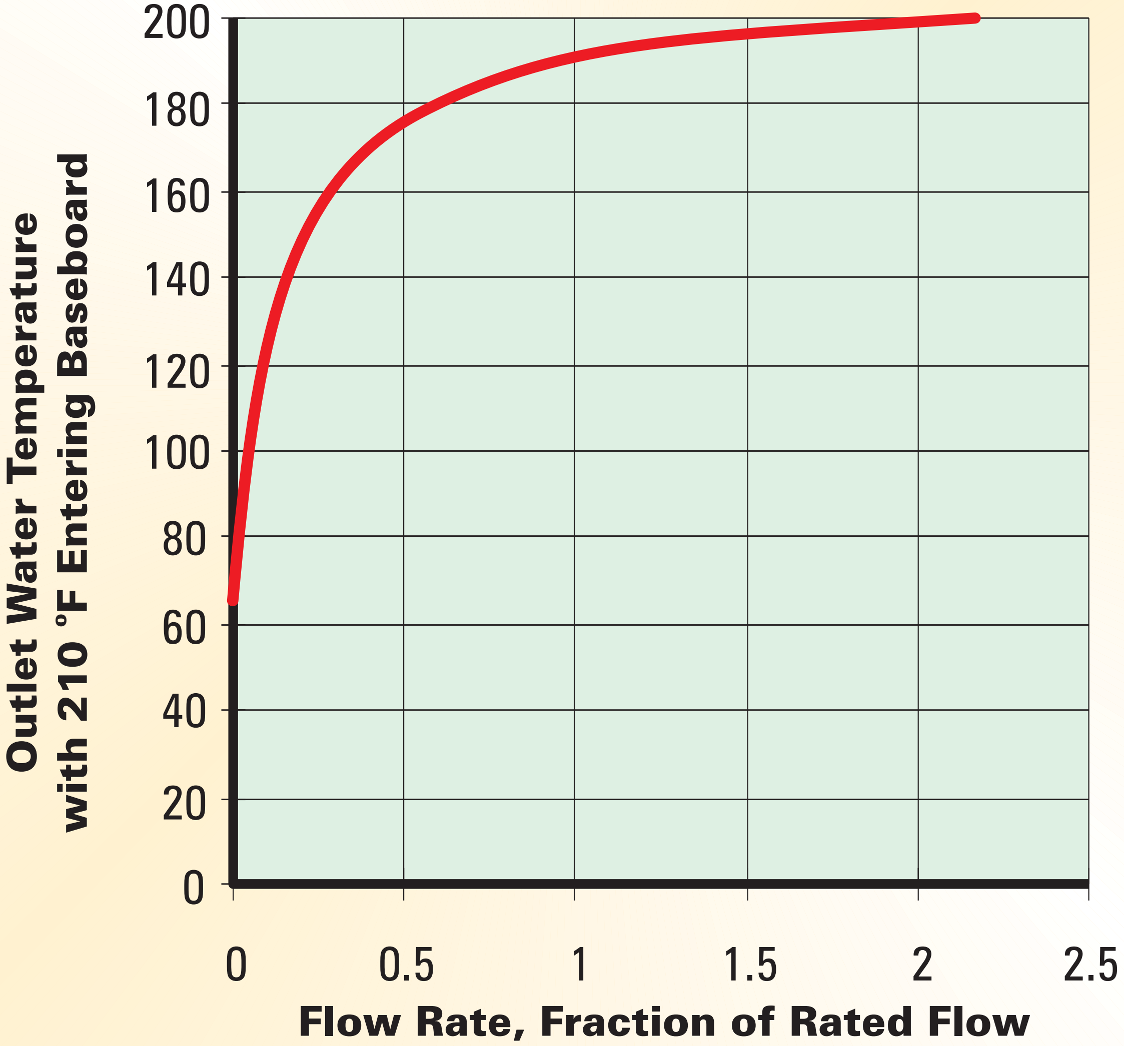


(Based on typical baseboard heater sized for 210 °F Inlet and 20 °F Drop)

Baseboard output for a single unit won't drop much as flow rate is reduced.

But it may cause problems with other units in series because they will receive cooler supply water.

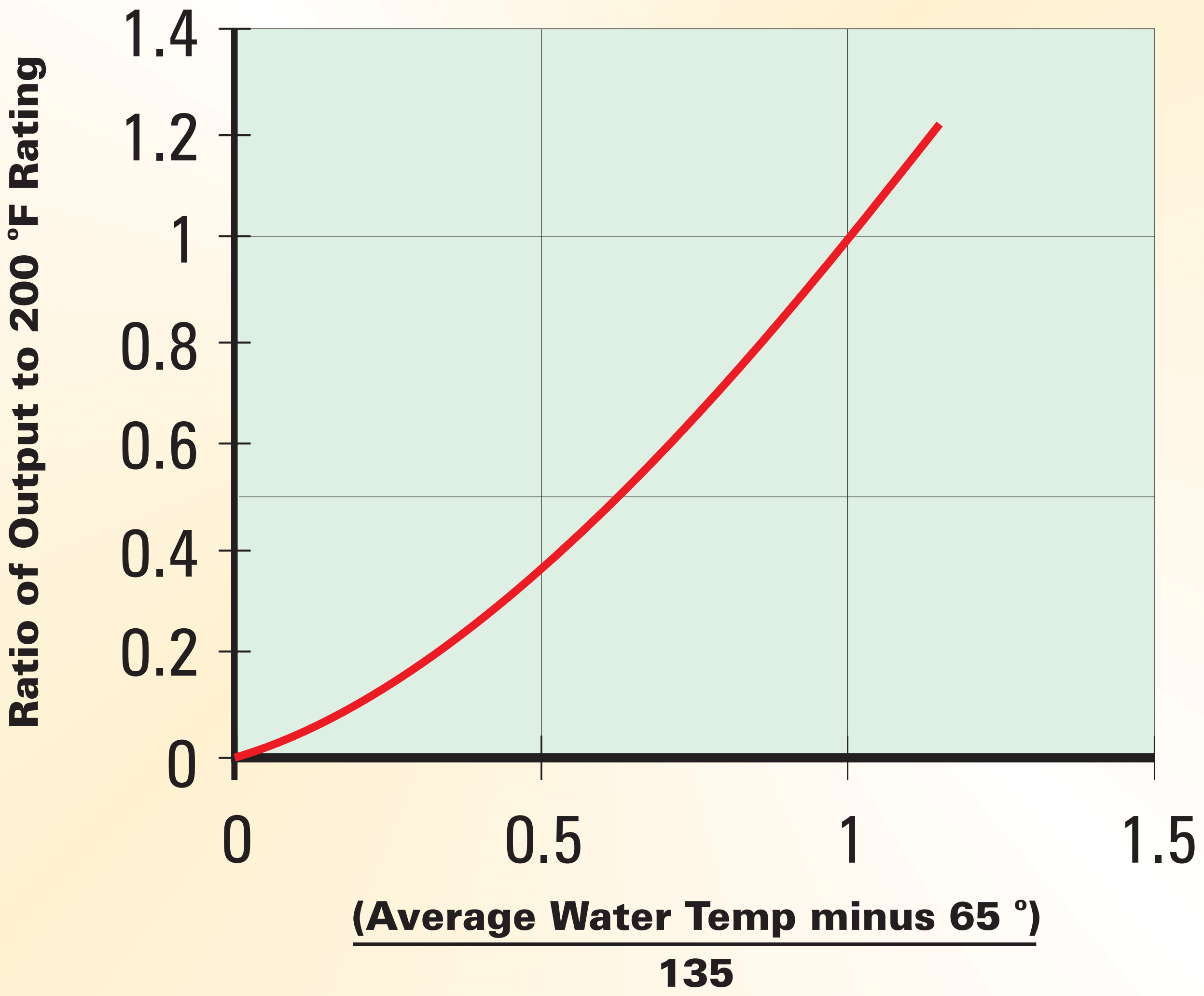
CHANGE IN LEAVING TEMPERATURE with FLOW RATE



(Based on typical baseboard heater sized for 210 °F Inlet and 20 °F Drop)

The leaving temperature of a baseboard unit drops as the flow is reduced. This can effect output from other units in series.

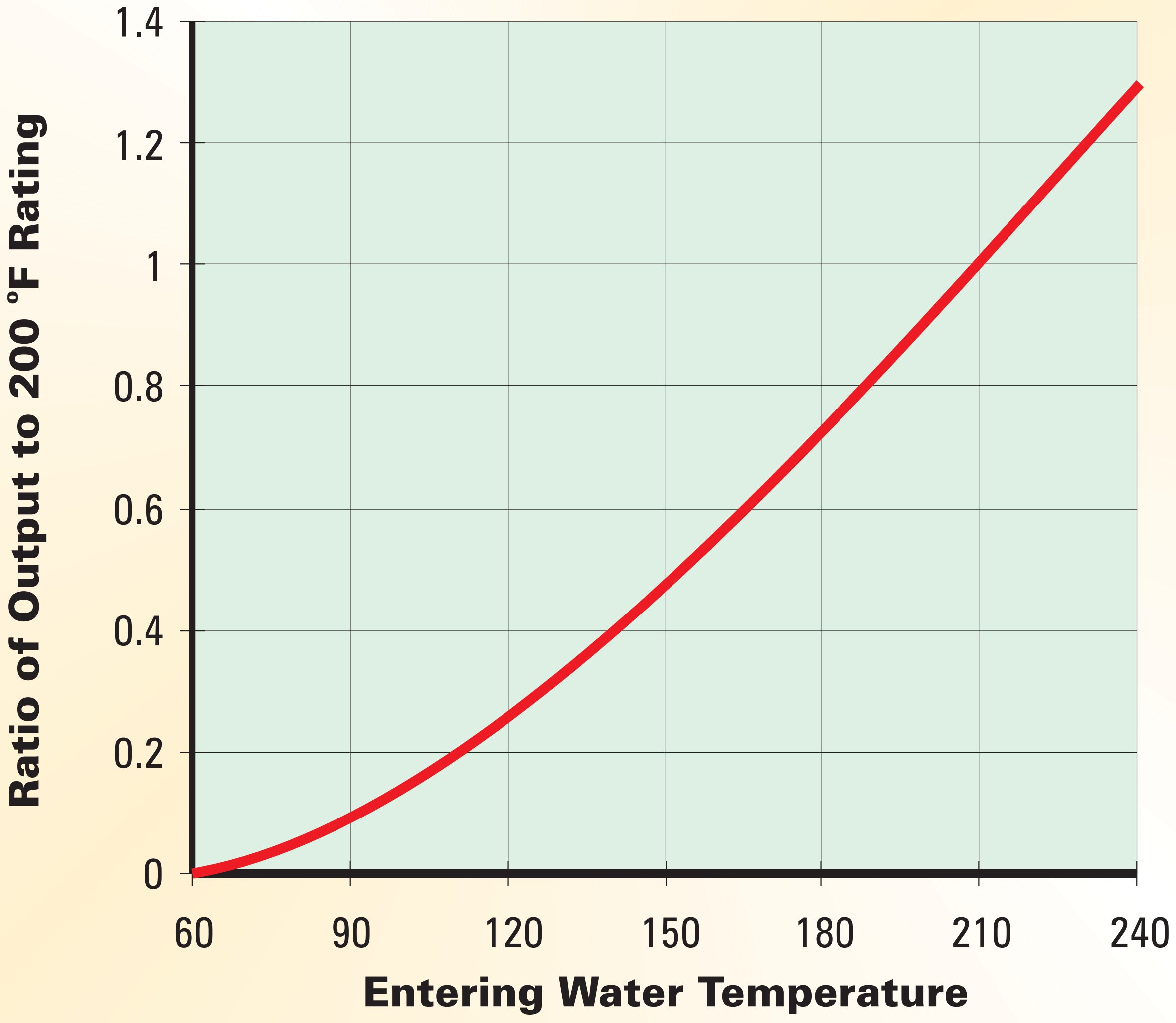
CHANGE IN BASEBOARD OUTPUT WITH AVERAGE TEMPERATURE



(Based on typical baseboard heater sized for 200 °F and 20 °F Drop)

Baseboard output drops quickly with reduced average temperature.

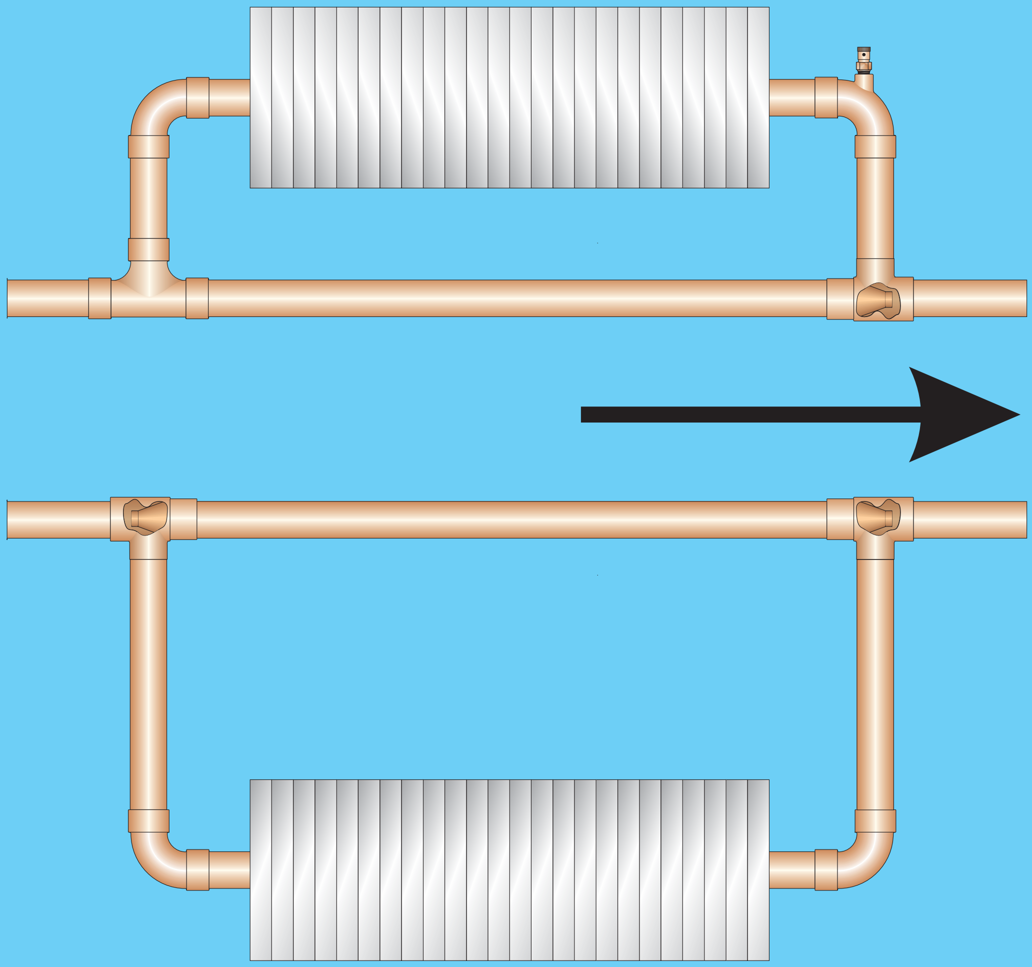
CHANGE IN BASEBOARD OUTPUT WITH ENTERING TEMPERATURE



(Based on typical baseboard heater sized for 210 °F Inlet and 20 °F Drop)

Baseboard output drops quickly with entering temperature reduction.

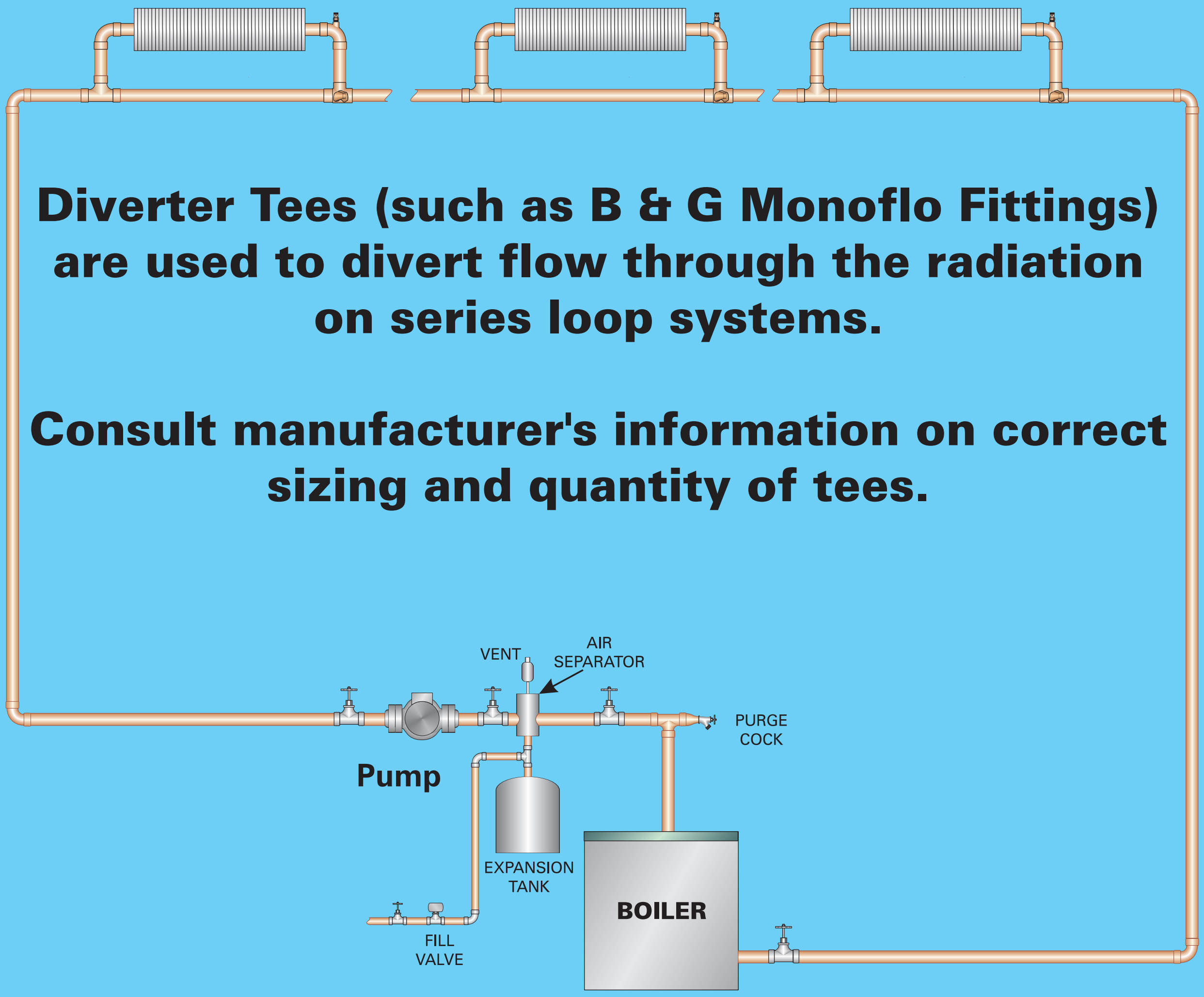
DIVERTER TEES (Typical)



Use two tees as shown when radiation is below. This helps fight the buoyancy caused by the hotter water being above.

Diverter tees are used on one pipe systems to regulate flow through radiation. Use the tee manufacturer's sizing information for the best selection.

ONE PIPE SYSTEM WITH DIVERTER TEES (Typical)

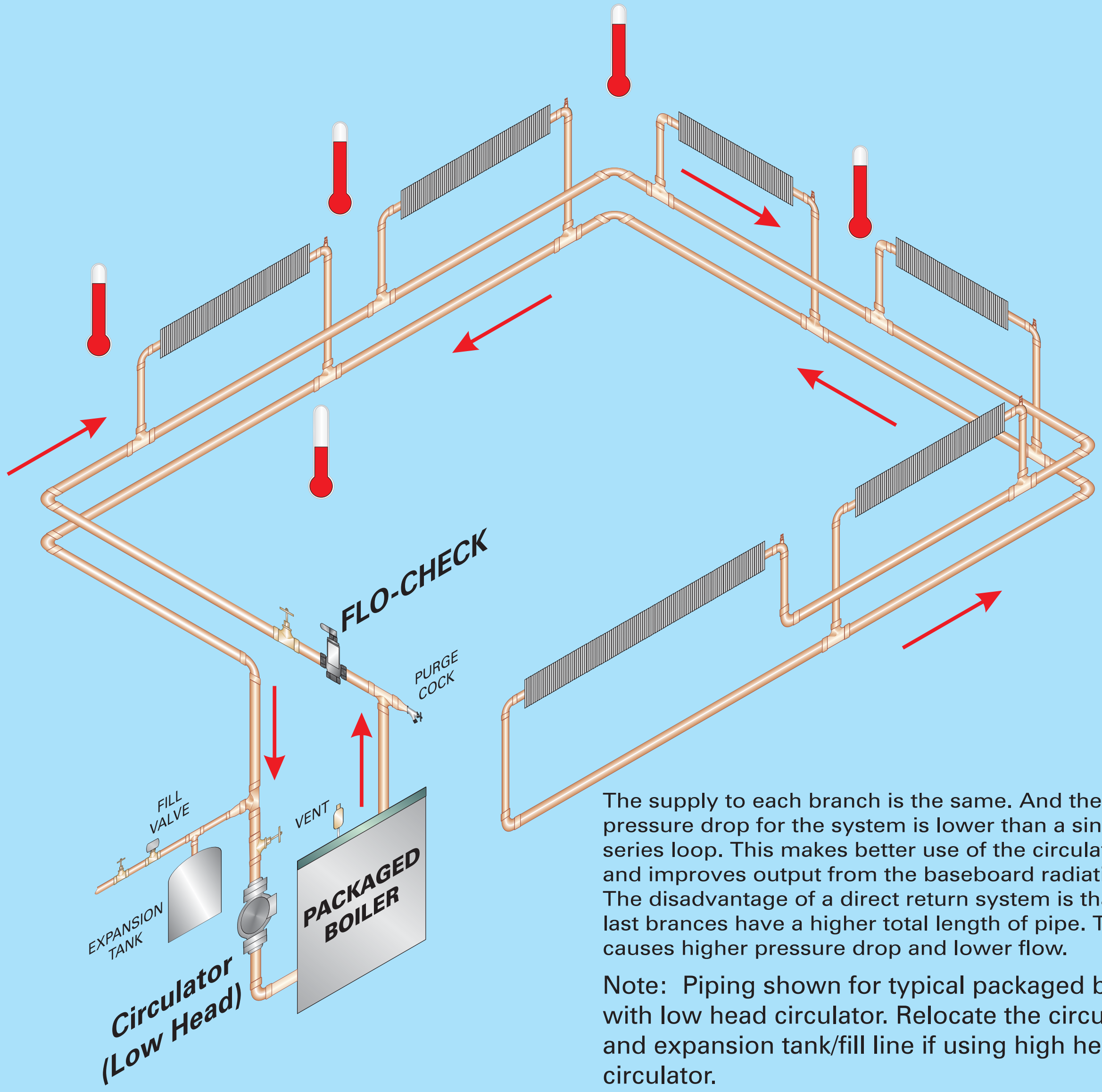


Diverter Tees (such as B & G Monoflo Fittings) are used to divert flow through the radiation on series loop systems.

Consult manufacturer's information on correct sizing and quantity of tees.

Diverter tees regulate water flow through radiation by introducing a pressure drop in the line.

TWO PIPE DIRECT RETURN RESIDENTIAL ONLY (Typical)



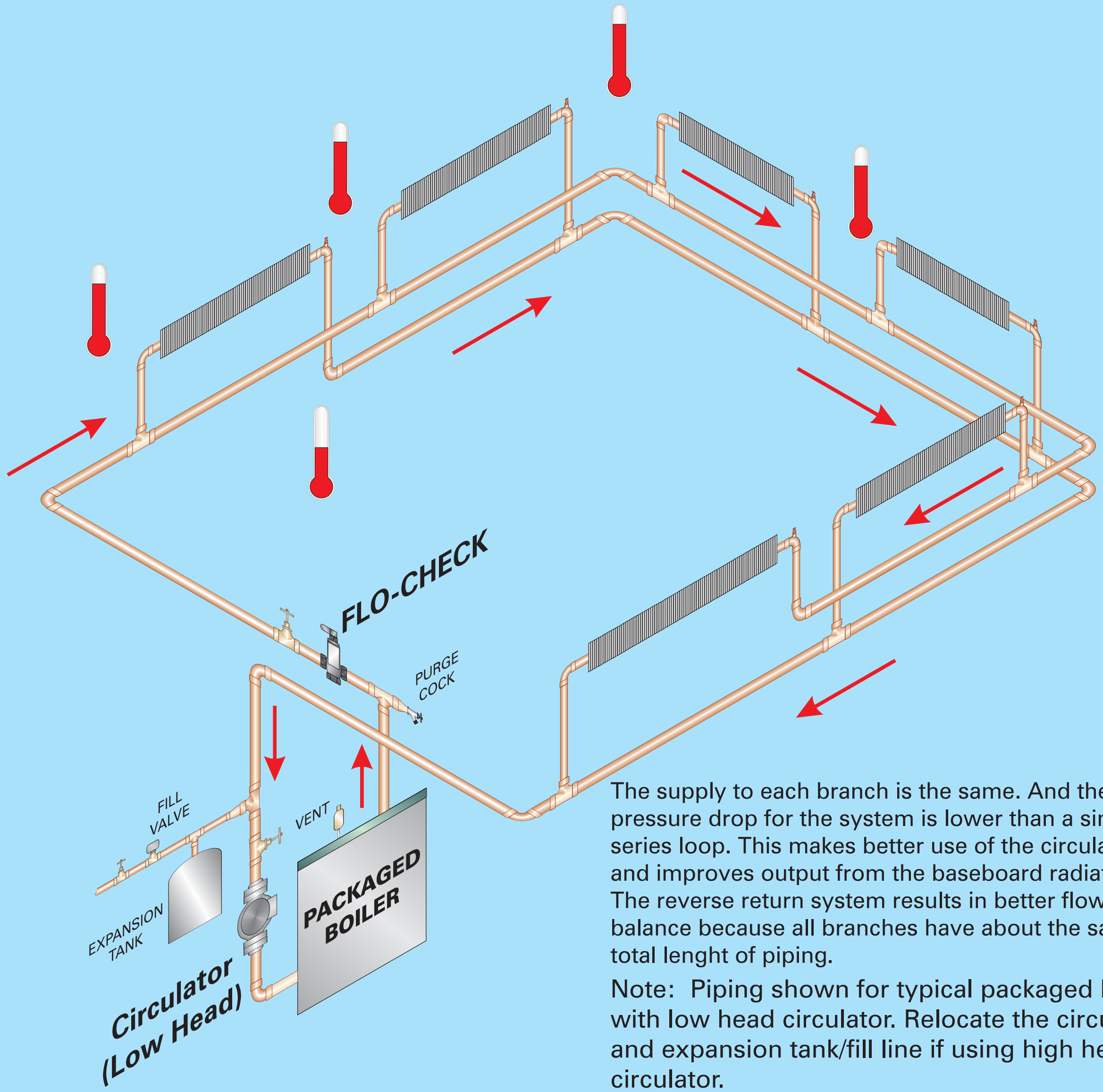
The supply to each branch is the same. And the pressure drop for the system is lower than a single series loop. This makes better use of the circulator and improves output from the baseboard radiation. The disadvantage of a direct return system is that the last brances have a higher total length of pipe. This causes higher pressure drop and lower flow.

Note: Piping shown for typical packaged boiler with low head circulator. Relocate the circulator and expansion tank/fill line if using high head circulator.

Two pipe systems provide the same supply temperature to each radiation unit.

Direct return systems are likely to have flow balance problems because the furthest radiation piping is longer than for closer units. This causes large differences in pressure drops in the branches.

TWO PIPE REVERSE RETURN RESIDENTIAL ONLY (Typical)



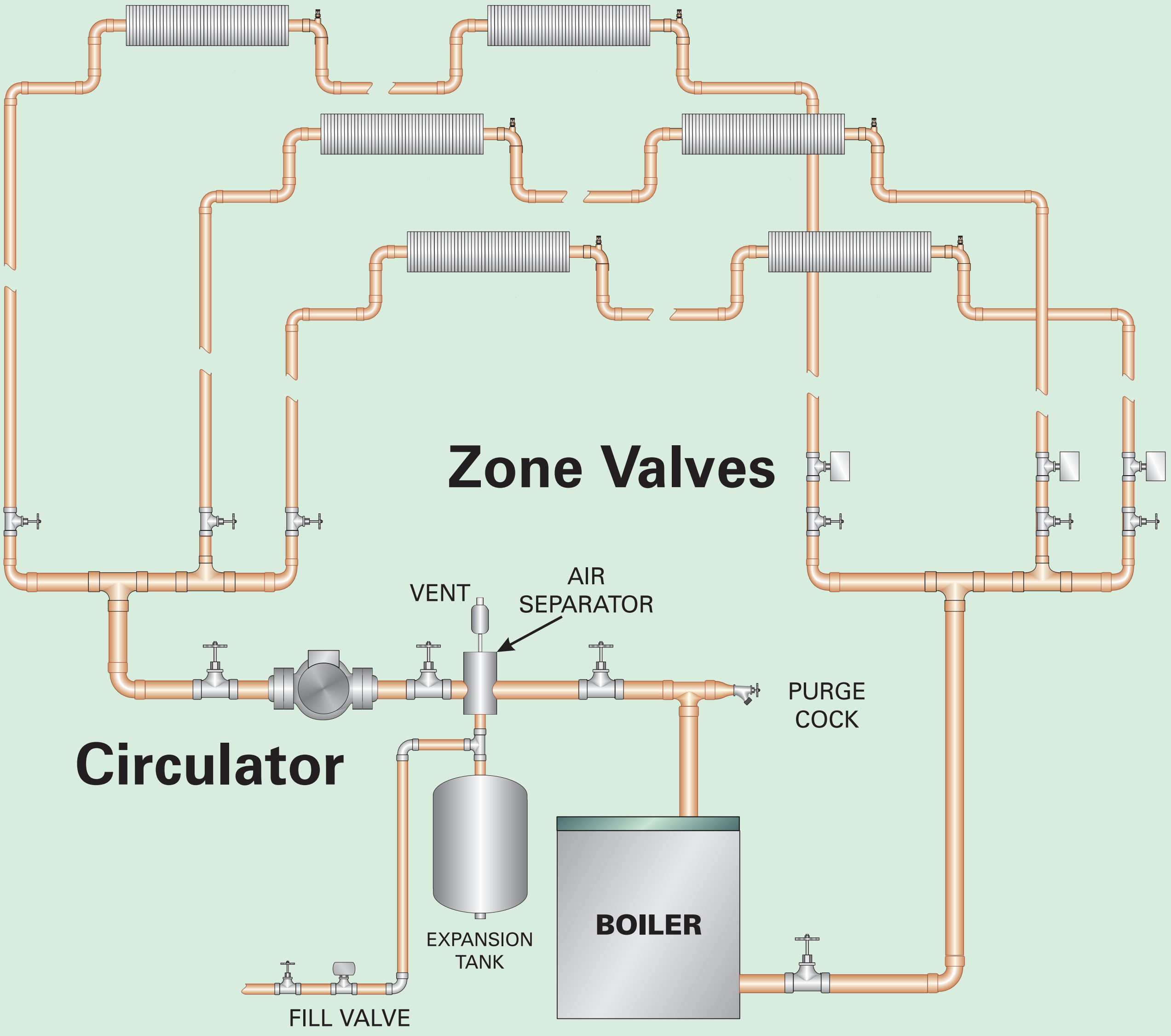
The supply to each branch is the same. And the pressure drop for the system is lower than a single series loop. This makes better use of the circulator and improves output from the baseboard radiation. The reverse return system results in better flow balance because all branches have about the same total lenght of piping.

Note: Piping shown for typical packaged boiler with low head circulator. Relocate the circulator and expansion tank/fill line if using high head circulator.

Two pipe systems provide the same supply temperature to each radiation unit.

Reverse return systems are easier to balance because each branch has about the same length of piping. So all pressure drops are about the same.

TWO PIPE SYSTEM WITH ZONE VALVES (Typical)

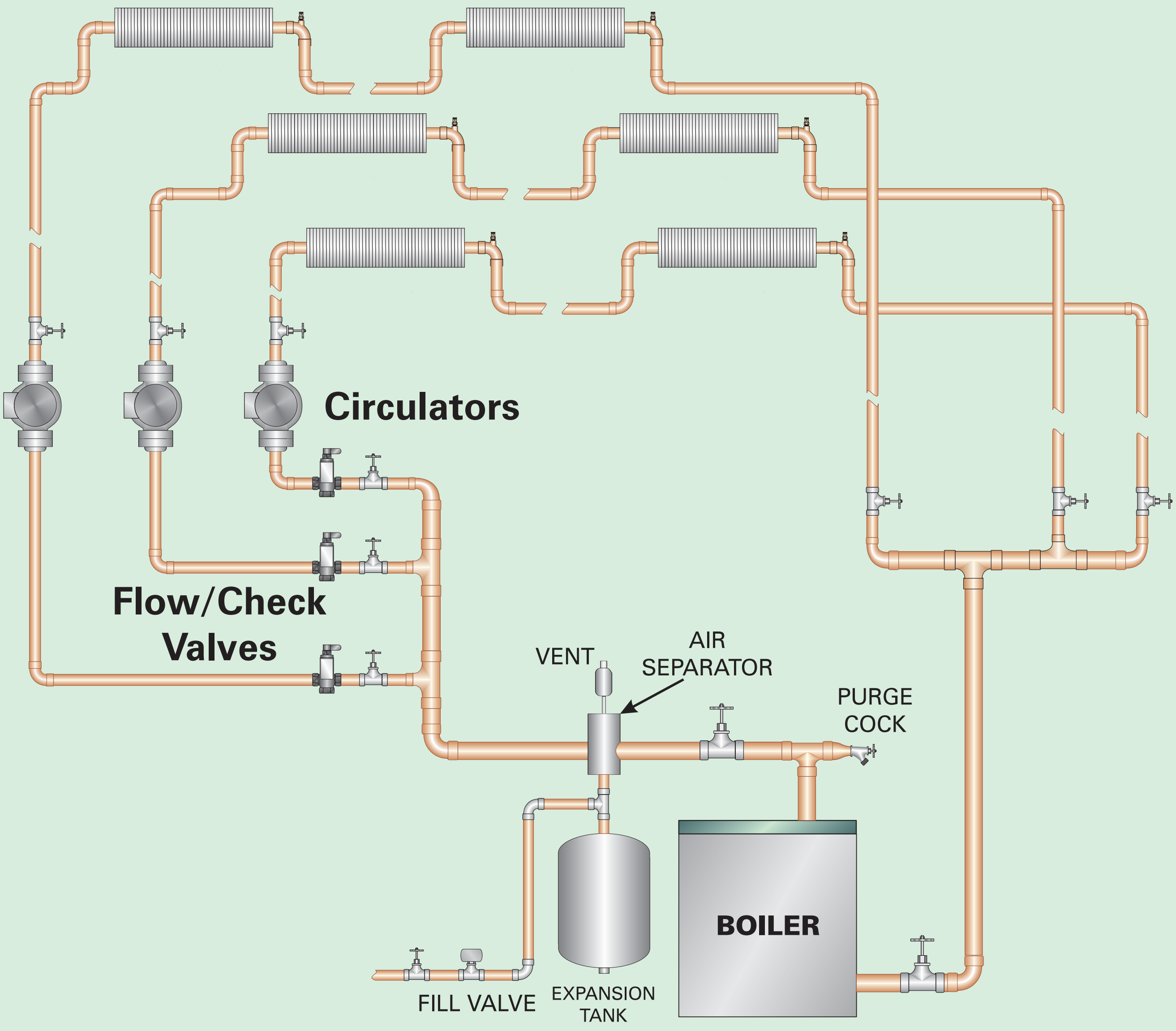


The boiler is operated by the end switches on the zone valves.

When a zone calls for heat its zone valve opens and trips the valve switch. The boiler then fires, providing heat as long as the valve is open.

Make sure when using three wire zone valves to check the electrical connections to the boiler. If the valves are correctly connected there should never be a voltage on the leads to the boiler.

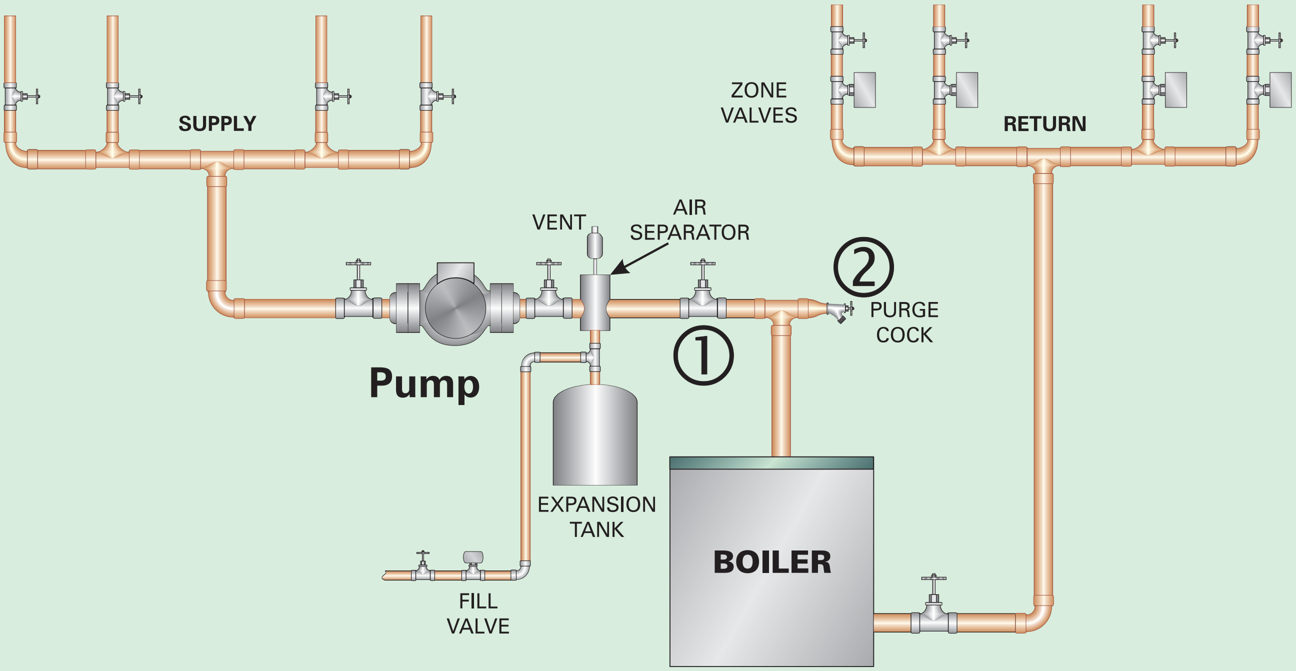
TWO PIPE SYSTEM WITH CIRCULATORS (Typical)



Zoning with circulators assures adequate flow through each zone while still allowing the use of low head circulators.

Circulators must be wired to circulator relays. Some circulator manufacturers now supply zoning circulators. These have the relay mechanism built in, allowing much simpler wiring.

RESIDENTIAL PIPING FOR AIR PURGING (Typical)

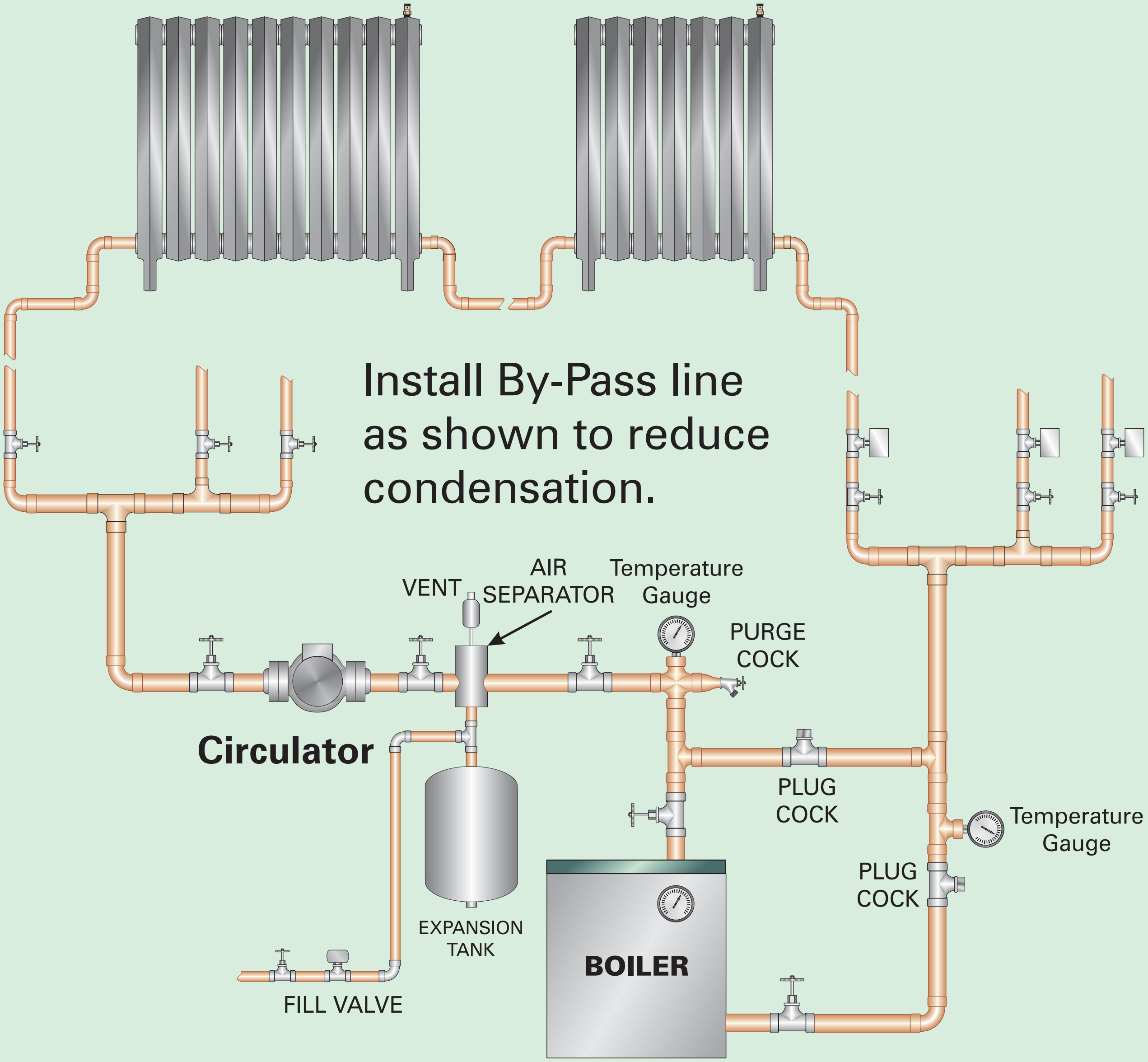


PURGE THE AIR FROM THE SYSTEM

- *Purge one zone at a time. Close all zone shut-off valves.*
- *Close the boiler main shut-off valve (valve 1).*
- *Open the purge valve (valve 2).*
- *One at a time, open each zone shut-off valve and allow water to flow through, pushing the air out through the purge valve. Close the zone shut-off valve and proceed with the next zone.*

Always pipe a purge valve (boiler cock) on the boiler supply piping to allow purging the air from the system.

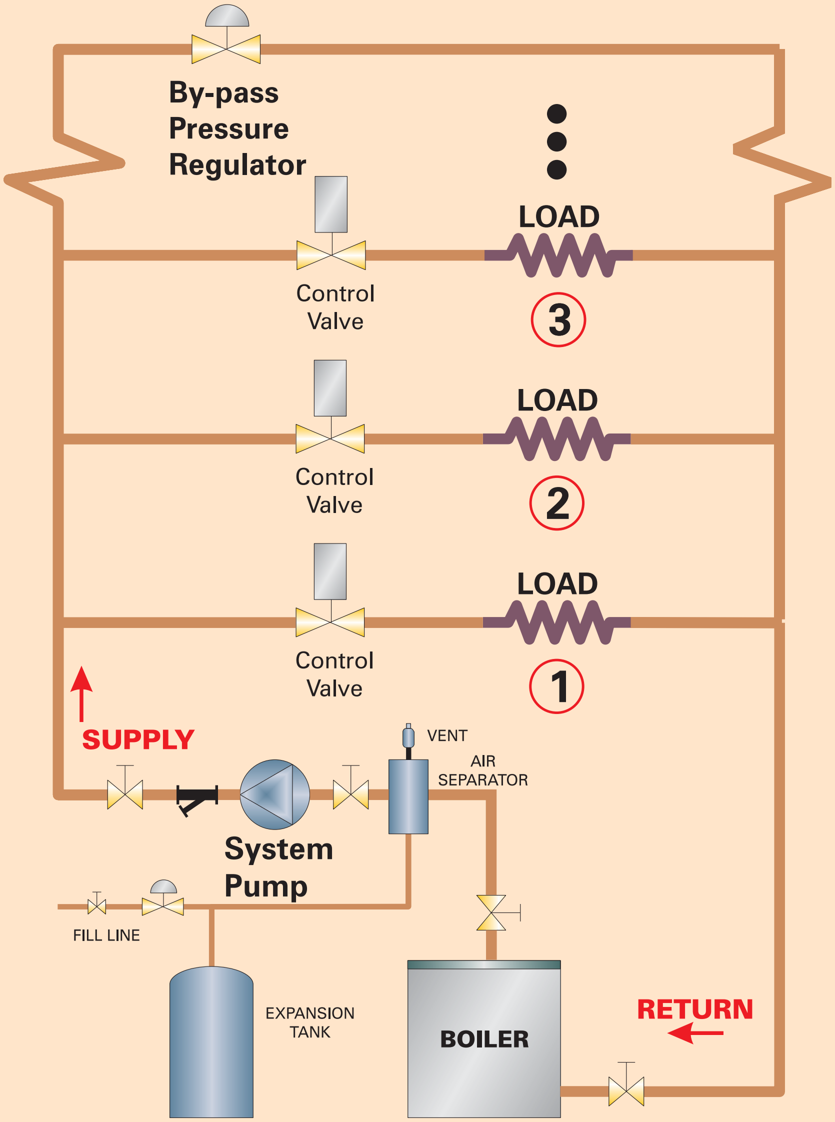
RESIDENTIAL PIPING HIGH VOLUME SYSTEMS (Typical)



On converted gravity return systems and other high volume residential systems, pipe a bypass line as shown.

The bypass line causes less water to flow through the boiler. This causes a higher temperature rise through the boiler, increasing the average temperature inside.

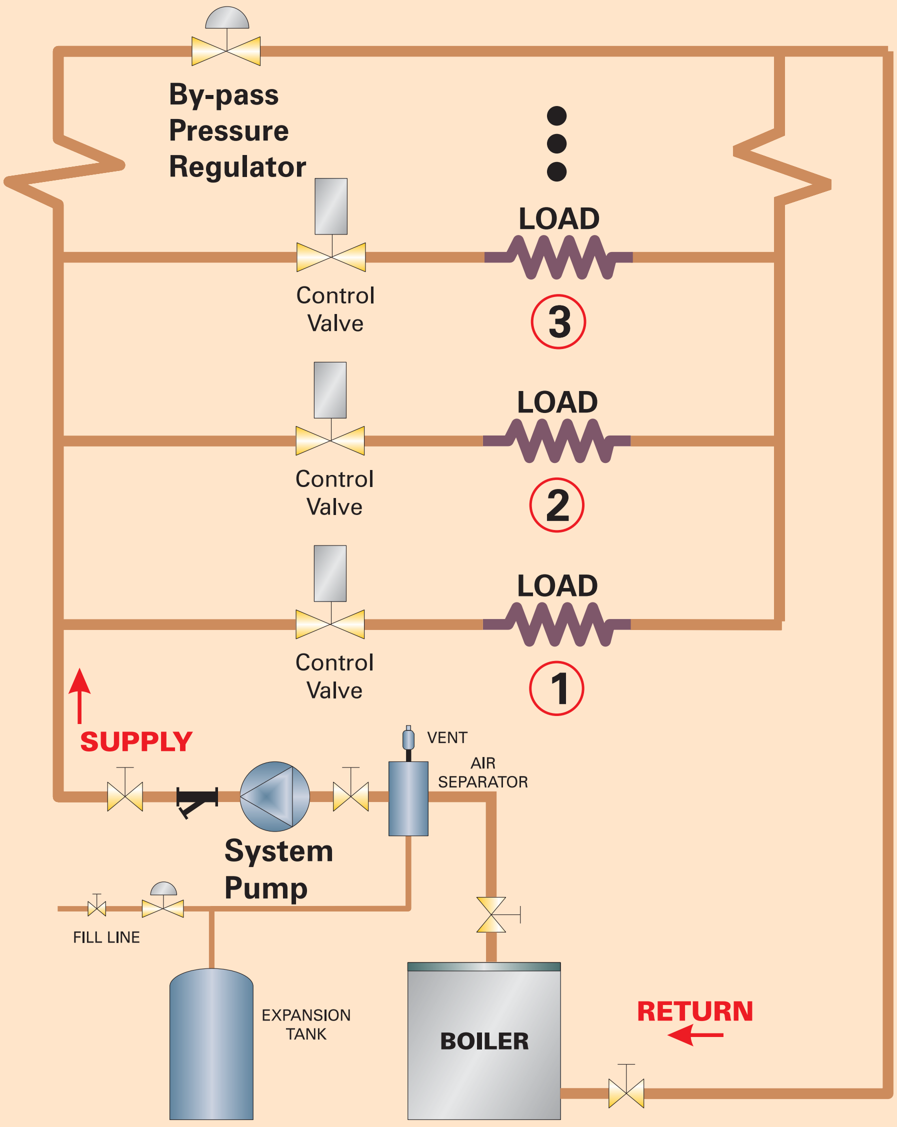
TWO PIPE SYSTEM DIRECT RETURN (Typical)



Two pipe systems are the most common design for commercial boiler applications. Direct return systems are harder to balance because the more remote branches have longer piping runs and higher pressure drop than the close branches.

Make sure to use a by-pass pressure regulator. This prevents the pump from building excess pressure as control valves close. It also prevents cavitation in the pump due to low flow.

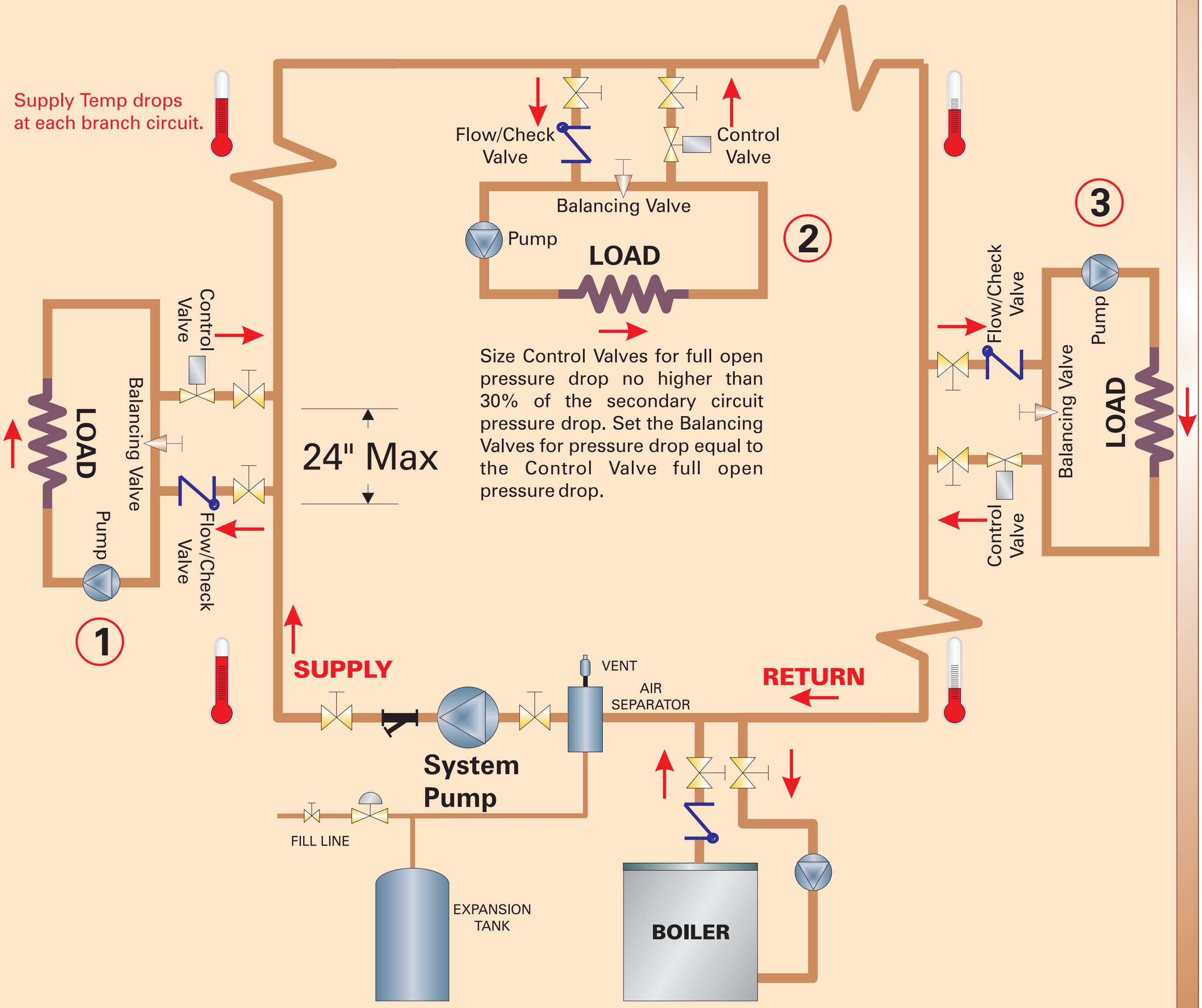
TWO PIPE SYSTEM REVERSE RETURN (Typical)



Two-pipe reverse return systems are easier to balance because all branches have about the same length of piping, thus the same pressure drop.

Make sure to use a by-pass pressure regulator. This prevents the pump from building excess pressure as control valves close. It also prevents cavitation in the pump due to low flow.

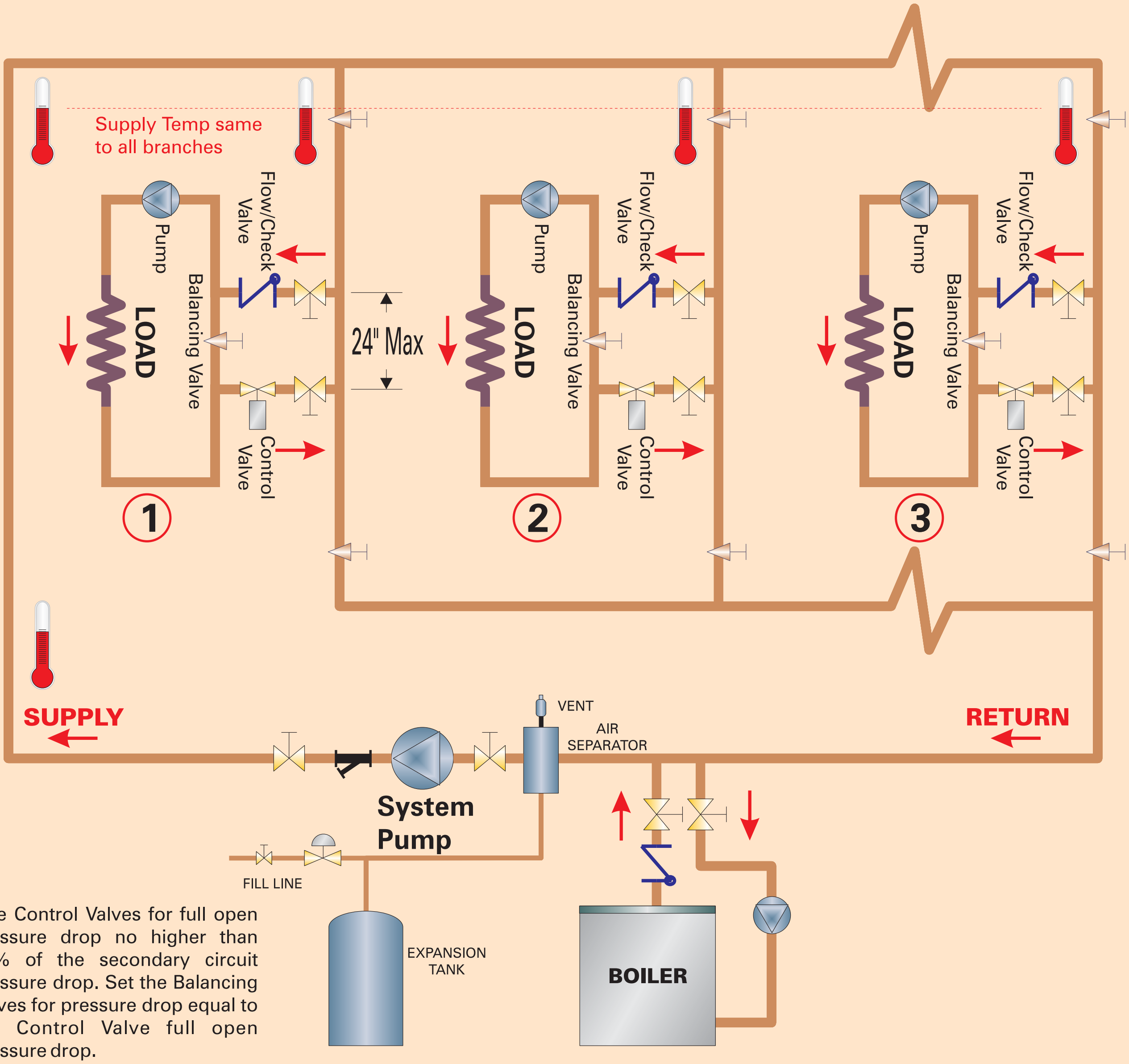
PRIMARY/SECONDARY SERIES LOOP SYSTEM (Typical)



Size Control Valves for full open pressure drop no higher than 30% of the secondary circuit pressure drop. Set the Balancing Valves for pressure drop equal to the Control Valve full open pressure drop.

A series primary/secondary system requires high flow rates. This is because the supply temperature to the branches drops as the water proceeds around the loop. To assure high enough water supply to the later branches the temperature drop for the system must be low, so the flow is high.

PRIMARY/SECONDARY TWO PIPE SYSTEM (Typical)



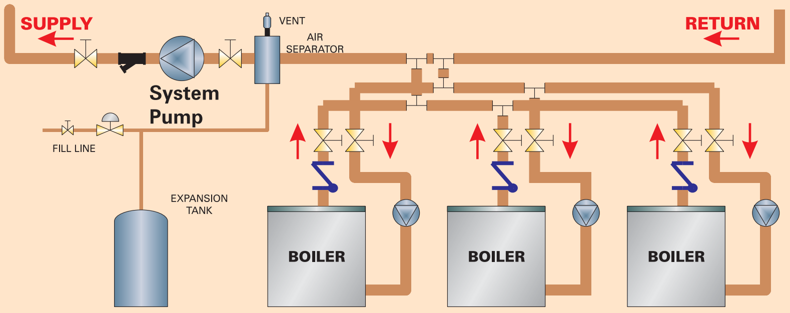
Size Control Valves for full open pressure drop no higher than 30% of the secondary circuit pressure drop. Set the Balancing Valves for pressure drop equal to the Control Valve full open pressure drop.

Two pipe primary/secondary piping allows low flow rate (high temperature drop) through the main loop because all branches receive supply water at the same temperature.

MULTIPLE BOILER PIPING

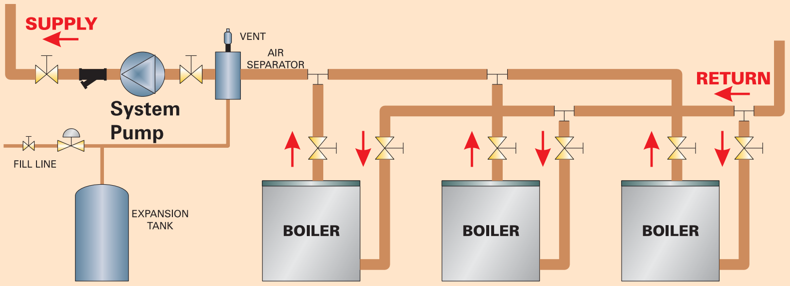
PREFERRED METHOD PRIMARY/SECONDARY

- 👍 No flow through idle boilers (energy saver)
- 👍 Isolating a boiler does not affect system flow
- 👎 Requires pump and flow control valve(s) for each boiler



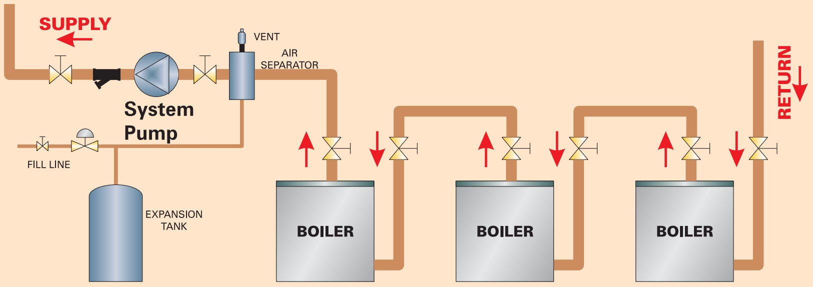
ALTERNATIVE METHOD PARALLEL PIPING

- 👍 Does not require pump & flow control valve on each boiler
- 👎 Pressure drop through boilers increases when one or more boilers is isolated
- 👎 Flow through idle boilers causes heat loss to room and chimney



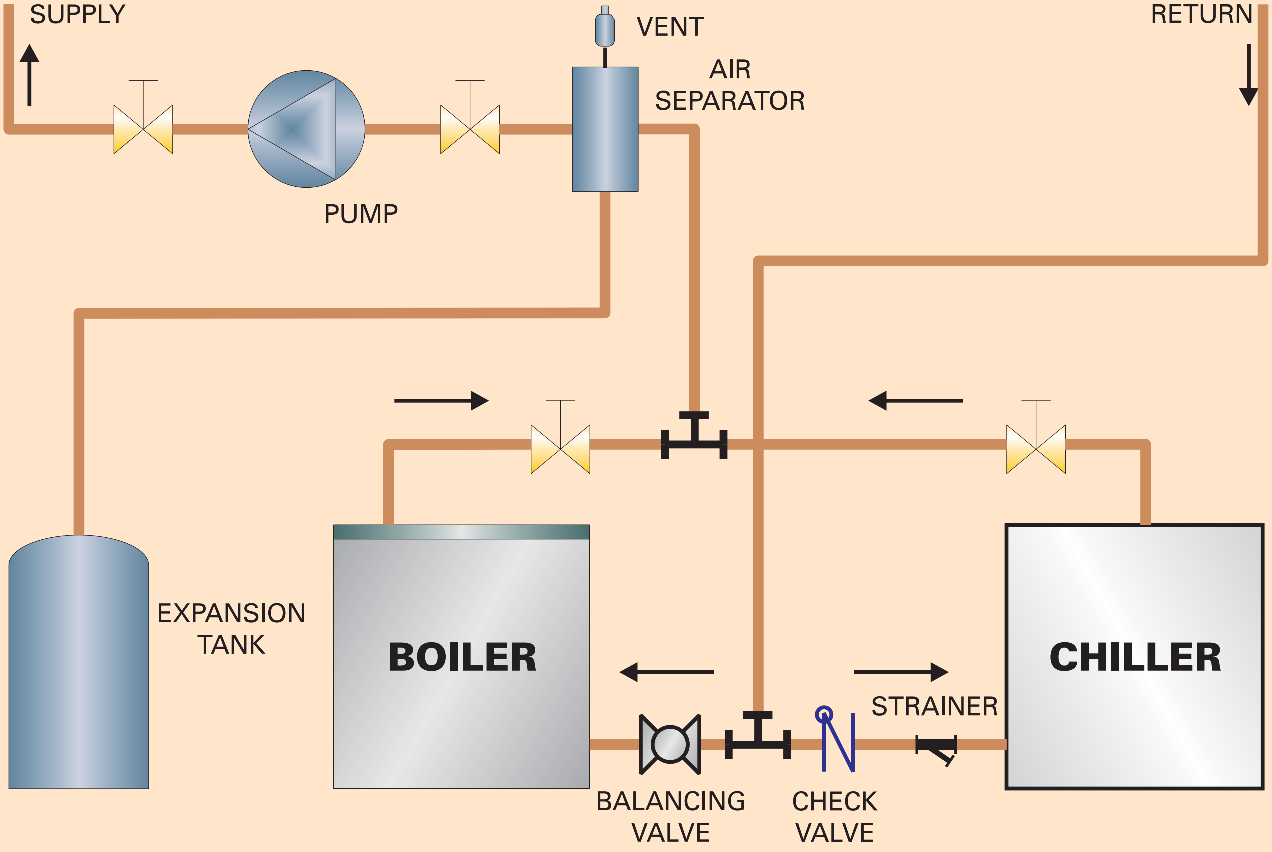
NOT RECOMMENDED SERIES PIPING

- 👎 Outlet temperature of each boiler increases, causing high limit tripping
- 👎 Cannot isolate a boiler for service without shutting down system
- 👎 Requires very high flow rates and flow through idle boilers wastes energy



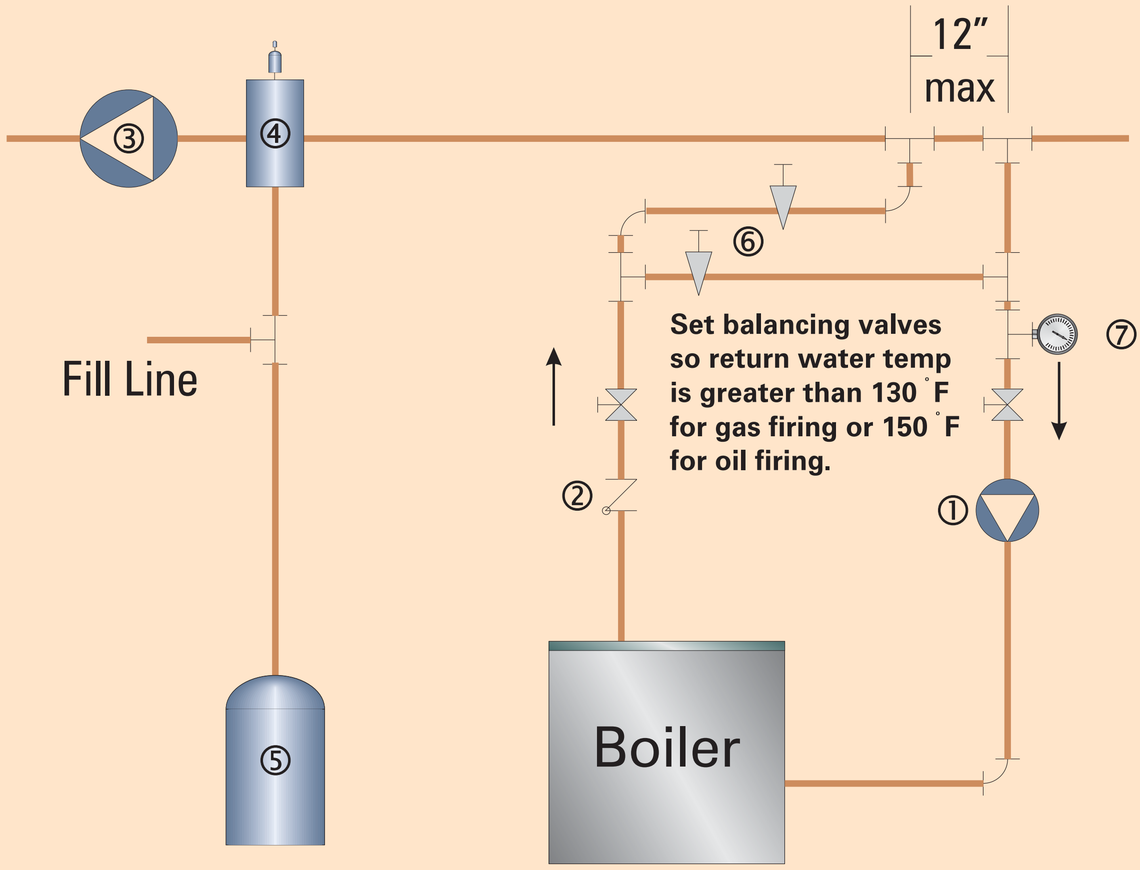
Primary/secondary piping is the best choice for multiple boilers. It assures better control of the return water temperature and prevents flow of hot system water through idle boilers.

ISOLATING BOILER ON CHILLED WATER SYSTEMS (Typical)



Pipe the chiller into the system as shown to prevent chilled water from flowing through the boiler.

PIPING FOR CONSTANT LOW TEMP OPERATION (Typical, Single Boiler)

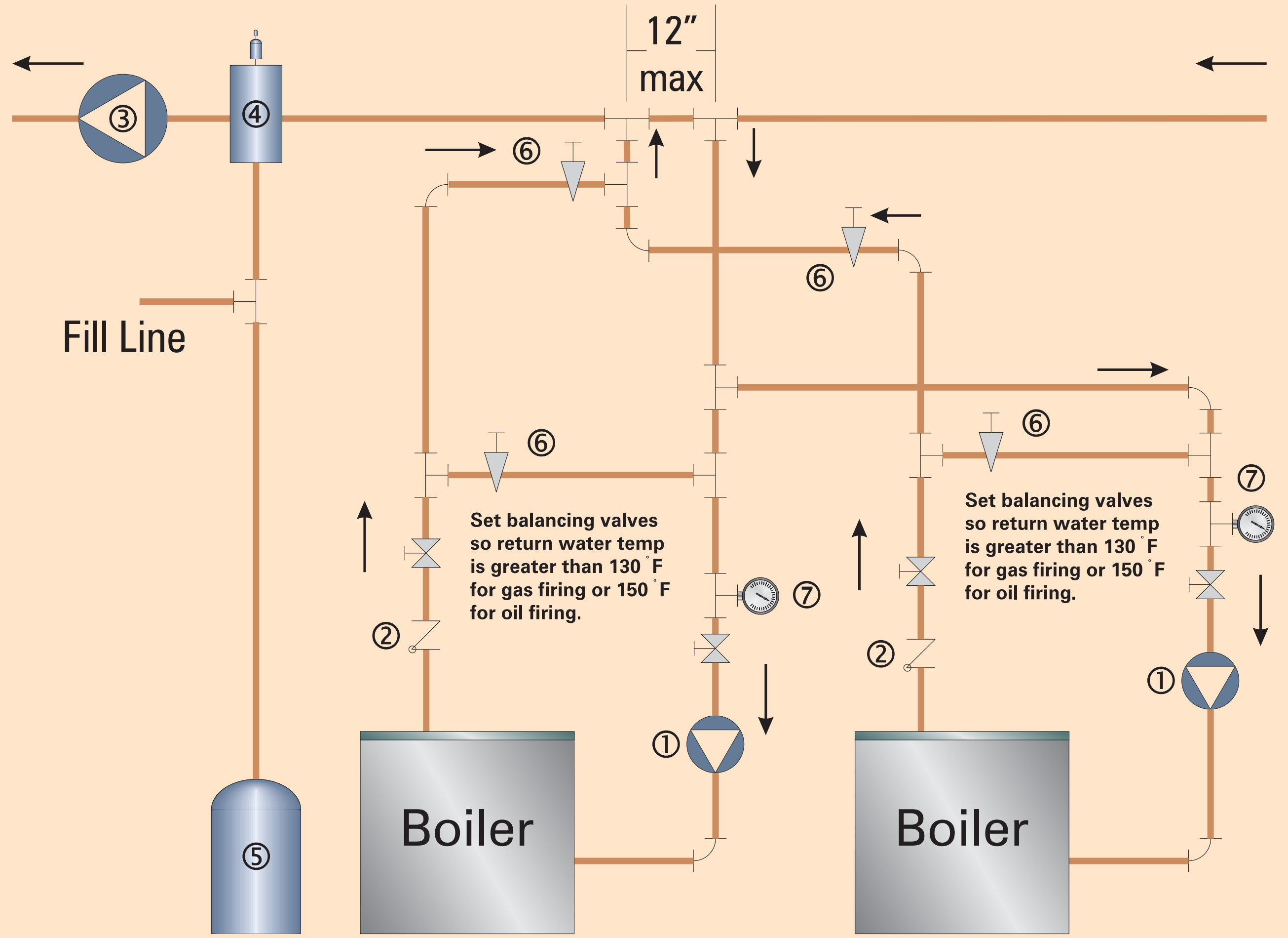


①	**Boiler Loop Circulator**	⑤	**Expansion Tank**
②	**Check Valve**	⑥	**Balancing Valves**
③	**System Pump**	⑦	**Temperature Gauges**
④	**Air Separator**		

For heat pump applications and most radiant floor applications or where the water temperature will always be low, you can use a fixed bypass as shown. This mixes hot boiler supply water with the cool return water so the return water to the boiler is high enough to prevent condensation.

If the return water temperature will be higher at some times during the season a fixed bypass will not work. This would cause the boiler to trip on high limit frequently. Use the piping for variable low temperature operation.

PIPING FOR CONSTANT LOW TEMP OPERATION (Typical, Multiple Boilers)



Set balancing valves so return water temp is greater than 130˚F for gas firing or 150˚F for oil firing.

Set balancing valves so return water temp is greater than 130˚F for gas firing or 150˚F for oil firing.

①	**Boiler Loop Circulator**	⑤	**Expansion Tank**
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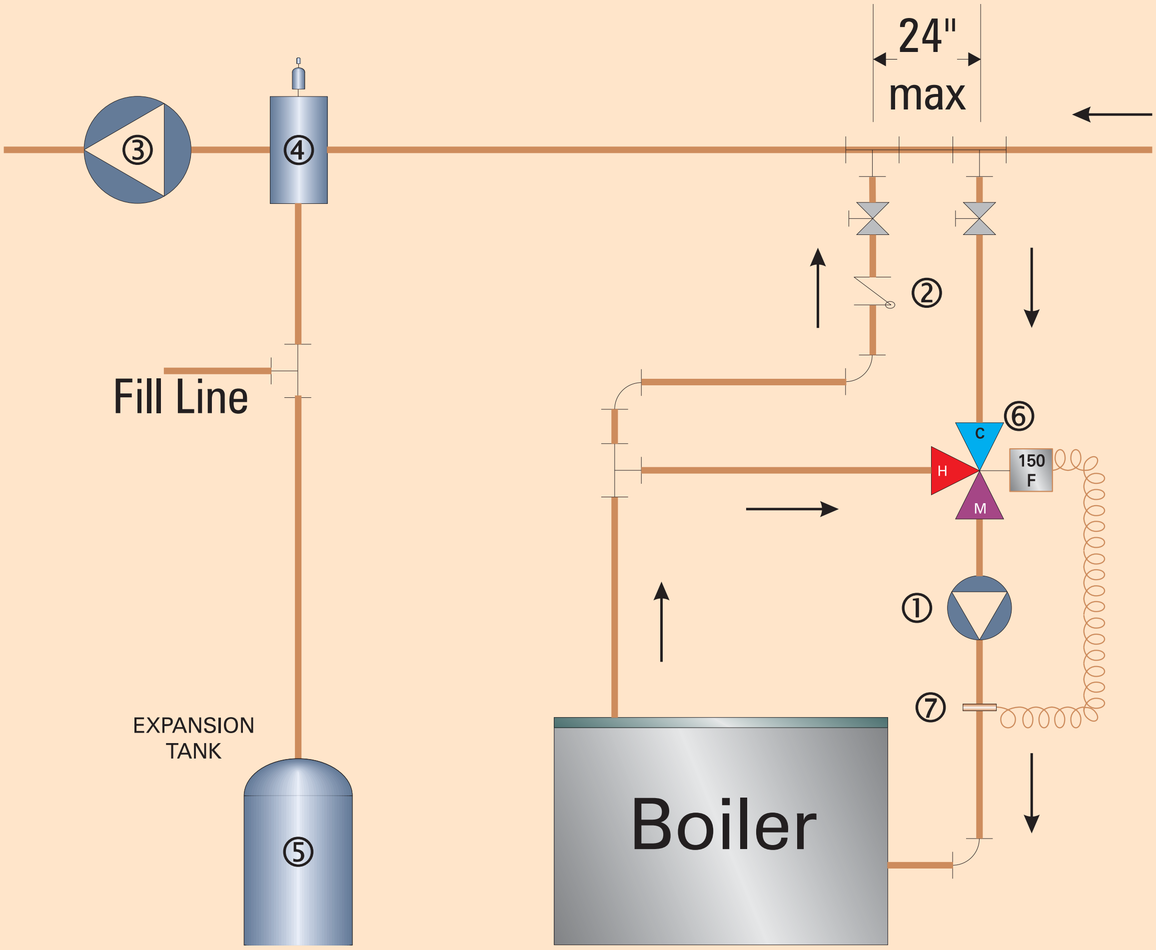
PIPING FOR VARIABLE LOW TEMP OPERATION (Typical)



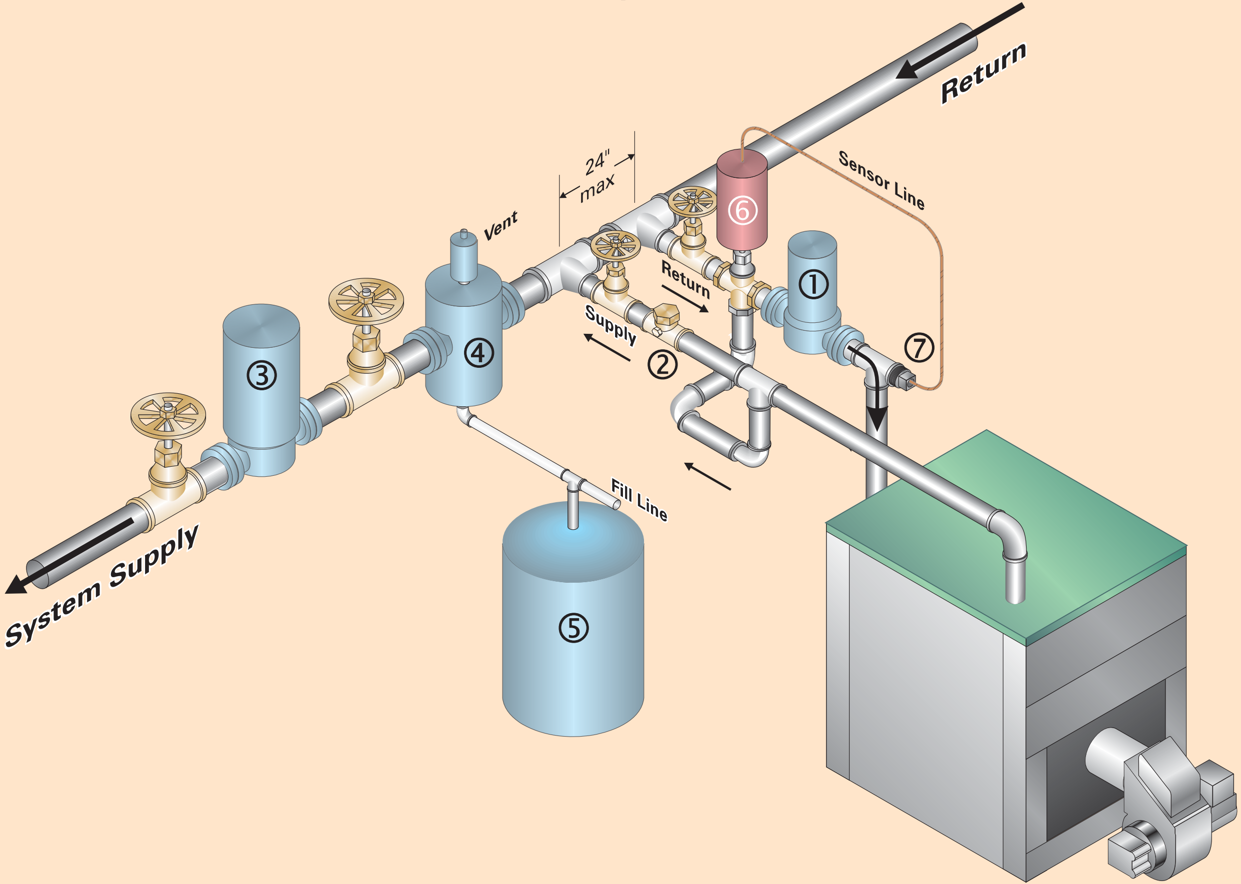
① **Boiler Loop Circulator**
② **Check Valve**
③ **System Pump**
④ **Air Separator**
⑤ **Expansion Tank**
⑥ **Mixing Valve, 150° F Set Point**
⑦ **Mixing Valve Temperature Sensor**

For systems which use outdoor reset temperature control, high volume systems, or systems which use night or weekend setback, install a mixing valve on the boiler return line as shown.

This mixing valve automatically controls the return water to the boiler, keeping it above the flue gas dewpoint temperature at all times. No additional controls will be needed to protect the boiler from condensation.

PIPING FOR VARIABLE LOW TEMP OPERATION (Typical)

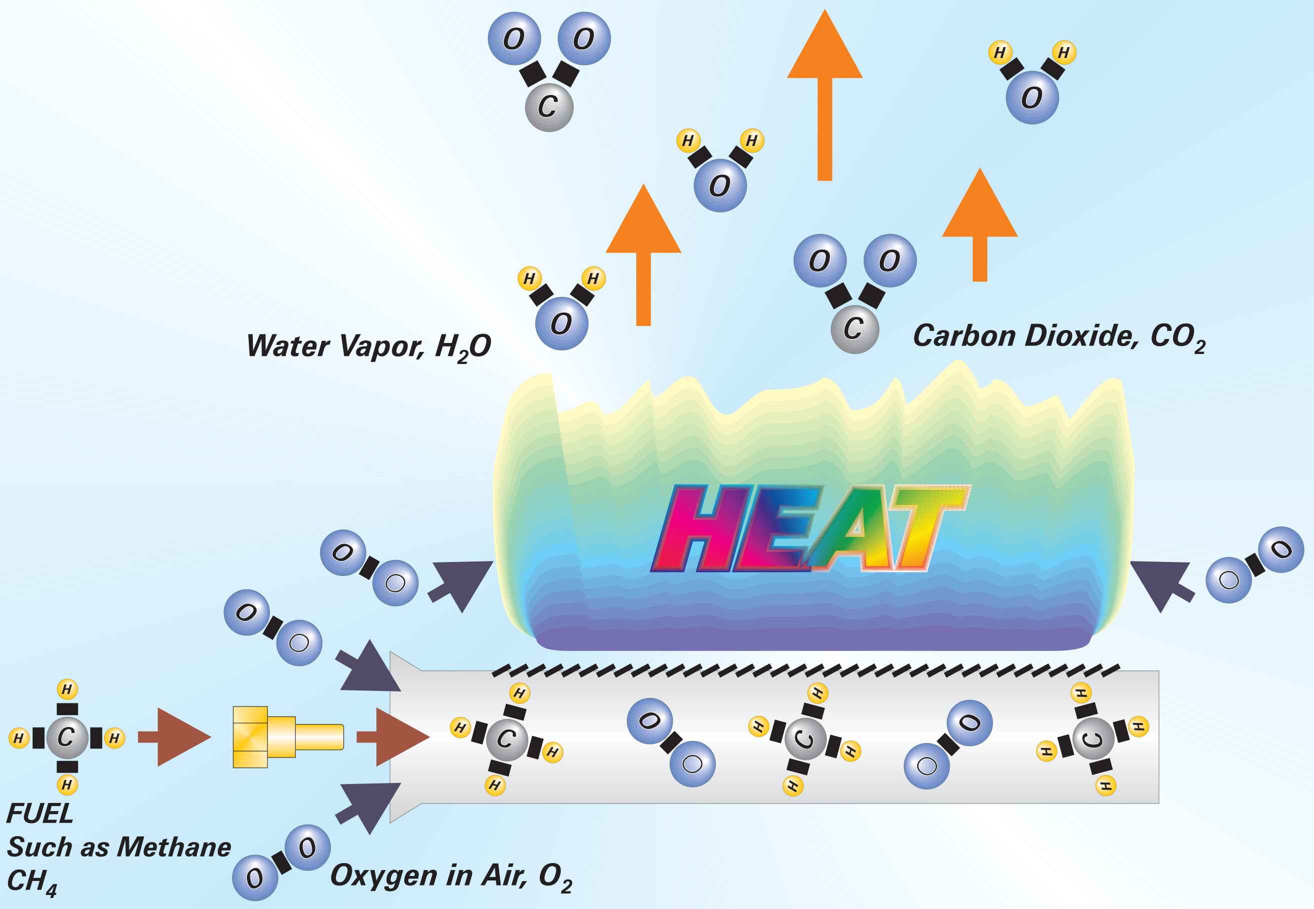
APPLY WHEN RETURN TEMP MAY BE BELOW: 130 °F FOR GAS; 150 °F FOR OIL



① **Boiler Loop Circulator**
② **Check Valve**
③ **System Pump**
④ **Air Separator**
⑤ **Expansion Tank**
⑥ **Mixing Valve, 150°F Set Point**
⑦ **Mixing Valve Temperature Sensor**

Always pipe the system to prevent condensation. This system, designed for all conditions of low operating temperature, assures that the boiler will never be exposed to cold return temperatures.

COMBUSTION



When fuel and air are ignited . . .
Carbon and Hydrogen combine with Oxygen . . .
Forming Carbon Dioxide and Water Vapor . . .
Giving Off ***HEAT*** *. . . . . . .*

Water vapor and carbon dioxide are formed when fuels are burned.

The level of carbon dioxide in the flue gases can tell us how much air is being used.

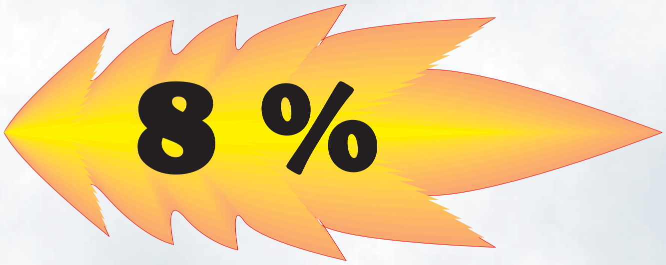
The water vapor in the flue products makes it necessary to consider the possibility of condensation in the boiler and/or the vent system. Design the piping and the vent appropriately.

% HEAT CONTAINED IN WATER VAPORIZATION

10 %

Natural Gas

93 # Water Vapor
per Million Btu



8 %

Propane Gas

75 # Water Vapor
per Million Btu

6 %

#2 Fuel Oil

59 # Water Vapor
per Million Btu

Large quantities of water vapor and formed in combustion.

Natural gas makes the most, with fuel oil making the least. This is because the ratio of hydrogen to carbon in the fuel is highest for natural gas.

Flue Gas Dewpoint

#2 Fuel Oil Flue Products

Water Vapor: 110°F
Sulfuric Acid: 150°F
(both at 12% CO_2)

Natural Gas Flue Products

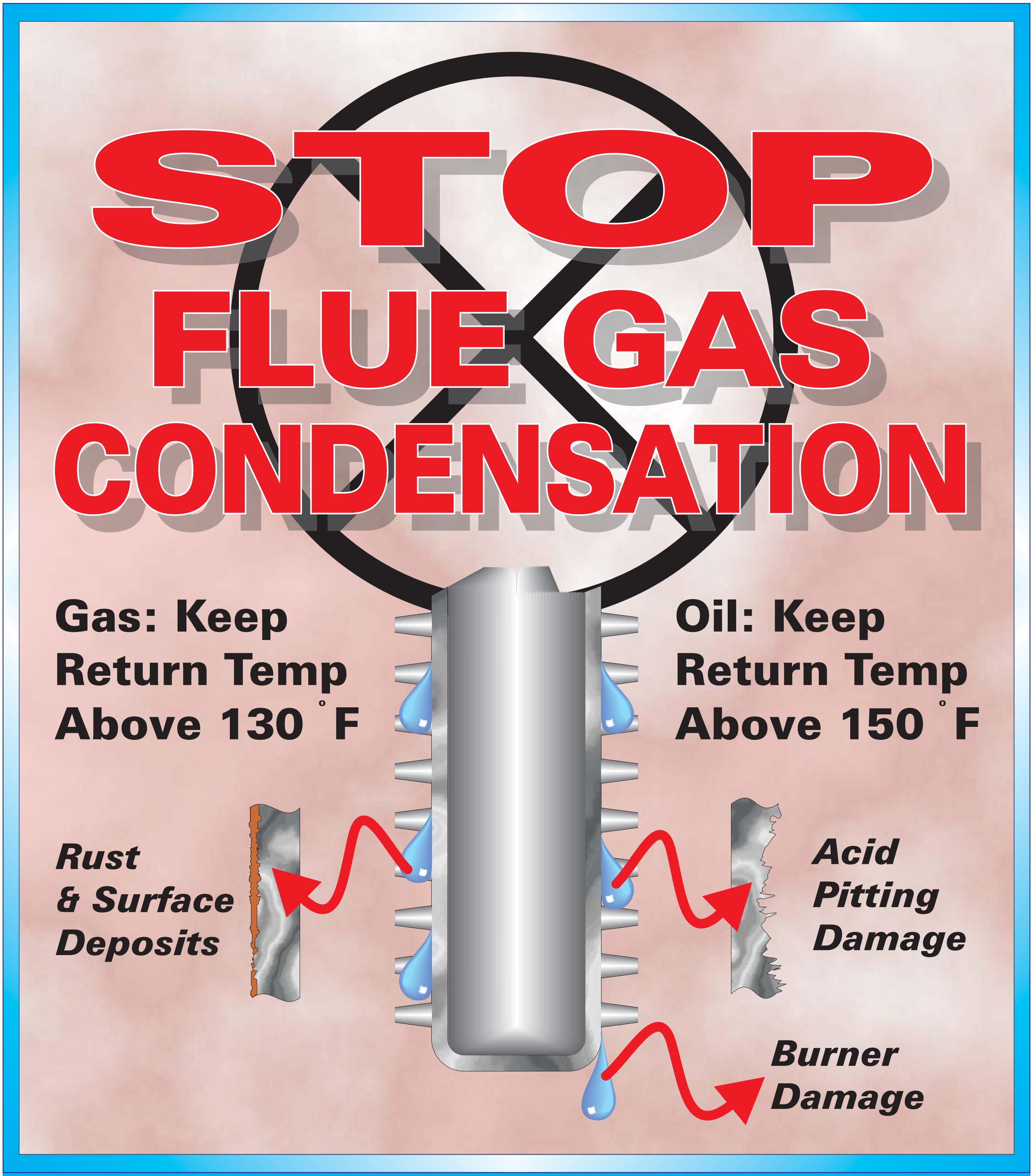
130°F at 9% CO_2
113°F at 4.5% CO_2

Propane Flue Products

122°F at 10% CO_2
103°F at 5% CO_2

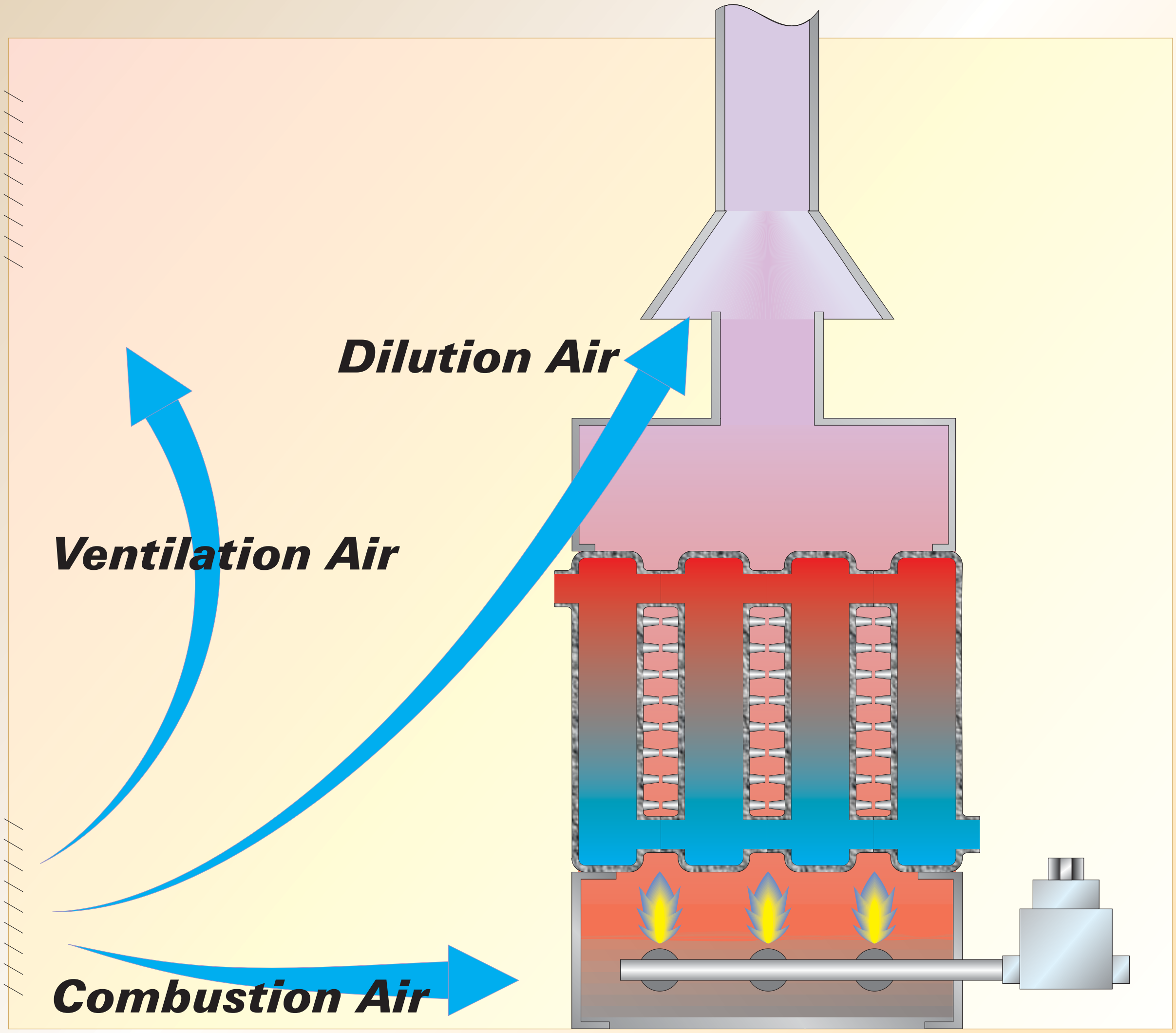
The water vapor dewpoint is higher for natural gas than for propane or fuel oil.

For fuel oil, the main concern in preventing condensation is the sulfuric acid dewpoint. The higher the amount of sulfur in the fuel, the higher the dewpoint will be. For most cases, though, with #2 fuel oil, the dewpoint will be around 150° F.



Prevent flue gas condensation in the boiler through proper piping design. Condensation will quickly corrode the heating surfaces of the boiler and can damage other components (such as the burner) as well.

AIR NEEDED FOR COMBUSTION & OPERATION



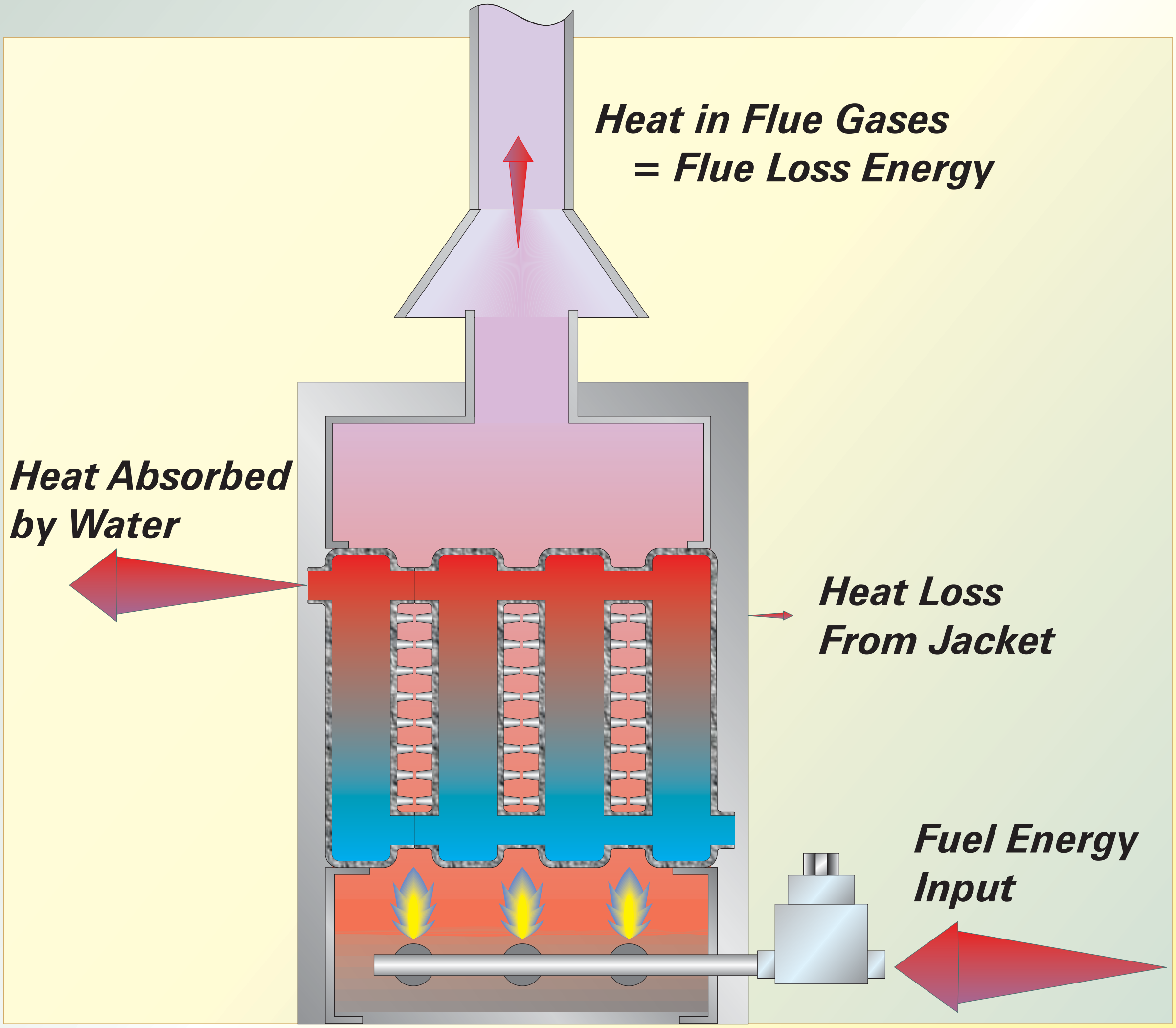
Gravity Vented Gas Boilers
Air for Combustion & Dilution
30 scfh Air per MBH (1000 Btuh)
(50 scfm per 100 MBH)

Forced Draft Gas or Oil Boilers
Air for Combustion & Dilution
12.5 scfh Air per MBH *
(21 scfm per 100 MBH)
* Add 25% if barometric damper used

Combustion requires a lot of air. Make sure the air openings are adequate and that the boiler room is never under a negative pressure.

The term "scfh" used above means Standard Cubic Feet per Hour, the amount of air that would flow at standard temperature and pressure, 60 oF and 14.7 psi atmospheric pressure. Actual cubic feet per hour, "acfh", would be calculated based on actual pressure and temperature of the air.

EFFICIENCY DEFINITIONS



COMBUSTION EFFICIENCY:
Based only on Flue Loss Energy
= 100% - % Heat Lost in Flue Gas

AFUE (Seasonal Efficiency):
Applies only to boilers under 300 MBH
Accounts for stand-by & cyclic losses
= Computer calculation of percent of seasonal energy delivered vs energy used

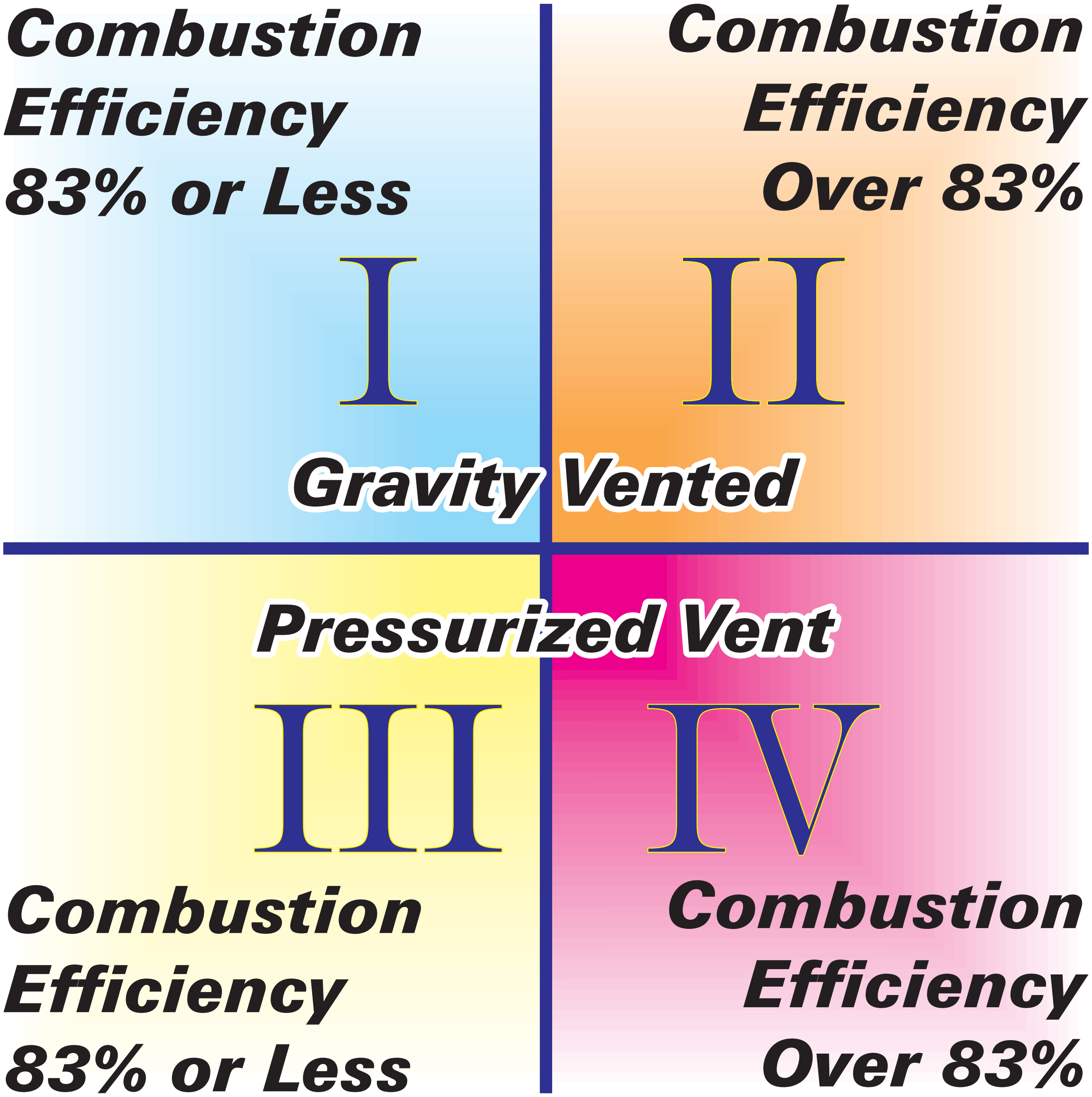
THERMAL EFFICIENCY:
Measures heat absorbed by water
Accounts for Loss Off of Jacket
= 100 x (Energy Absorbed/Energy Input)

STEADY STATE EFFICIENCY:
Thermal Efficiency of the boiler measured after boiler has run long enough to reach steady state operation.

The differences in efficiency numbers, for the most part, depend on whether jacket losses and stand-by losses are deducted.

AFUE (Annual Fuel Utilization Efficiency) is the standardized efficiency rating introduced with the 1992 energy regulations (National Appliance Energy Conservation Act). It applies only to boilers under 300 MBH (residential size).

VENT CATEGORIES
(Per ANSI Z21.13/CSA 4.9)



Combustion Efficiency 83% or Less

Combustion Efficiency Over 83%

I

II

Gravity Vented

Pressurized Vent

III

IV

Combustion Efficiency 83% or Less

Combustion Efficiency Over 83%

The vent categories describe the likelihood of the flue gases to condense in the vent system and whether the vent system will be pressurized or gravity.

Appliances which have a combustion efficiency higher than 83% under ANSI test conditions are rated as Condensing and will fall under Category II or IV.

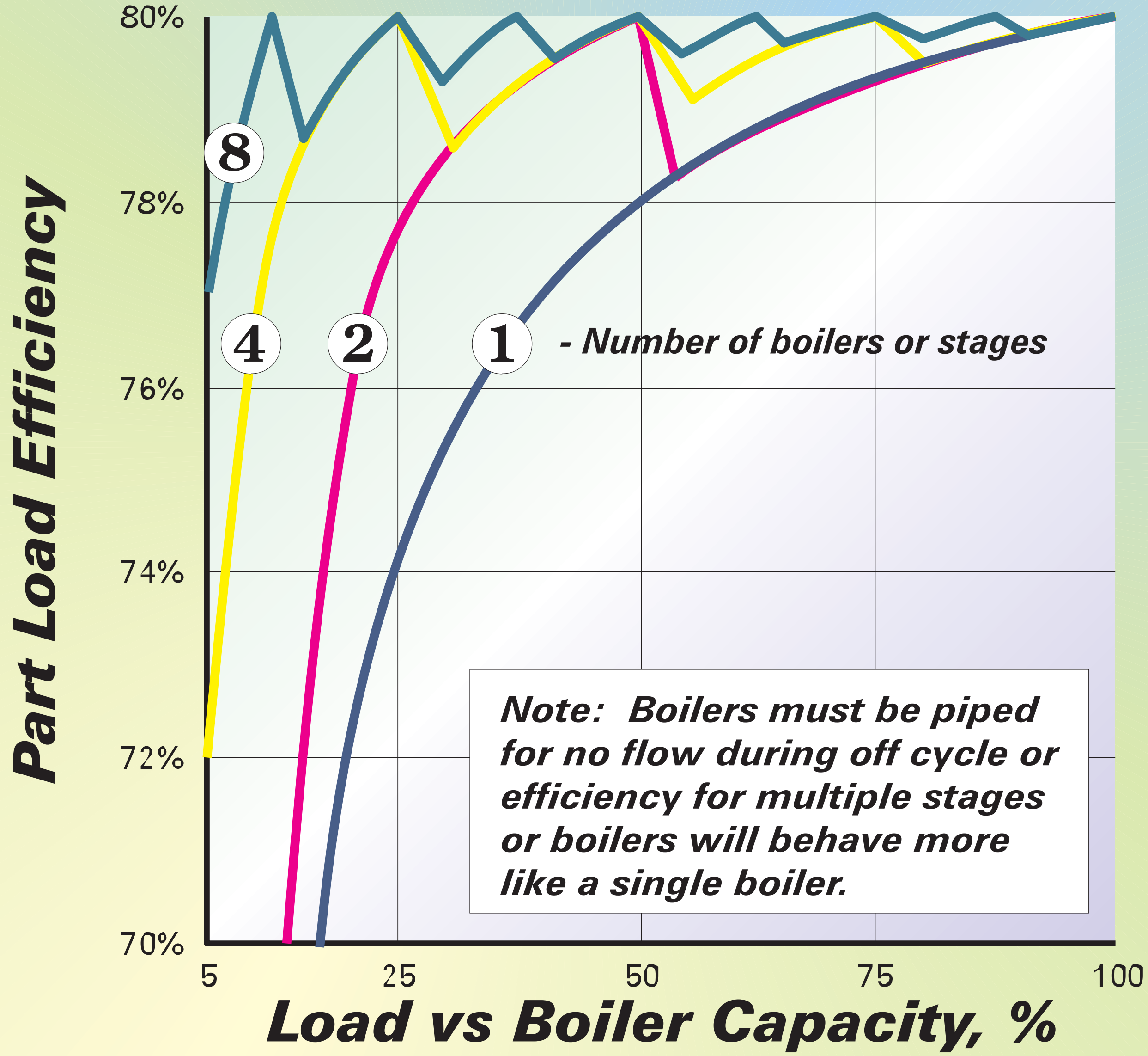
ONLY Category I appliances may use B vent.

VENTING REQUIREMENTS

	Gravity Vented	
	Category I	**Category II**
	Standard Venting B Vent Allowed Use ANSI Tables	Special Vent Corrosion Resistant Consult Boiler Mfr Cannot Use B Vent
Pressurized Vent	**Category III**	**Category IV**
	Gas Tight Vent Consult Boiler Mfr Cannot Use B Vent	Gas Tight Vent Corrosion Resistant Consult Boiler Mfr Cannot Use B Vent

Follow the appliance manufacturer's instructions on venting carefully. The venting must be suitable for the flue gases it has to handle.

IMPROVE PART LOAD EFFICIENCY WITH MULTIPLE BOILERS OR STAGES



Note: Boilers must be piped for no flow during off cycle or efficiency for multiple stages or boilers will behave more like a single boiler.

Typical variation in part load efficiency of multiple boilers or stages, each with a steady state efficiency of 80% and 2% jacket loss.

Part load efficiency represents the effective efficiency under loads less than the boiler output. At below 50% the part load efficiency drops off sharply. This is because the standby losses for a warm boiler become a larger percentage of the total energy input.

Increase part load efficiency by using multiple boilers or multi-stage or modulating boilers.

GLYCOL DATA

Rule of Thumb

Increase the size of expansion tanks by 20% for most systems because glycol/water expands more.

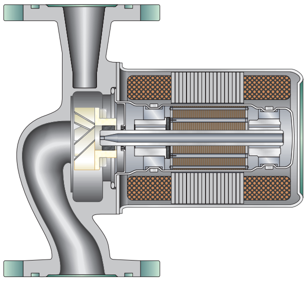
- **Do not use galvanized pipe** in the system. The coating reacts with the glycol.
- **Clean the system before filling,** preferably with trisodium phosphate or another chemical cleaner.
- **Do not use an automatic fill valve.** Use manual fill only. This way a leak will show up as a drop in system pressure. The glycol is diluted when fresh water is added, reducing its level of protection.
- **Do not use chromate water treatment.** The chromate reacts with glycol.
- **Use pumps with only mechanical seals.** Packing gland seals leak easily with glycol in the water.
- To get the same heat transfer with glycol as with water, **increase the flow rate for 50/50 glycol water to 14% higher than water alone** for most systems operating between 180 and 220°F.
- For a given flow rate, the **pressure drop for 50/50 glycol water will be equal to the pressure drop for water at 140°F. From 140°F to 220°F, the pressure drop continues to decrease. At 220°F the pressure drop of 50/50 glycol water is 10% less than the pressure drop for water.**
- At the 14% higher flow rate to get the same heat transfer, the **pressure drop for 50/50 glycol water is 23% higher than water.**

WARNING

USE ONLY INHIBITED PROPYLENE GLYCOL – NOT ETHYLENE GLYCOL. ETHYLENE GLYCOL IS TOXIC AND WILL ATTACK RUBBER GASKETS AND MEMBRANES IN THE SYSTEM.

Remember to check the inhibitor level and glycol concentration at least annually to make sure it is still correct.

FULL-COLOR TRAINING GUIDE SERIES



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