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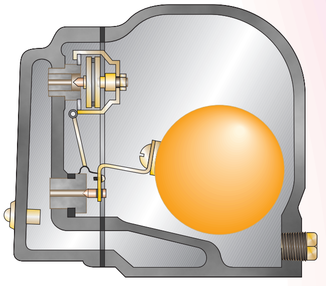
The COLOR of Steam



TWO-PIPE STEAM & PUMPED RETURN

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Installation and Training Information

The Color of Steam

Two-Pipe Steam and Pumped Return

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The Color of Steam

PUMPED RETURN SYSTEMS WHEN IS A PUMP NEEDED?

✂

When the "A" dimension isn't there

✂

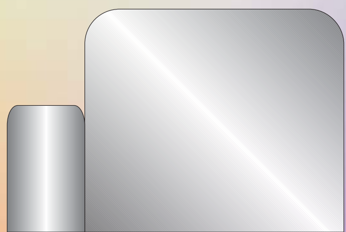
When gravity can't return the condensate from long systems

✂

When a boiler feed system is needed for storage on a system with a long condensate return time lag

Use feed systems to convert one pipe systems to pumped return when the return isn't high enough, such as when zone valves are to be added or when a new boiler has a higher water level than the old one.

PUMPED RETURN SYSTEMS



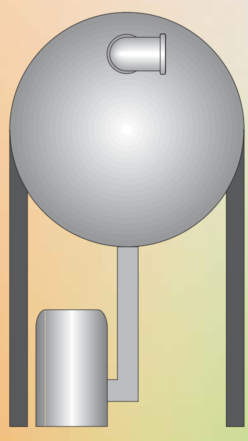
Condensate Return Unit

APPLICATIONS

- Needed where not enough height in returns for gravity feed
- Practical limit = 60 BHP (8000 ft^2 EDR)
- Needed for any application requiring transfer pumping to return condensate

CONSIDERATIONS

- Does not respond to needs of boiler - only dumps condensate when receiver fills
- Not effective on systems with long condensate return delay times



Boiler Feed System

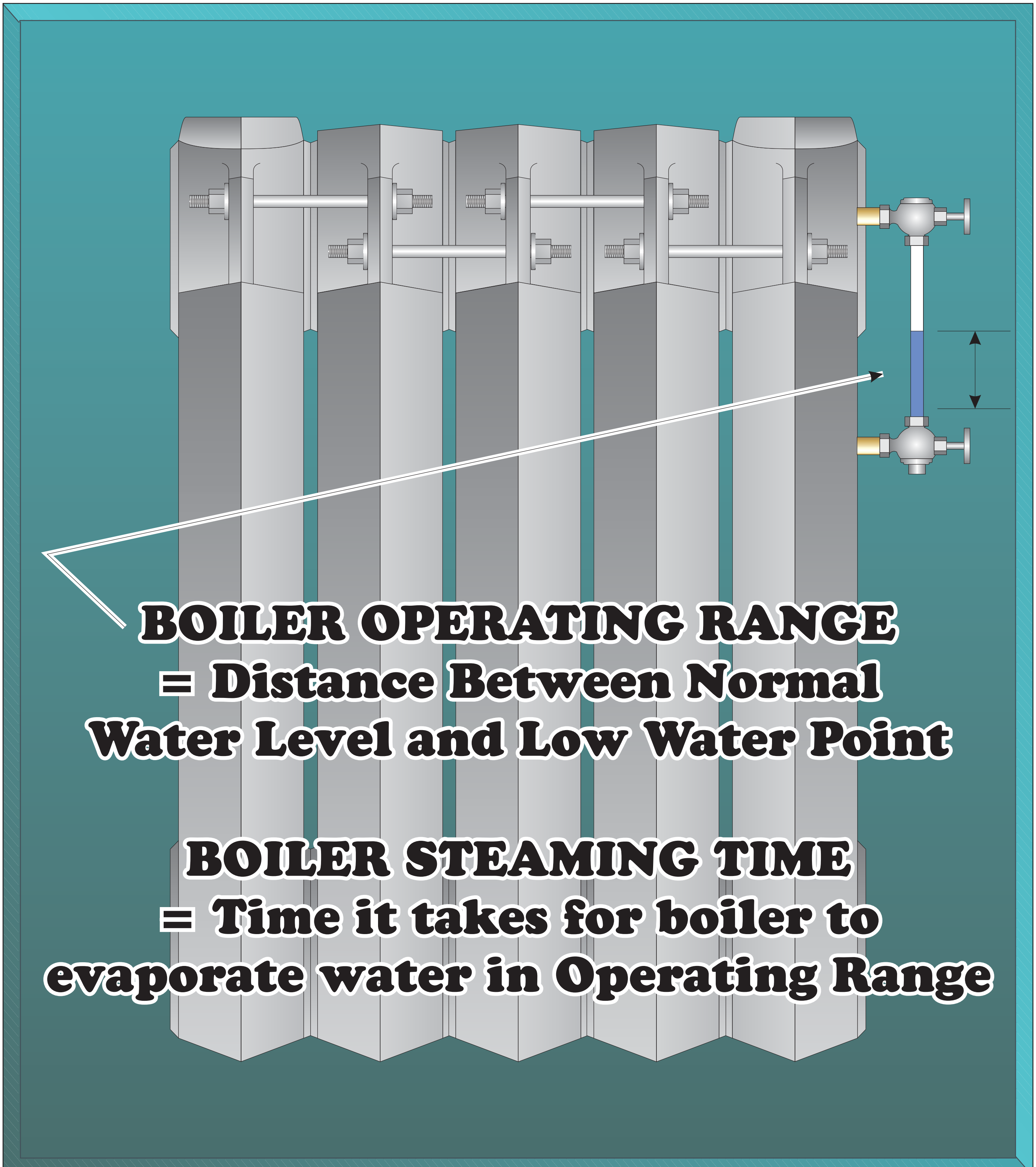
APPLICATIONS

- Can always be used where pumped return is needed – always preferable to a condensate unit, though more expensive
- Must be used where condensate return delay time is longer than boiler steaming time

CONSIDERATIONS

- Feeds water to boiler on call from the boiler water level controller
- Helps cool condensate and provides higher NPSH for feed pump

Condensate return units will work in many systems (particularly on residential and small systems.) But the best choice is always a boiler feed system. The boiler feed system provides plenty of steaming time and feeds water to the boiler only when the boiler calls for it.



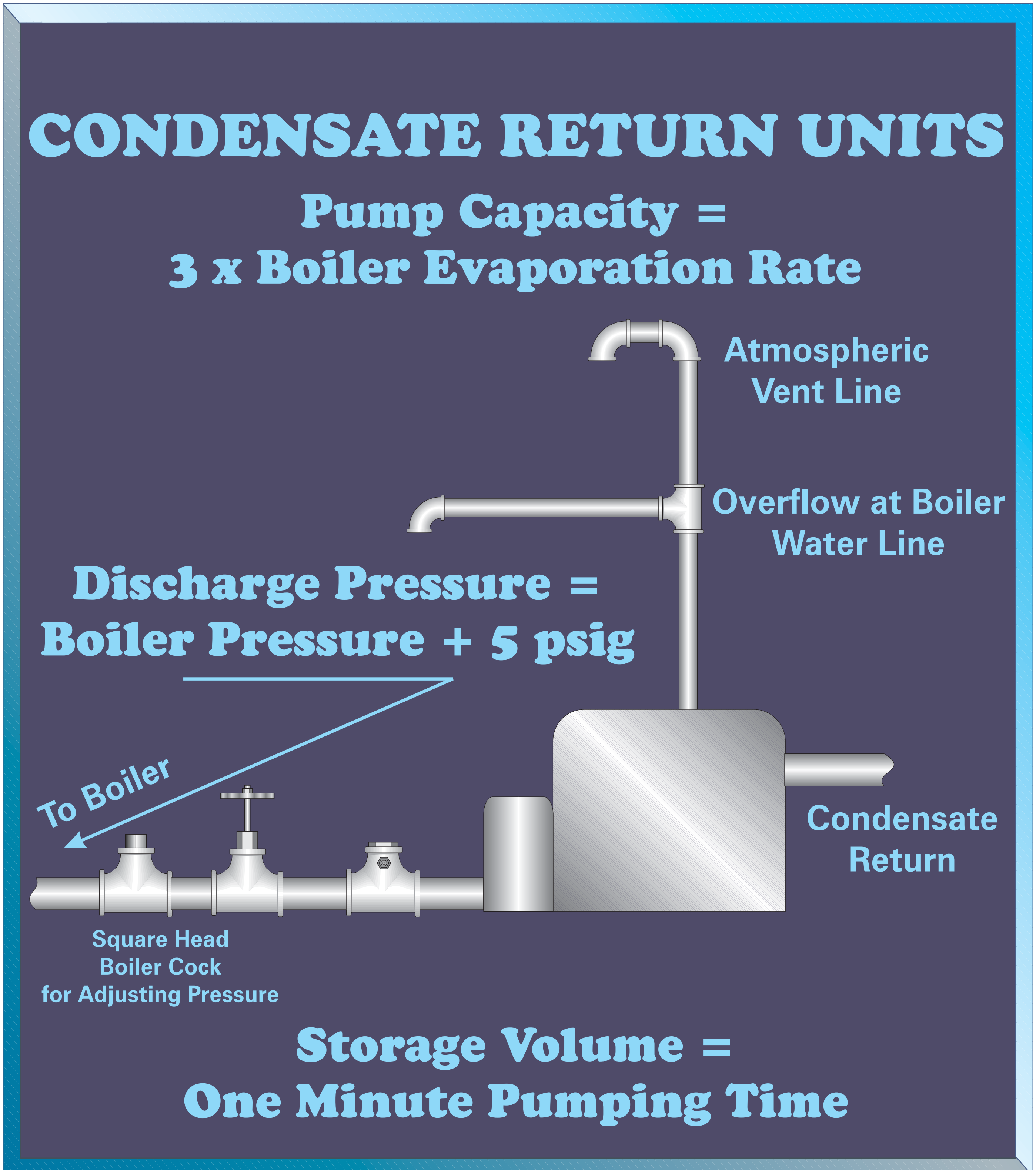
Modern boilers have less steaming time than older units being replaced. Newer boilers are usually smaller and more efficient. Consider installing a boiler feed system when removing an old, large boiler, particularly on commercial installations. The feed system tank provides water storage to increase steaming time.

TYPICAL STEAMING TIMES (MINUTES)

Model	IBR Output	PPH	GPM	Operating Volume	Steaming Time
61-03	72	74	0.15	1.89	12.52
61-04	97	100	0.20	2.45	12.05
61-05	129	133	0.27	3.01	11.13
61-06	161	166	0.34	3.57	10.58
61-07	193	199	0.40	4.13	10.21
61-08	225	232	0.47	4.69	9.95
62-09	256	264	0.54	5.25	9.79
62-10	288	297	0.60	5.81	9.63
62-11	320	330	0.67	6.37	9.50
62-12	352	363	0.74	6.93	9.39
62-13	384	396	0.80	7.49	9.31
62-14	416	429	0.87	8.05	9.23
62-15	448	462	0.94	8.61	9.17

PB Heat Series 63 and 64 Gas Boilers

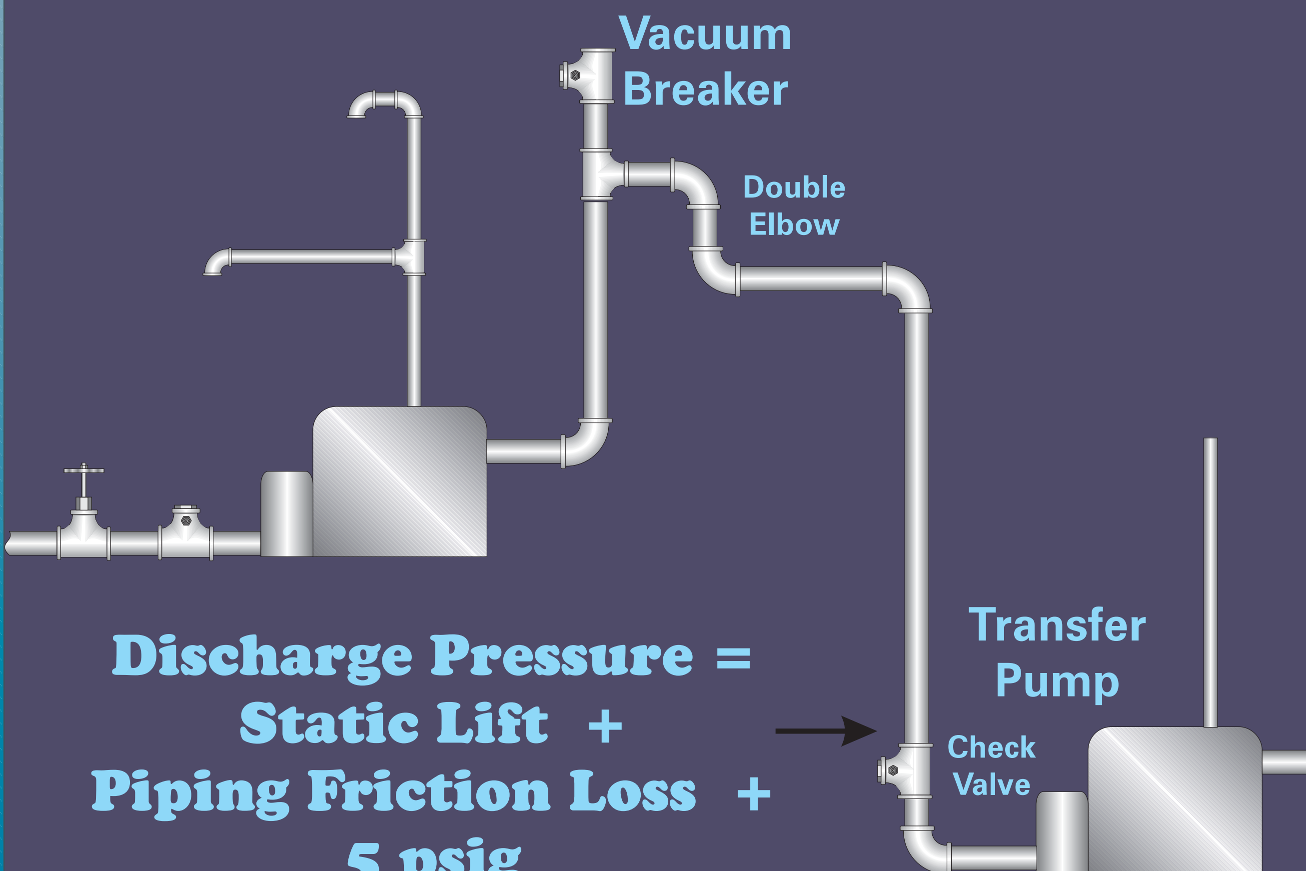
Make sure the boiler steaming time is long enough for condensate to return from the system. If not, install a boiler feed system to provide the needed storage and extended steaming time.



Never oversize a condensate receiver system. Too large a volume will cause flooding of the boiler.

TRANSFER PUMP PIPING

Pump Capacity = 3 x Boiler Evaporation Rate



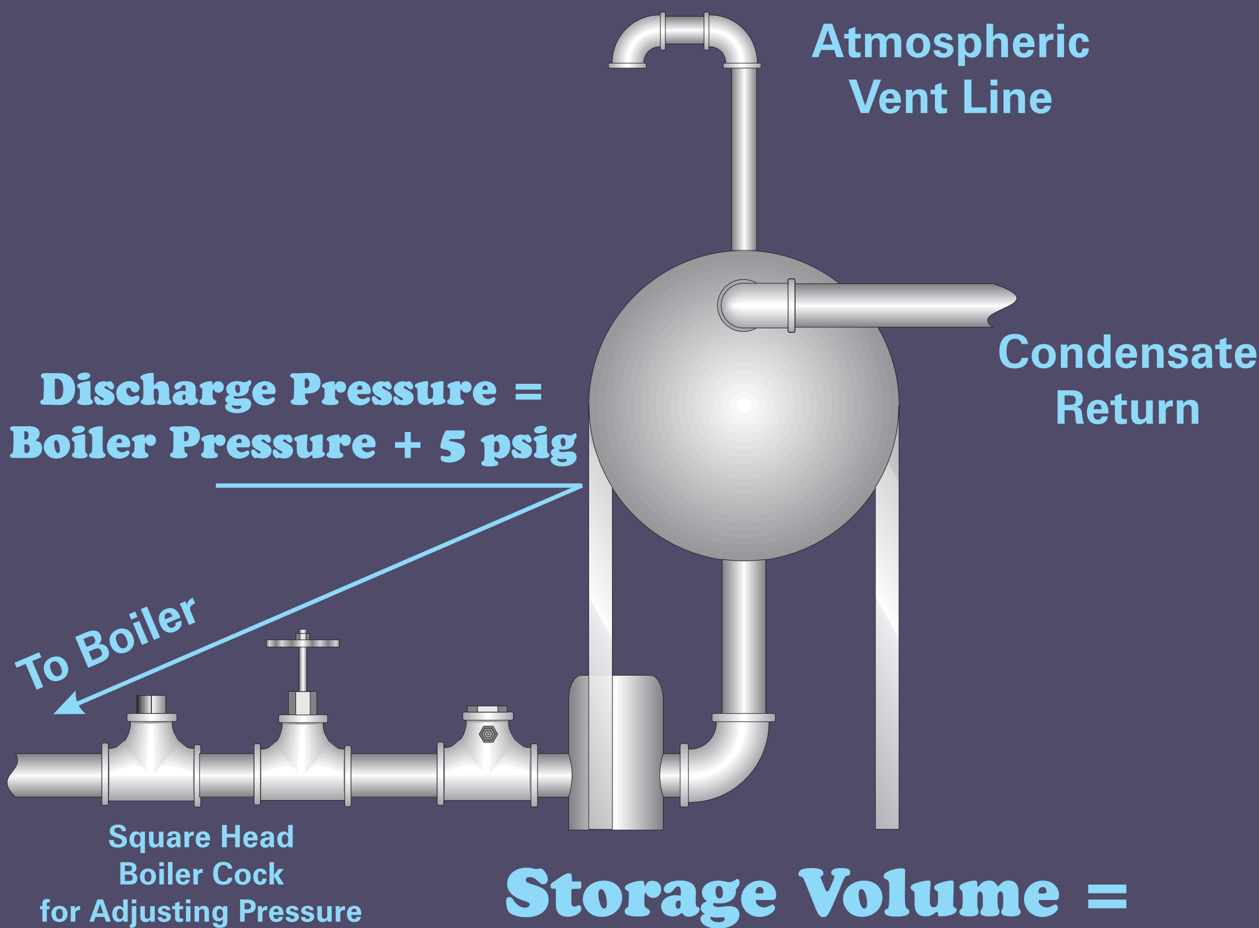
Discharge Pressure =
Static Lift +
Piping Friction Loss +
5 psig

Storage Volume = One Minute Pumping Time

Use transfer pumps when condensate cannot return to the boiler room by gravity.

BOILER FEED SYSTEMS

Pump Capacity = 2 x Boiler Evaporation Rate



Storage Volume = Boiler Evaporation Rate x System Time Lag x 1.33

Size the storage tank on a boiler feed system to allow a steaming time longer than the system time lag (time required for condensate to begin returning to the feed system tank.)

NPSH

= Difference in pressure (in feet of water)
between atmospheric pressure and saturation
pressure for the temperature of the condensate
\- plus -
The elevation (in feet) of the water above the pump

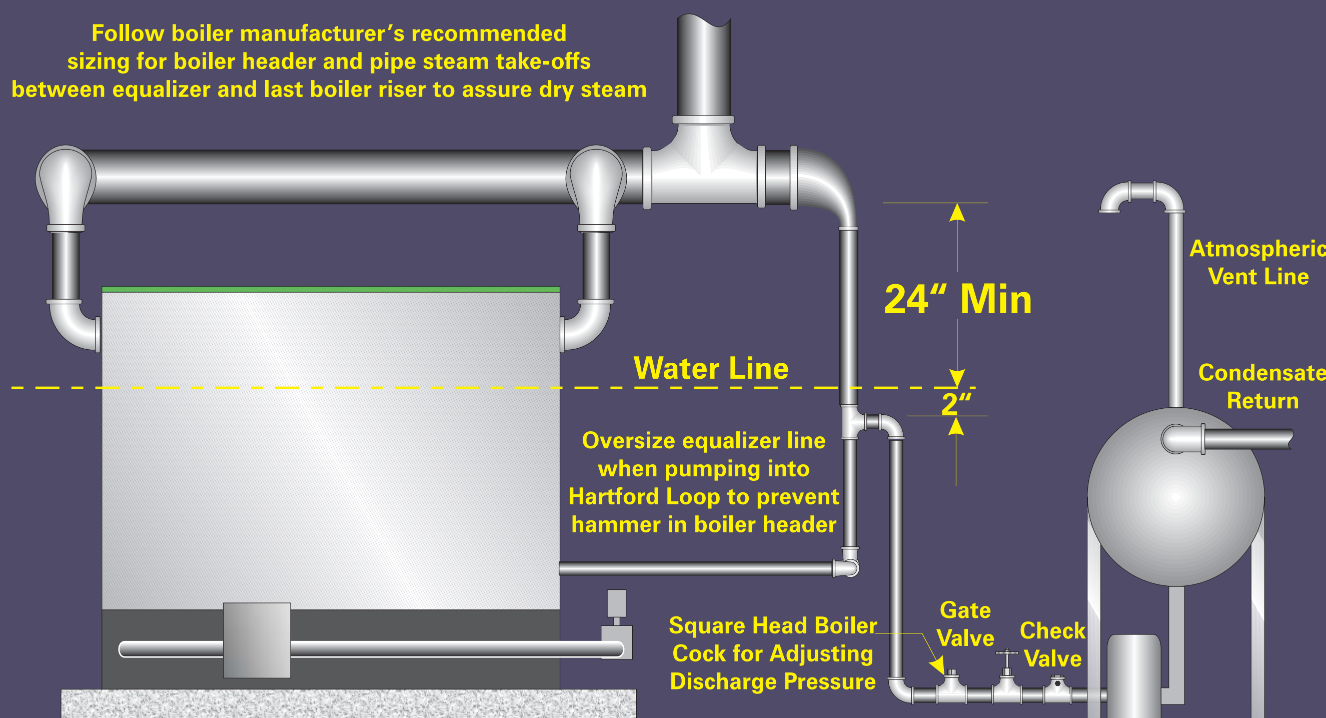
Water Temp °F	Static Suction Head in Feet of Water					
	0.0	1.0	2.0	3.0	4.0	5.0
	NPSH AVAILABLE					
212	0.0	1.0	2.0	3.0	4.0	5.0
211	0.5	1.5	2.5	3.5	4.5	5.5
210	1.4	2.4	3.4	4.4	5.4	6.4
208	2.6	3.6	4.6	5.6	6.6	7.6
206	1.0	5.0	6.0	7.0	8.0	9.0
204	5.1	6.1	7.1	8.1	9.1	10.1
200	7.5	8.5	9.5	10.5	11.5	12.5
190	12.5	13.5	14.5	15.5	16.5	17.5
155	24.3	25.3	26.3	27.3	28.3	29.3

ALTITUDE: Boiling point decreases 1°F for every 500 feet of elevation above sea level

On most steam heating systems NPSH should not be a concern because the condensate is relatively cool. But make sure the location of the receiver tank or feed system tank is high enough above the pump suction to assure adequate NPSH available in all cases.

Keep in mind that on heating systems which use pressure reduction from high pressure steam the condensate will be hotter and NPSH available will be important.

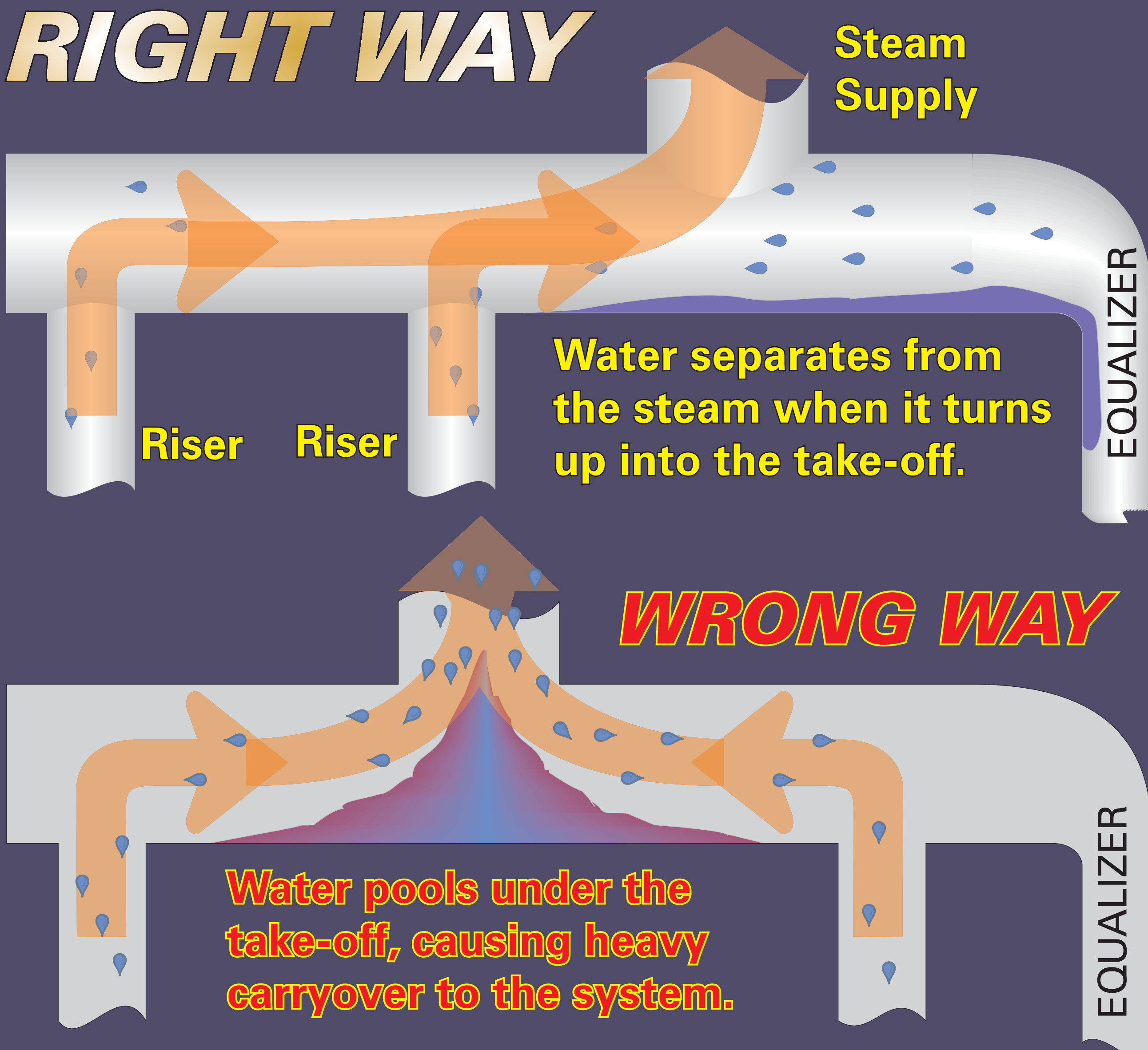
STEAM BOILER PIPING PUMPED RETURN



Follow the boiler manufacturer's instructions for the near boiler piping to assure reliable operation and dry steam to the system.

Always pipe the steam supply between the last boiler riser and the equalizer.

BOILER HEADER CONNECTIONS



Pipe the steam supply between the last boiler riser and the equalizer. This separates the water from the steam and sweeps water in the header toward the equalizer.

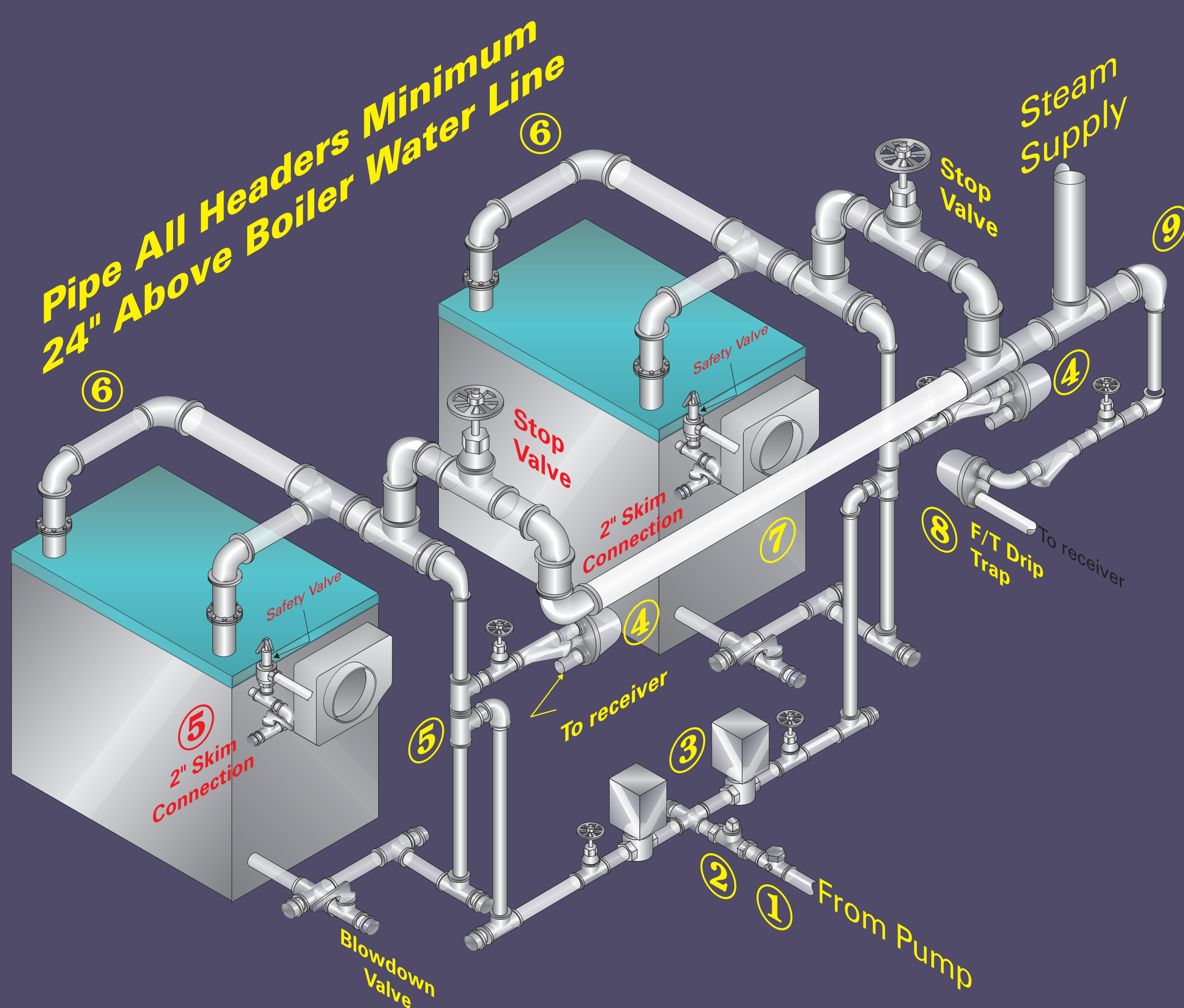
Never pipe the steam supply between the risers.

PIPING
MULTIPLE BOILERS

1. Install a spring loaded check valve after the pump. Spring loaded valves provide zero pressure closing and are less likely to hammer when the pump shuts off.
2. Install a square head cock with removable handle after the check valve. Adjust this cock for feed rates just more than enough to satisfy the boilers. If the flow is too high, steam bubbles in the boiler will be quenched, causing water level nuisance problems.
3. Unless using a separate pump for each boiler, install electric valves to isolate flow to each boiler. The valves need end switches. Wire the valves to open when the boiler water level controls call for water. The valve end switches then turn on the feed pump.
4. Install float and thermostatic traps off of the equalizer lines as shown about 2 inches above the normal water line. These traps will drain condensate that builds up in idle boilers. Without them the idle boilers will flood. When they fire large amounts of water would carry to the system and cause damage to system components. Pipe the trap outlets to the receiver or feed system tank.
5. Use a Hartford loop connection even for pumped return. Oversize the equalizer slightly to make sure water doesn't spray into the header and cause hammering. The Hartford loop is an extra precaution against a leaky check valve.
6. Always pipe the boiler header connection offset as shown. The swing joints in the offset piping absorb the expansion of the header.
7. Install the combined header for the boilers as a dropped header as shown. This allows collection of any water carryover or pipe condensate to a drip trap.
8. Install an F/T trap on the drip line of the combined header. Pipe its outlet to the receiver or feed system tank.
9. Always pipe the steam supply connection after the last boiler connection and before the drip line. This way any water in the steam flow will be thrown toward the drip line.

Always install float and thermostatic traps just above the water line on multiple steam boiler installations. These prevent flooding of the boilers and resultant damage to the system components due to water carryover in the steam.

PIPING MULTIPLE BOILERS

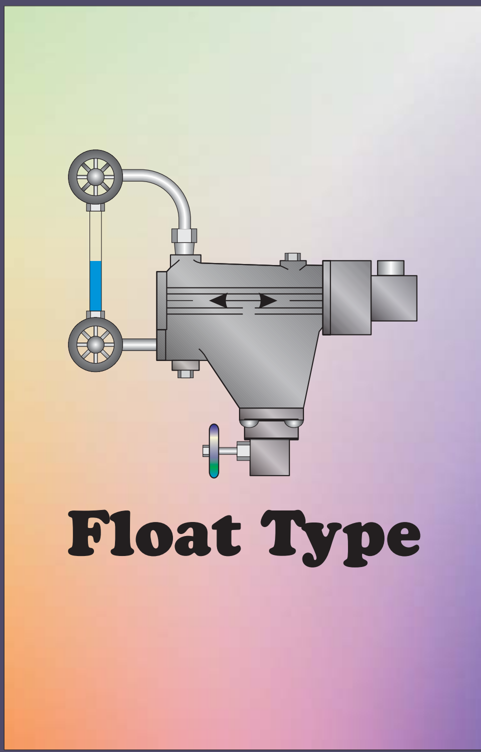


Alternate Piping: Use two separate pumps, separate return lines and no electric valves

Always provide isolated feeds to multiple boilers. Either use separate pumps or electric valves. Each boiler requires its own feed for correct water level control.

Condensate return units seldom work well with multiple boilers. It is too difficult to control the feed water and water levels correctly.

BOILER WATER LEVEL CONTROLS



Low Water Cut-Offs

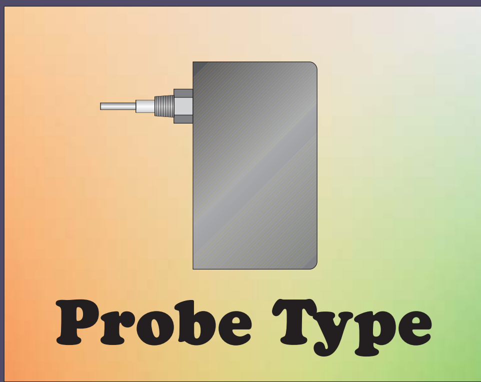
- McDonnell & Miller #67, example
- Used with Gravity return, Condensate units, Water feeders (VXT, etc.) and for Auxiliary controls
- Requires regular blowdown

Low Water Cut-Off/Pump Controls

- McDonnell & Miller 150, 157, examples
- Operate Boiler Feed Pump
- Require regular blowdown
- Feeding too fast can cause nuisance outage

Low Water Cut-Off/Feeders

- McDonnell & Miller #47-2, 51-2, examples
- Used to provide LWCO protection and to automatically feed boiler
- Adjust feed rate to avoid nuisance outages and overfilling



Probe Low Water Cut-Offs

- Hydrolevel OEM650P, example
- Used to provide LWCO protection can also be used with VXT auto feeder
- Adjust feed rate to avoid nuisance outages and overfilling

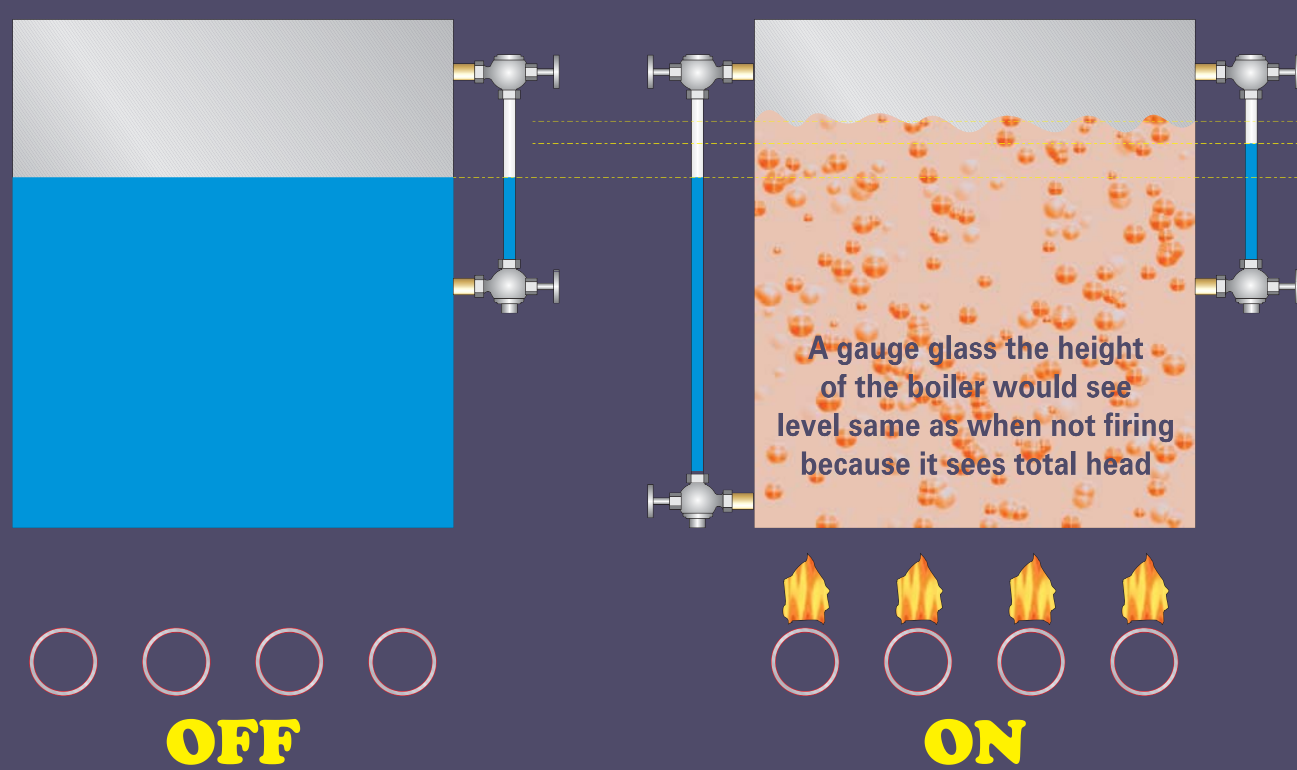
The best choice for reliable water level control is a boiler feed system and a low water cut-off/pump control on the boiler.

Condensate receiver units work well on small systems, but the long time lag on commercial systems makes the boiler feed system more effective.

BOILER WATER LEVEL DENSITY CHANGES WHEN FIRING

Gauge glass sees same water level as boiler because density in glass is same as density in boiler

Gauge glass sees level lower than actual in boiler due to reduced density caused by steam bubbles



When a boiler is steaming the fluid inside is a mixture of steam bubbles and water. This makes it important where the gauge glass and water level control pipes are connected.

The steam bubbles collapse when the boiler stops firing. This is why the water level drops in the gauge glass on shut down.

RADIATOR SUPPLY VALVES, TYPICAL, PACKED TYPES

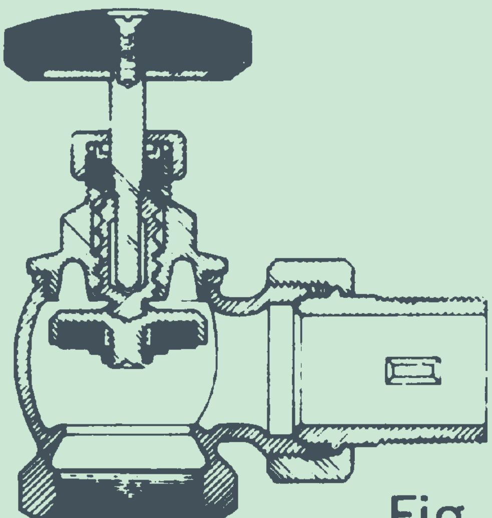


Fig. 41

RISING STEM VALVE WITH PACKING NUT

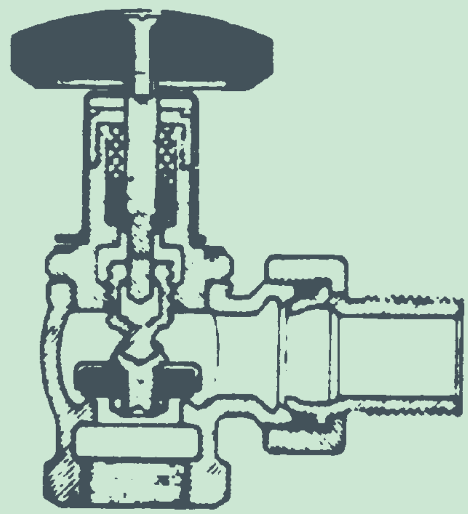


Fig. 42

NON-RISING STEM VALVE WITH SPRING PACKING

From Hoffman "Steam Heating Systems, Design Manual and Engineering Data"

Use packed type radiator valves on pressurized systems only. They are not recommended for use on vacuum systems.

RADIATOR SUPPLY VALVES, TYPICAL, PACKLESS TYPES

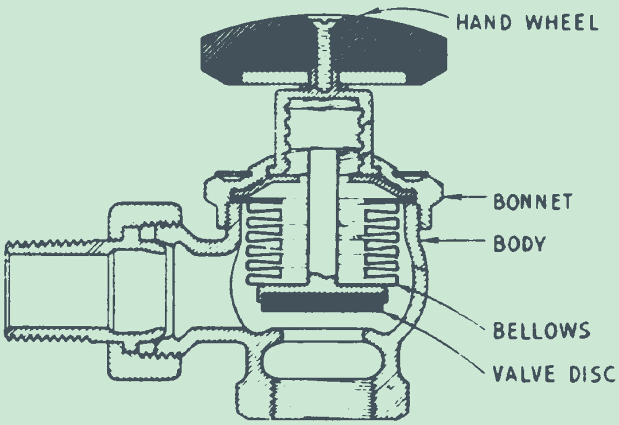


Fig. 43

MODULATING PACKLESS VALVE, WITH BELLOWS SEAL

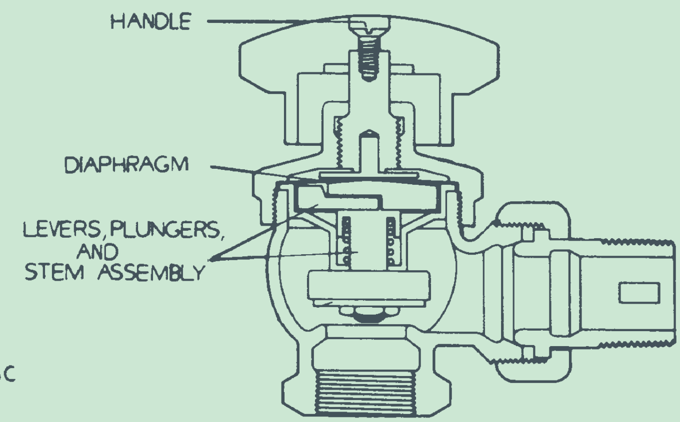


Fig. 44

MODULATING PACKLESS VALVE, WITH DIAPHRAGM SEAL

These valves are required for vacuum systems to prevent air leakage through valve.

From Hoffman "Steam Heating Systems, Design Manual and Engineering Data"

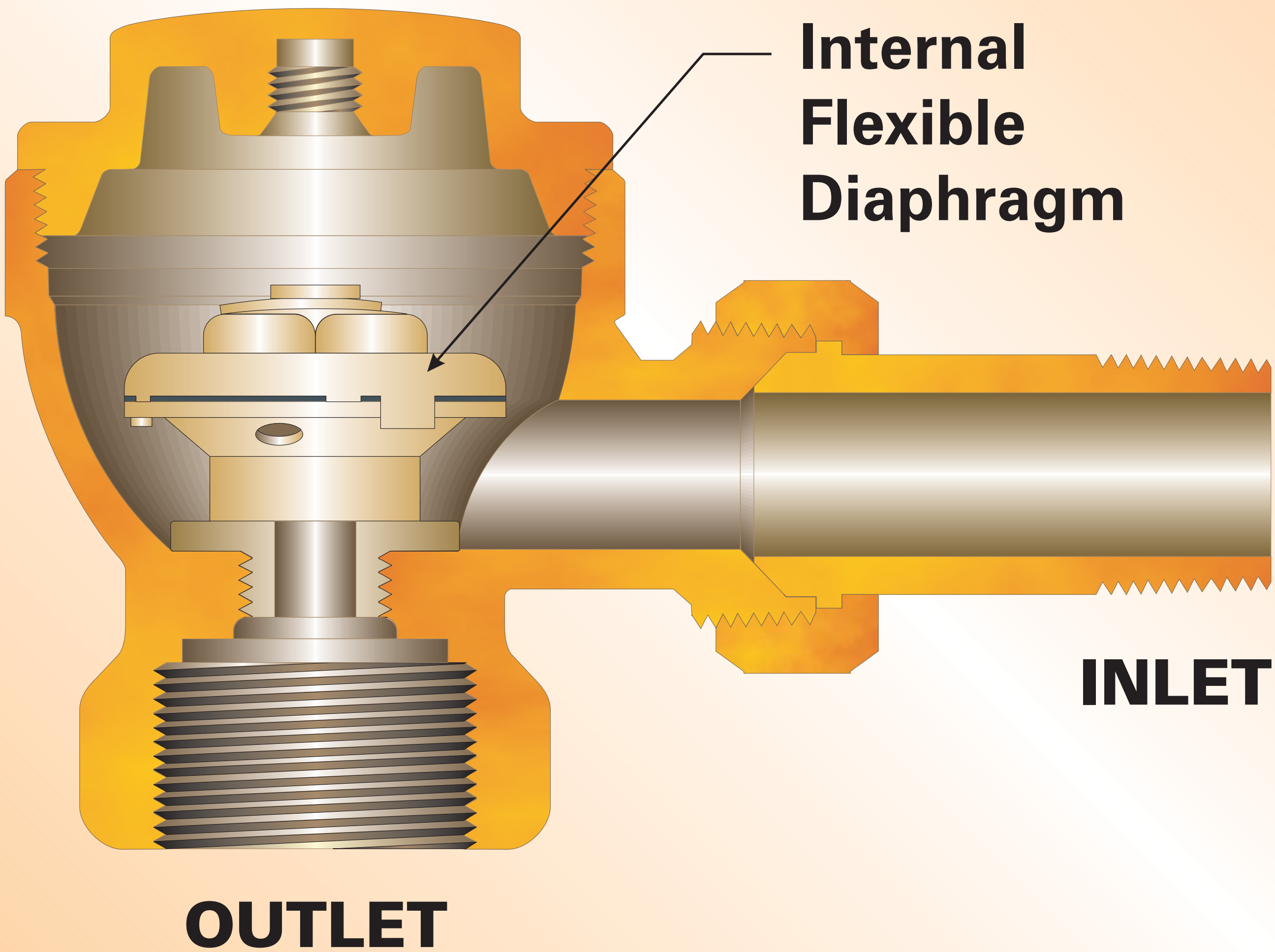
Always use packless radiator valves on vacuum systems to prevent air leakage and loss of vacuum.

THERMOSTATIC TRAPS

- Thermal elements adjust to pressure, opening when condensate is from 10 to 30 ºF below saturation temperature
- Used to provide cooled condensate for draining or dripping into dry return lines
- Effective for fast removal of air
- Applied on radiators and convectors and on drips (when piped with a minimum 5 foot long cooling leg)
- Are susceptible to damage from water hammer, though heavy duty thermostatic traps are available
- Susceptible to freezing – not suitable for outdoor applications

The most important function of a thermostatic trap is to force the condensate to cool 10 to 30°F below steam temperature before allow it through. This prevents flashing of the condensate in the returns.

THERMOSTATIC TRAP, TYPICAL



Drawn From Hoffman "Steam Traps Engineering Data Manual"

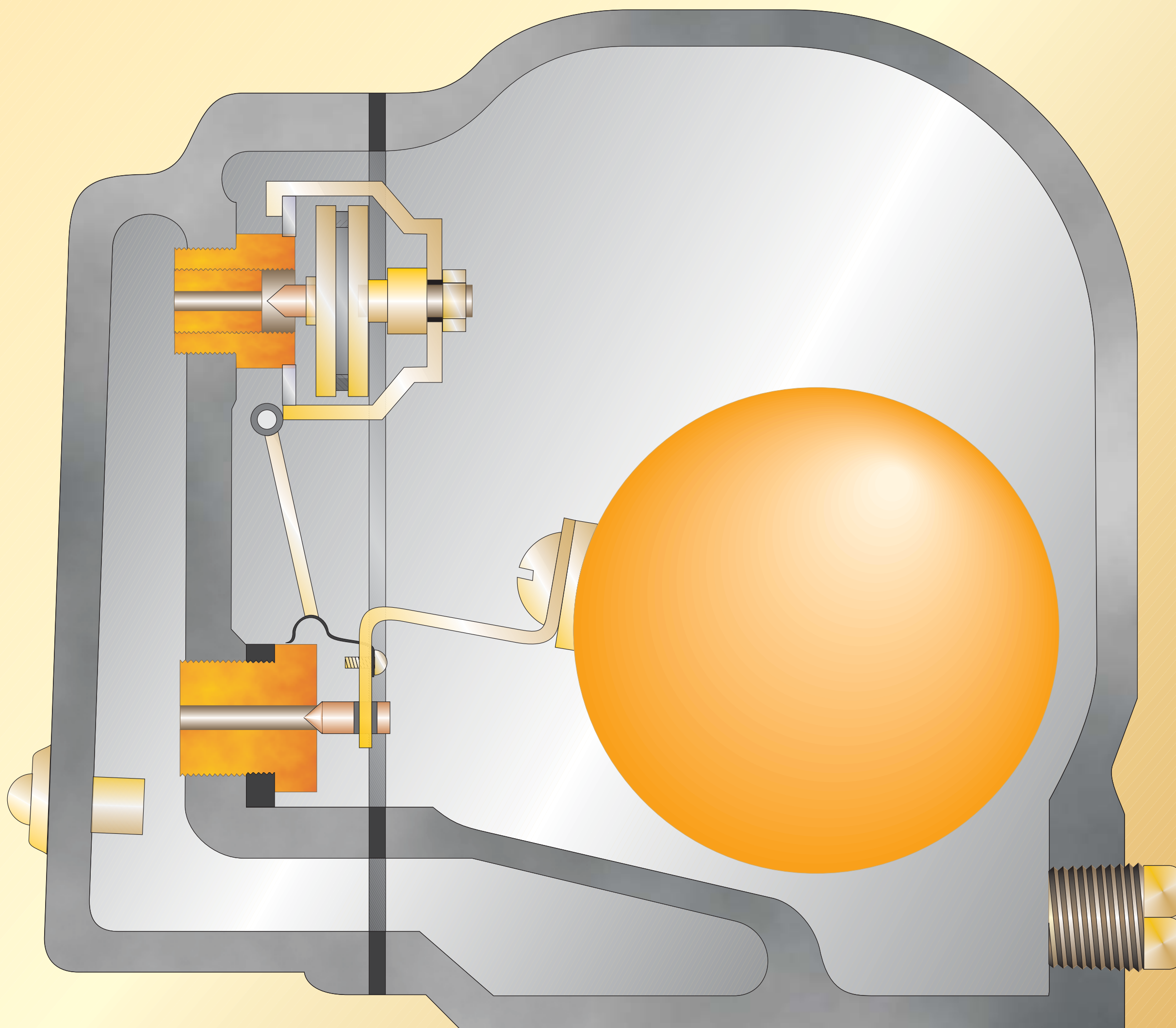
Thermostatic traps are used to drain radiators and where cooling of the condensate is necessary.

FLOAT & THERMOSTATIC TRAPS

- Will drain condensate at saturation temperature
- Effective for fast air elimination because of built-in thermostatic air vent
- Used for most drip applications where condensate does not have to be cooled
- Effective for handling varying loads without wire drawing of the seat
- Seat must be sized for maximum pressure to be seen at trap – low pressure orifice will not work on higher pressure
- Can be damaged by water hammer or freezing; primary failure mode is closed

Float and thermostatic traps are effective for air movement and where it is necessary to drain condensate at the steam temperature. They also work well under varying loads. This makes them ideal for drip traps and for use on heat exchangers.

FLOAT & THERMOSTATIC TRAP, TYPICAL



Drawn from Hoffman "Steam Traps Engineering Data Manual"

The thermostatic element allows air to flow through, but stops steam because it expands and closes the valve when exposed to steam temperature.

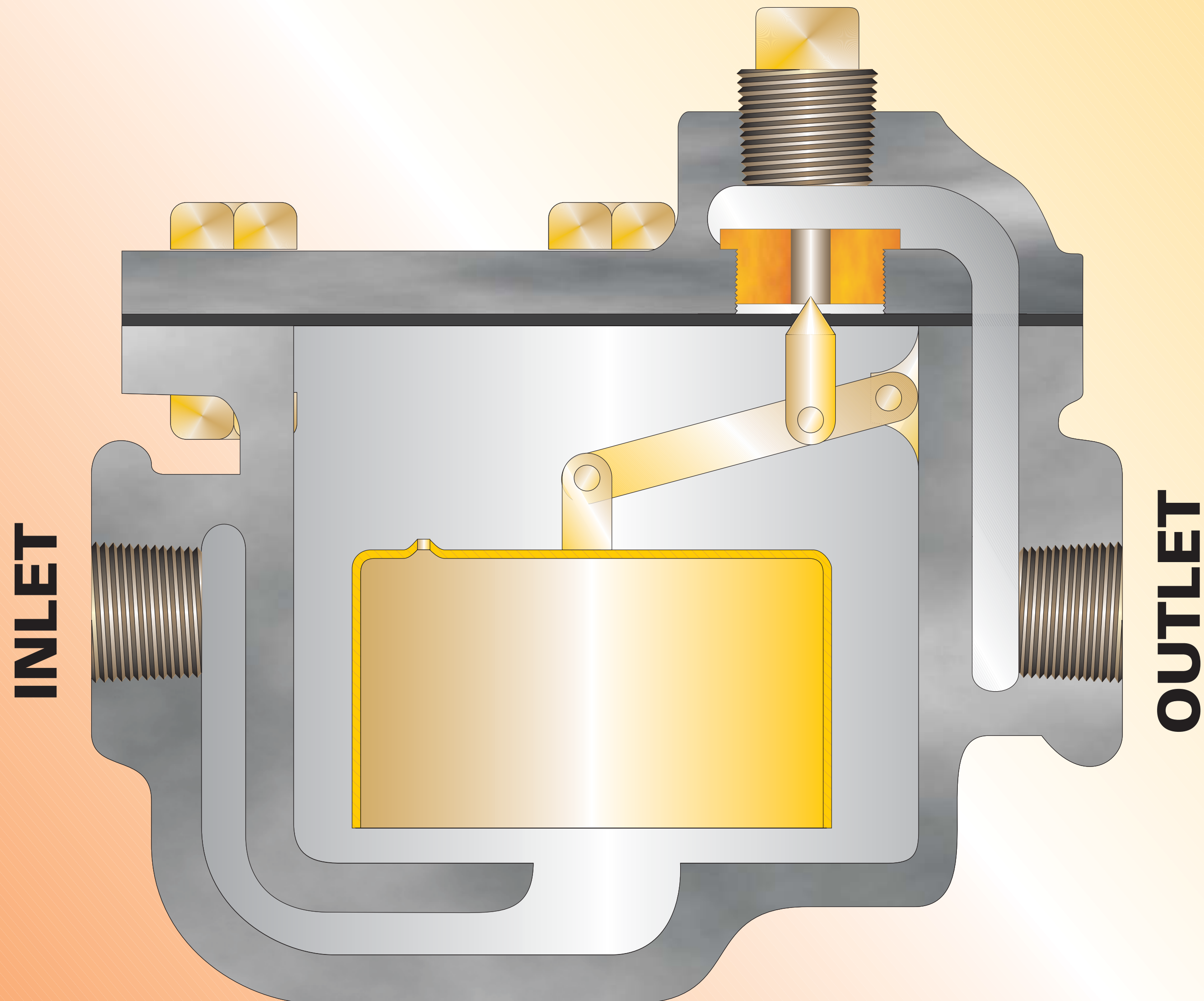
The float valve remains closed until condensate lifts the float high enough. The valve then opens and allows the condensate to drain.

INVERTED BUCKET TRAPS

- Completely drain condensate at saturation temperature
- Used where water hammer is likely (process main drips, drains into wet returns, steam kettles)
- Not effective for venting air because air must pass through the water in the trap, though traps are available with built-in thermostatic air vents to handle this problem
- Traps require manual priming with water to achieve the seal – can lose their prime, allowing live steam to blow through
- Not effective for varying loads – cycle fully open or closed; Normal failure mode is open; Susceptible to freezing

Use bucket traps where water hammer is likely (high pressure systems particularly.) They are not effective for air movement, so they generally aren't a good choice for drip traps on low pressure heating systems.

INVERTED BUCKET TRAP, TYPICAL

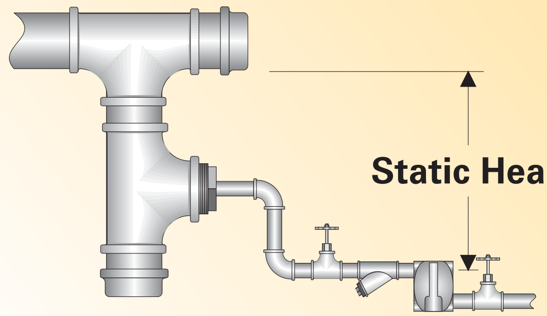


Drawn from Hoffman "Steam Traps Engineering Data Manual"

Inverted bucket traps allow condensate to flow through freely, but the bucket rises when steam enters, closing off the valve. These traps must be primed.

SIZING DRIP TRAPS

- Drip traps for heating systems will usually have to be sized for the start-up load since the system operates automatically. See the table below. Multiply the total number of feet of pipe times the load per foot to obtain the PPH requirement for the trap.
- The differential pressure across the trap for sizing start-up is only the vertical height of the drip pipe ahead of the trap.



- The trap must be sized to handle the start-up load from all piping dripped through this trap.

Start-Up Load for Drip Traps, Automatic Firing

Pipe Size (Inches)	Start-Up Load (PPH Condensate) Per Linear Foot	Pipe Size (Inches)	Start-Up Load (PPH Condensate) Per Linear Foot
3/4	0.023	3	0.153
1	0.034	4	0.218
1 1/4	0.046	6	0.384
1 1/2	0.055	8	0.578
2	0.074	10	0.819
2 1/2	0.117	12	1.083
Based on 70 °F Room Temp, 10 psig Steam (239 °F), Schedule 40 Pipe			

MULTIPLY ABOVE BY 4 FOR 15 MINUTE PICKUP - MULTIPLY BY 2 FOR 30 MINUTE PICKUP

Make sure to install drip traps with enough piping below the main or riser to provide static head. Size the trap based on this head to make sure it has the capacity needed. This assures the trap will drain condensate at the beginning and end of the heating cycle, when there is little or no pressure in the lines.

SIZING DRIP TRAPS

Pounds of Condensate per Lineal Foot of Pipe - UNINSULATED

Pipe Size	Steam Pressure (PSIG)					
(Inches)	1	2	4	6	8	10
3/4	0.11	0.13	0.14	0.14	0.15	0.15
1	0.15	0.15	0.16	0.16	0.17	0.18
1 1/2	0.21	0.21	0.22	0.23	0.23	0.24
2	0.24	0.25	0.26	0.27	0.27	0.29
2 1/2	0.30	0.31	0.32	0.33	0.34	0.36
3	0.38	0.39	0.40	0.41	0.43	0.44
4	0.46	0.47	0.48	0.49	0.51	0.53
5	0.55	0.56	0.59	0.60	0.62	0.64

Pounds of Condensate per Lineal Foot of Pipe - INSULATED (With 2-inch Thick Magnesia Insulation)

Pipe Size	Steam Pressure (PSIG)			
(Inches)	1	3	5	10
3/4	0.02	0.02	0.03	0.03
1	0.03	0.03	0.03	0.03
1 1/2	0.03	0.03	0.04	0.04
2	0.04	0.04	0.04	0.04
2 1/2	0.04	0.04	0.05	0.05
3	0.05	0.05	0.05	0.05
4	0.06	0.06	0.06	0.07
5	0.07	0.07	0.07	0.09
6	0.09	0.09	0.10	0.11
8	0.11	0.11	0.12	0.13
10	0.13	0.14	0.14	0.15
12	0.15	0.15	0.17	0.18
Note: Based on steam velocity at 8000 fpm				

From Hoffman “Steam Traps, Engineering Data Manual”

When the steam pipes are insulated, drip trap sizing will usually be based on the start-up load. But uninsulated pipes give off a lot of heat and could require a larger trap.

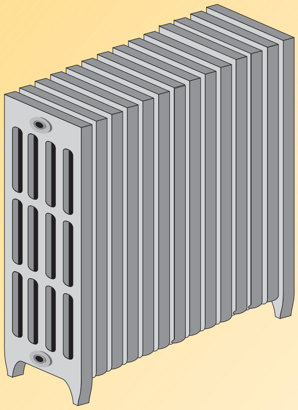
Never line size a trap.

SIZING DRAIN TRAPS

- Determine the maximum condensate load (pounds per hour) that the trap will see. For radiators, divide the EDR (square feet) for the radiator by 4; i.e., PPH Condensate = EDR / 4
- Determine the differential pressure across the trap. This is the minimum steam pressure the trap will see minus any static lift on the outlet of the trap.
- Select the right trap for the application: Thermostatic traps for radiators and convectors, Float and thermostatic traps for heat exchangers
- Multiply the trap condensate load times the recommended safety factor: 2 to 4 for Thermostatic Traps; 1.5 to 2.5 for Float & Thermostatic Traps. NOTE: When using the SHEMA rating for these traps, the safety factor is already included.
- Select the trap size which will handle the condensate load at the available differential pressure. Never line size a trap.

Size drain traps using the guidelines above.

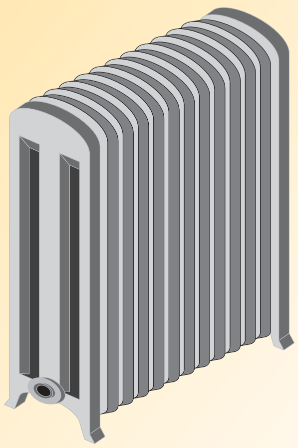
Never line size a trap.



TUBULAR RADIATION

RATING - Square Feet per Section

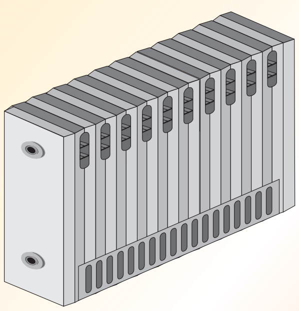
Height	3 Tube	4 Tube	5 Tube	6 Tube	7 Tube
14"					2.67
17"					3.25
20"	1.75	2.25	2.67	3.00	3.67
23"	2.00	2.50	3.00	3.50	
26"	2.33	2.75	3.50	4.00	4.75
32"	3.00	3.50	4.33	5.00	5.50
38"	3.50	4.25	5.00	6.00	6.75



COLUMN RADIATION

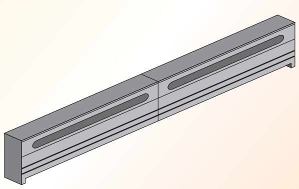
RATING - Square Feet per Section

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

SIZE THE BOILER TO HANDLE THE RADIATION

Steam boilers cannot be sized by building heat loss like hot water boilers.

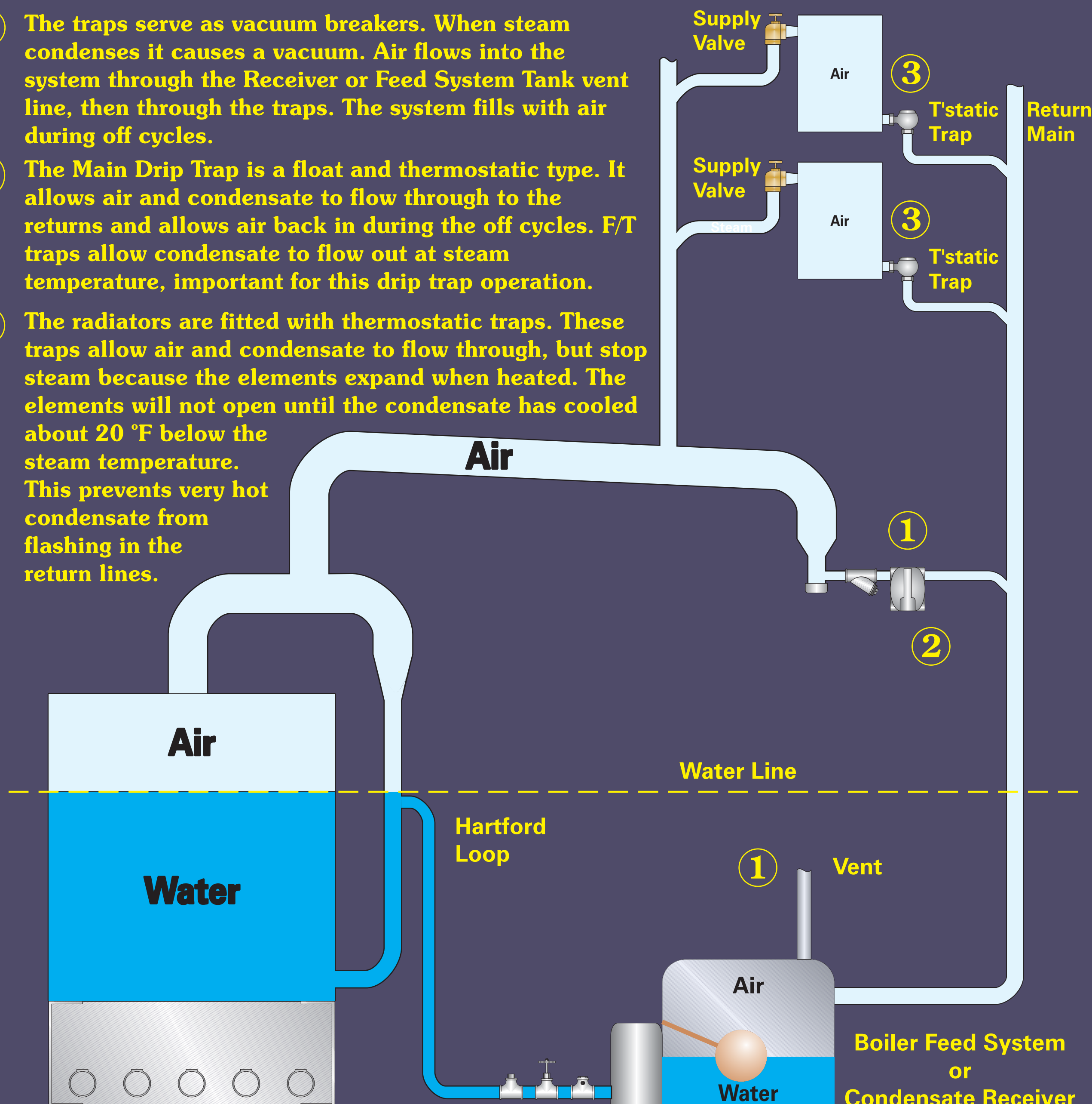
They must be sized to slightly exceed the connected radiation. Otherwise the most remote radiators will not receive steam. Remember that boiler Net Load Ratings include piping and pickup factors. Select a boiler with a Net Load Rating slightly larger than the total connected radiation.

TWO-PIPE STEAM SYSTEM
Off Cycle

① The traps serve as vacuum breakers. When steam condenses it causes a vacuum. Air flows into the system through the Receiver or Feed System Tank vent line, then through the traps. The system fills with air during off cycles.

② The Main Drip Trap is a float and thermostatic type. It allows air and condensate to flow through to the returns and allows air back in during the off cycles. F/T traps allow condensate to flow out at steam temperature, important for this drip trap operation.

③ The radiators are fitted with thermostatic traps. These traps allow air and condensate to flow through, but stop steam because the elements expand when heated. The elements will not open until the condensate has cooled about 20 °F below the steam temperature. This prevents very hot condensate from flashing in the return lines.



Most steam systems must breathe to operate correctly. They move air out during the heating cycle and let it back in during the off cycle. The components and piping must be unobstructed to be sure this happens.

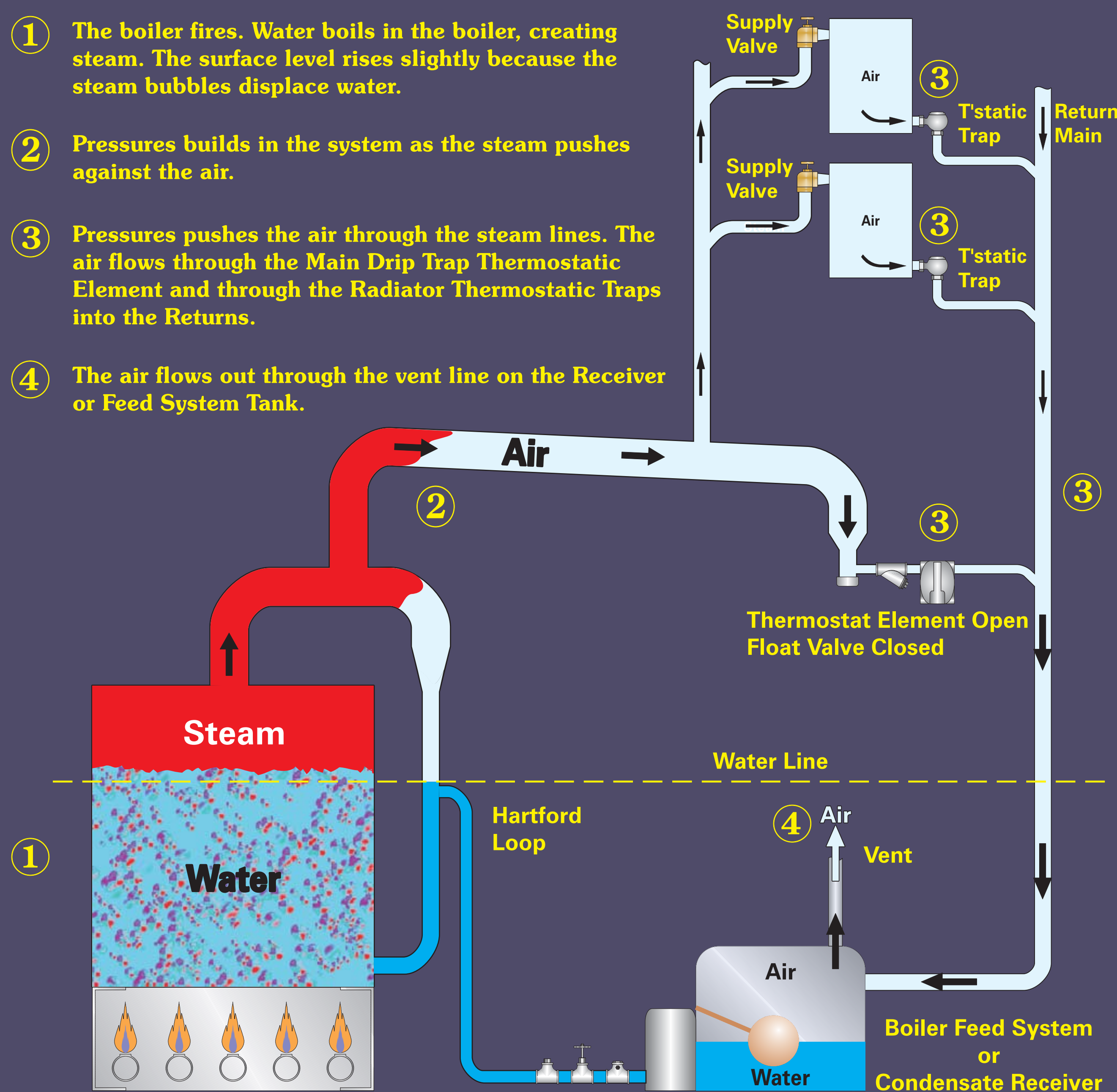
TWO-PIPE STEAM SYSTEM
Thermostat Calls for Heat

1. The boiler fires. Water boils in the boiler, creating steam. The surface level rises slightly because the steam bubbles displace water.

2. Pressures builds in the system as the steam pushes against the air.

3. Pressures pushes the air through the steam lines. The air flows through the Main Drip Trap Thermostatic Element and through the Radiator Thermostatic Traps into the Returns.

4. The air flows out through the vent line on the Receiver or Feed System Tank.



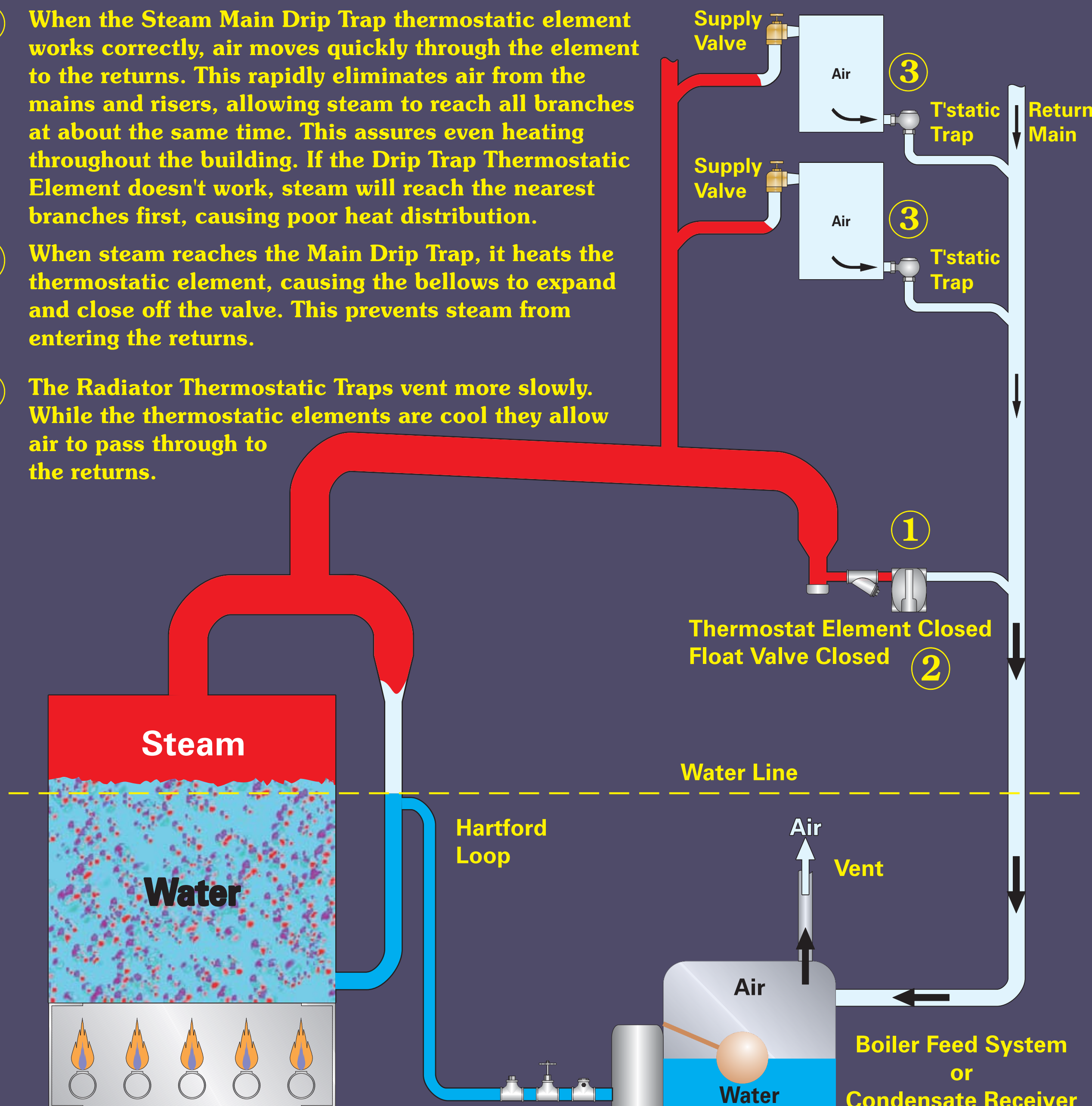
The Main and Riser Drip Traps must allow air to flow out through the returns to the receiver or feed system tank vent line. At the end of the cycle they must allow the air to return.

TWO-PIPE STEAM SYSTEM
The Steam Main Drip Trap

① When the Steam Main Drip Trap thermostatic element works correctly, air moves quickly through the element to the returns. This rapidly eliminates air from the mains and risers, allowing steam to reach all branches at about the same time. This assures even heating throughout the building. If the Drip Trap Thermostatic Element doesn't work, steam will reach the nearest branches first, causing poor heat distribution.

② When steam reaches the Main Drip Trap, it heats the thermostatic element, causing the bellows to expand and close off the valve. This prevents steam from entering the returns.

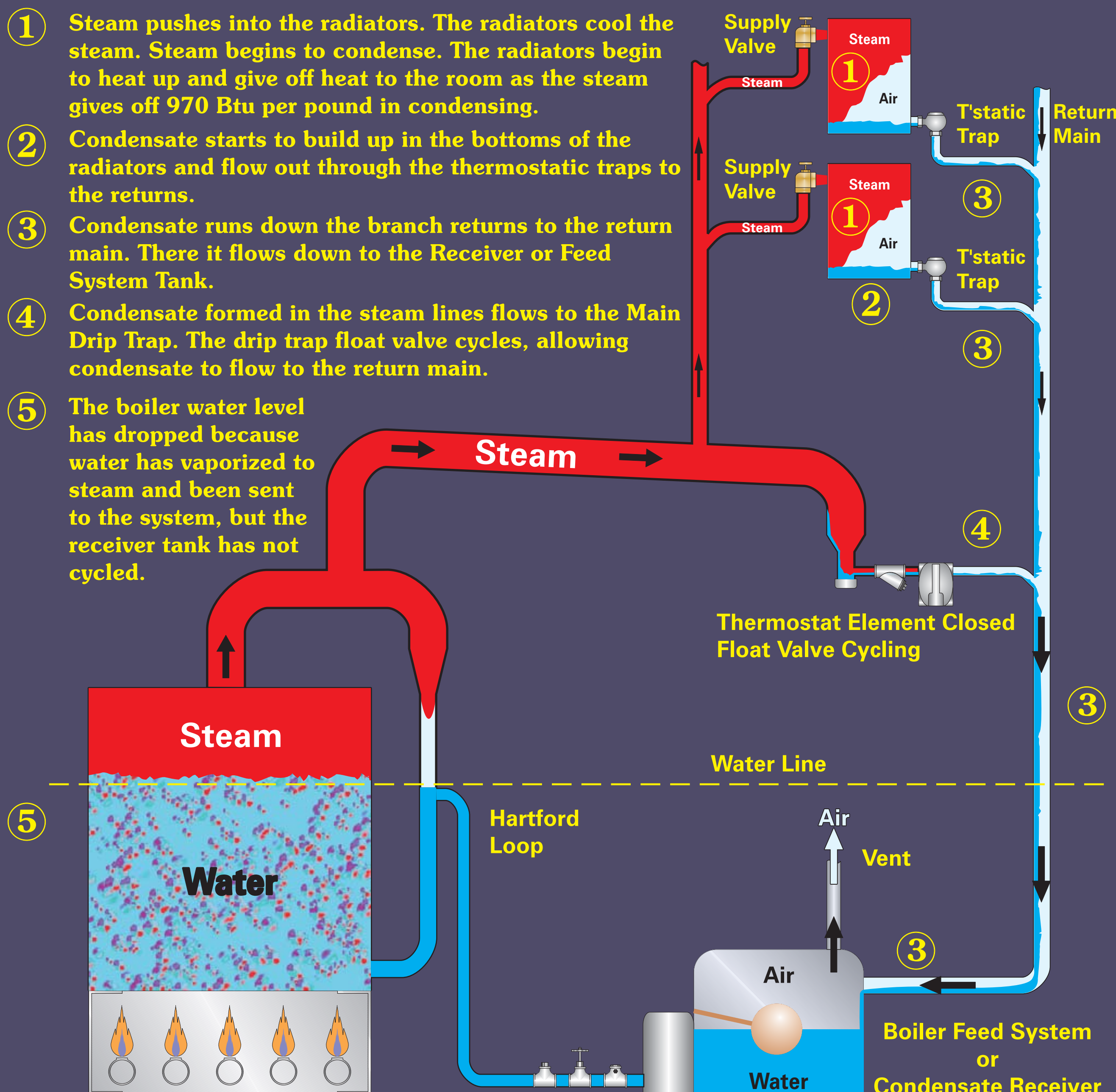
③ The Radiator Thermostatic Traps vent more slowly. While the thermostatic elements are cool they allow air to pass through to the returns.



When the drip traps allow rapid, free movement of air all branches receive steam at about the same time. This assures uniform and reliable heating of the building.

TWO-PIPE STEAM SYSTEM
Heating Begins in Radiators

1. Steam pushes into the radiators. The radiators cool the steam. Steam begins to condense. The radiators begin to heat up and give off heat to the room as the steam gives off 970 Btu per pound in condensing.
2. Condensate starts to build up in the bottoms of the radiators and flow out through the thermostatic traps to the returns.
3. Condensate runs down the branch returns to the return main. There it flows down to the Receiver or Feed System Tank.
4. Condensate formed in the steam lines flows to the Main Drip Trap. The drip trap float valve cycles, allowing condensate to flow to the return main.
5. The boiler water level has dropped because water has vaporized to steam and been sent to the system, but the receiver tank has not cycled.

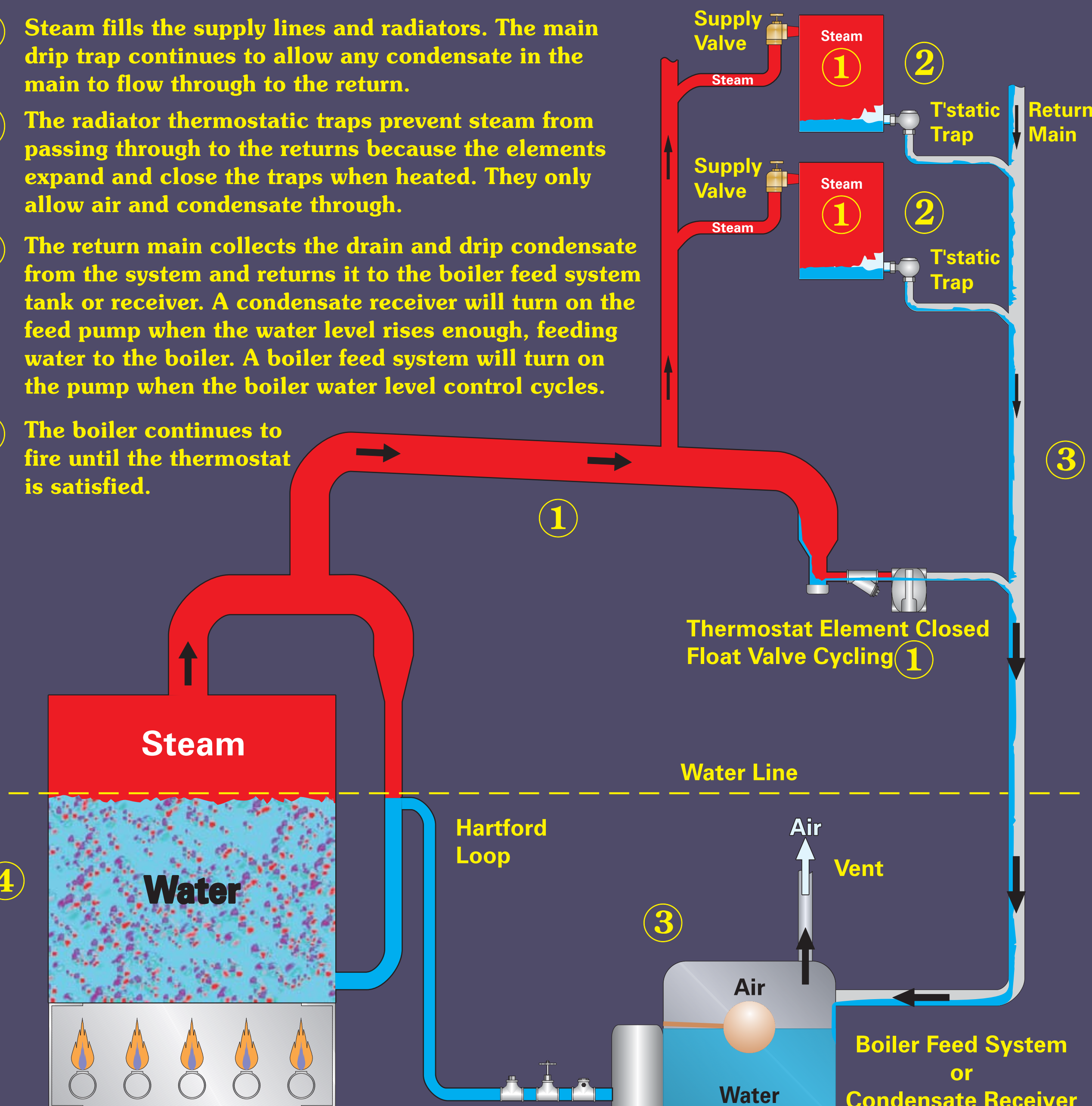


The drip trap thermostatic elements close when steam reaches them. Their float valves cycle to remove condensate in the lines.

Radiator traps remain open to allow condensate and air to flow through until heated by the steam. They then close until the condensate has cooled about 10 to 30 oF below the steam temperature.

TWO-PIPE STEAM SYSTEM
Steady State Heating

1. Steam fills the supply lines and radiators. The main drip trap continues to allow any condensate in the main to flow through to the return.
2. The radiator thermostatic traps prevent steam from passing through to the returns because the elements expand and close the traps when heated. They only allow air and condensate through.
3. The return main collects the drain and drip condensate from the system and returns it to the boiler feed system tank or receiver. A condensate receiver will turn on the feed pump when the water level rises enough, feeding water to the boiler. A boiler feed system will turn on the pump when the boiler water level control cycles.
4. The boiler continues to fire until the thermostat is satisfied.



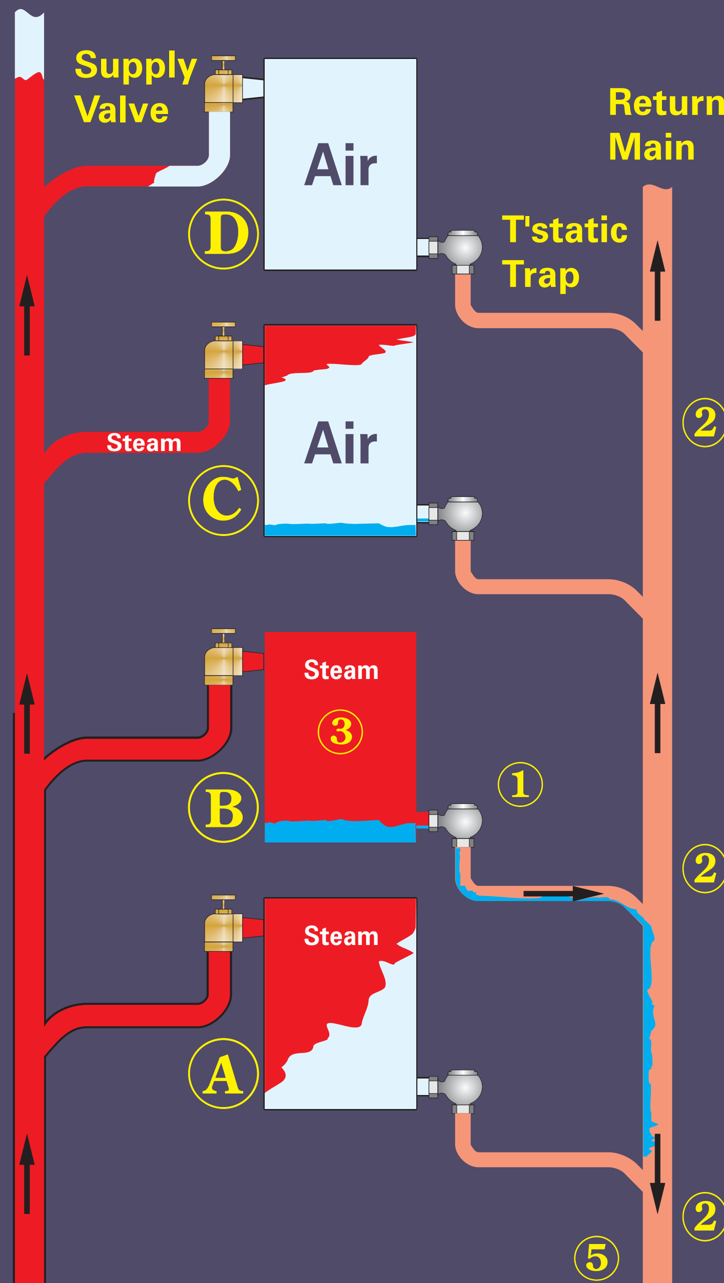
The traps cycle to allow condensate to flow through during the heating period.

Condensate receiver units feed water to the boiler when the float rises high enough. This receiver is about ready to cycle.

Boiler feed systems feed water on demand from the boiler water level control.

TWO-PIPE STEAM SYSTEM
Effects of Radiator Trap Failure

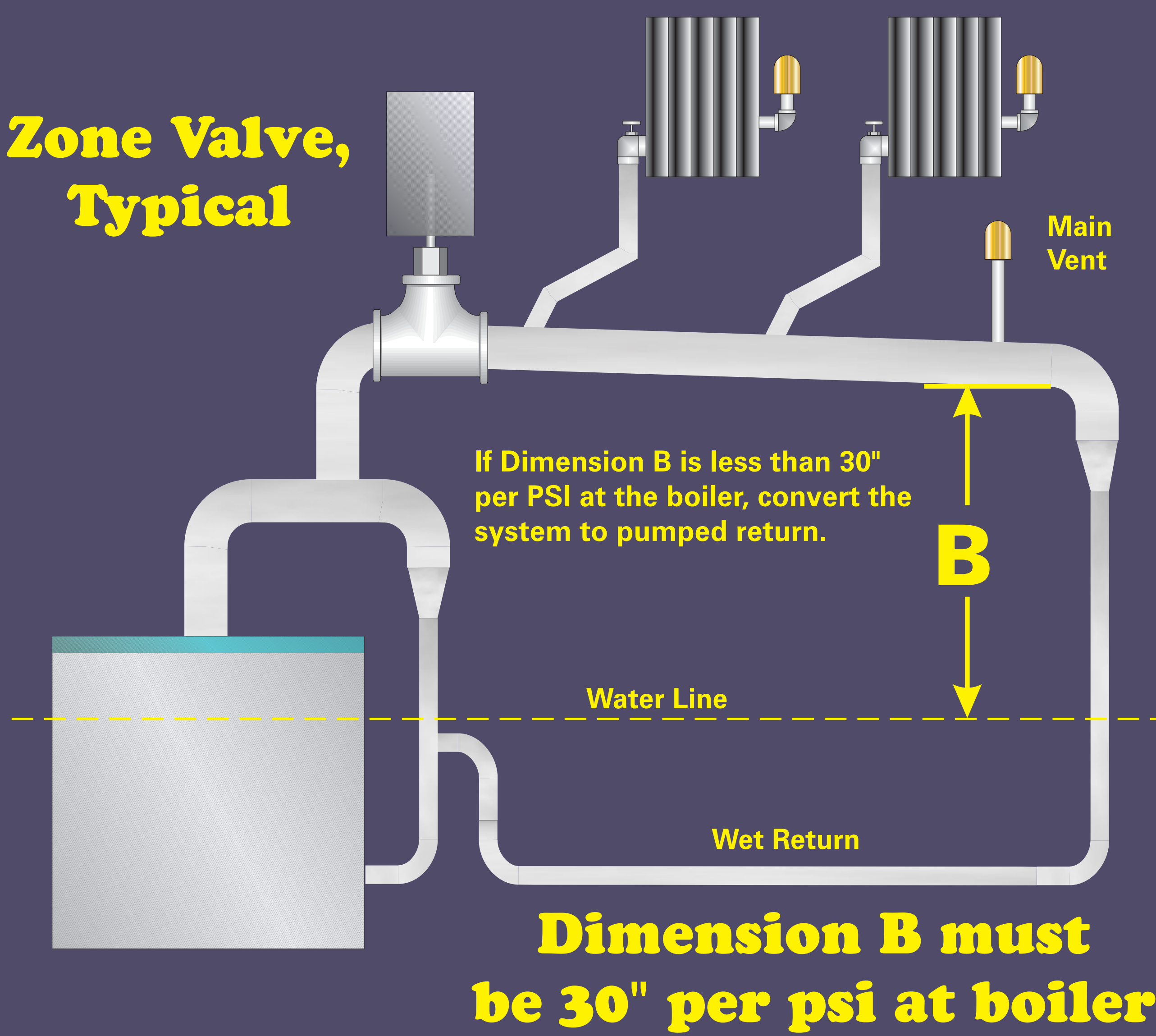
1. Radiator B thermostatic trap has failed open, the most common way these traps fail.
2. Steam now flows directly through the failed trap into the return lines at only a slightly lower pressure than the supply lines.
3. Radiator B heats very well since it has a constant supply of steam. But the other radiators are air bound because there is only a small pressure difference across their traps.
4. The other radiators will slowly move the air out. When they do and they start to make condensate, the condensate will try to flow through the trap AGAINST the flow of steam in the returns. This will cause severe water hammer in the radiator return and will probably crush the radiator's thermostatic trap element, causing it to fail as well. Once it fails (probably failing open) it will heat similarly to radiator B.
5. Steam will flow down the return main and into the receiver or feed system tank. This will heat up the condensate and can cause cavitation of the feed pump due to excessively hot condensate.
6. DO NOT replace traps when the system is operating. Try to wait until summer to do it. Otherwise, defective traps can lead to failure of the new ones.



When a trap fails open (the usual failure mode for a thermostatic trap) the radiator with the failed trap will heat.

Other radiators will be air bound because the defective trap allows steam to flow through and pressurize the return lines.

ONE-PIPE SYSTEM WITH ZONE VALVES

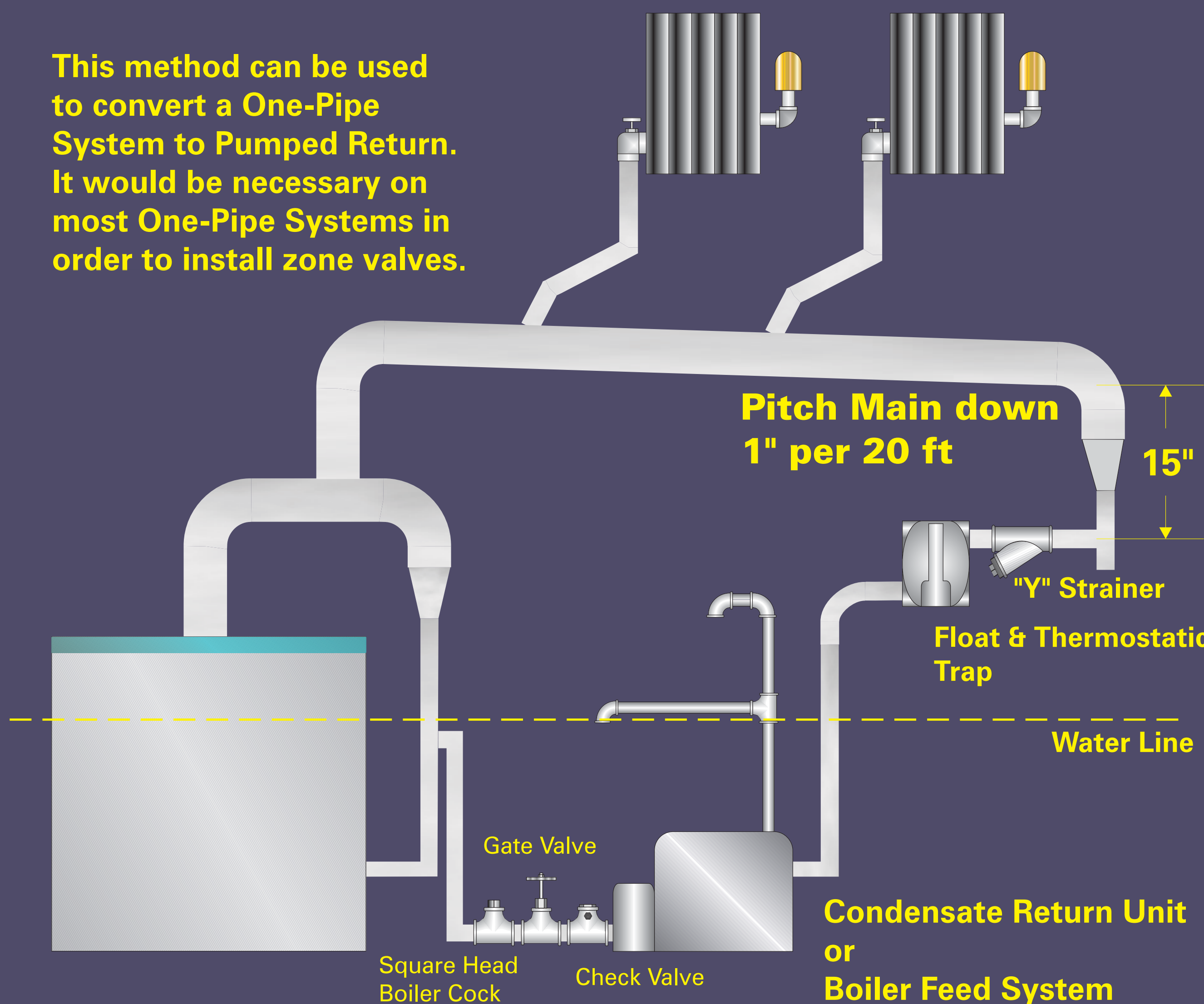


Most one pipe systems don't have enough riser height above the water line to allow installing zone valves or traps. These components close off the line to steam pressure, so water backs up the returns until the height matches the boiler operating pressure.

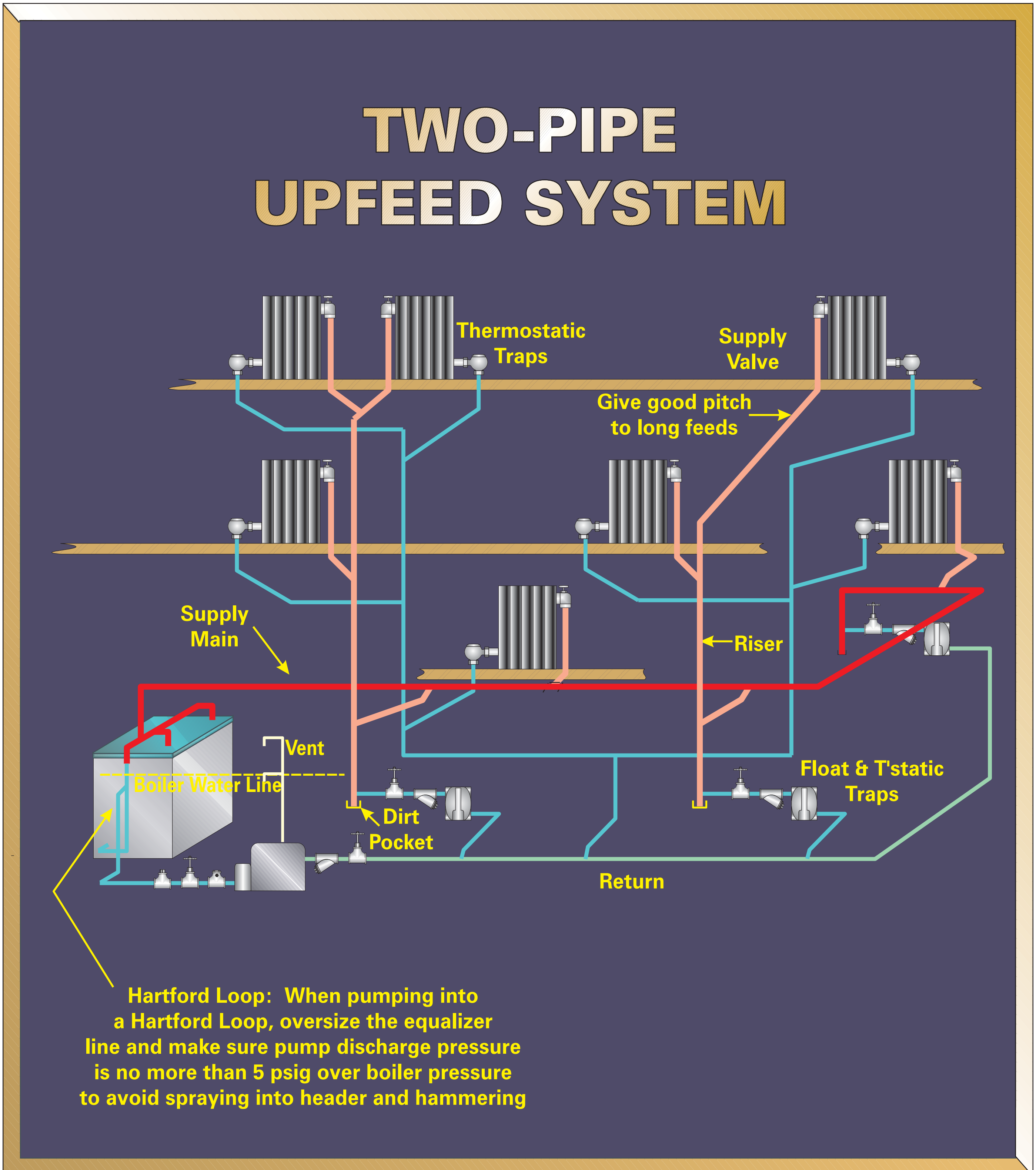
If the height to the lowest steam carrying pipe isn't enough, severe water hammer occurs.

ONE-PIPE PUMPED RETURN PARALLEL FLOW SYSTEM

This method can be used to convert a One-Pipe System to Pumped Return. It would be necessary on most One-Pipe Systems in order to install zone valves.

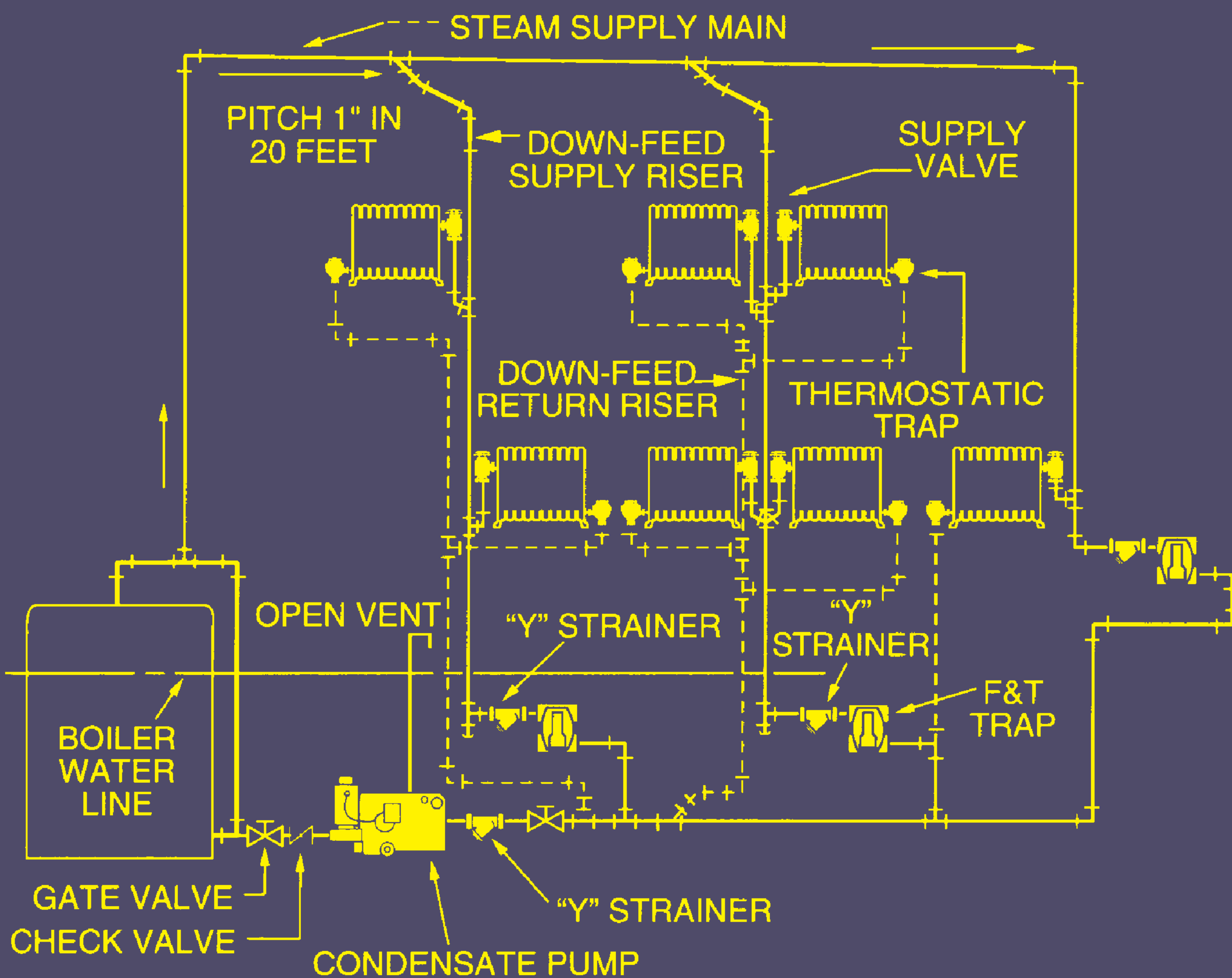


Convert one-pipe systems to pumped return when installing zone valves or when the return riser height above the water line isn't enough (usually at least 28 inches minimum.)



This is a schematic of a typical two pipe upfeed system. Note the use of float and thermostatic drip traps on the steam main and supply risers.

TWO-PIPE DOWNFEED SYSTEM

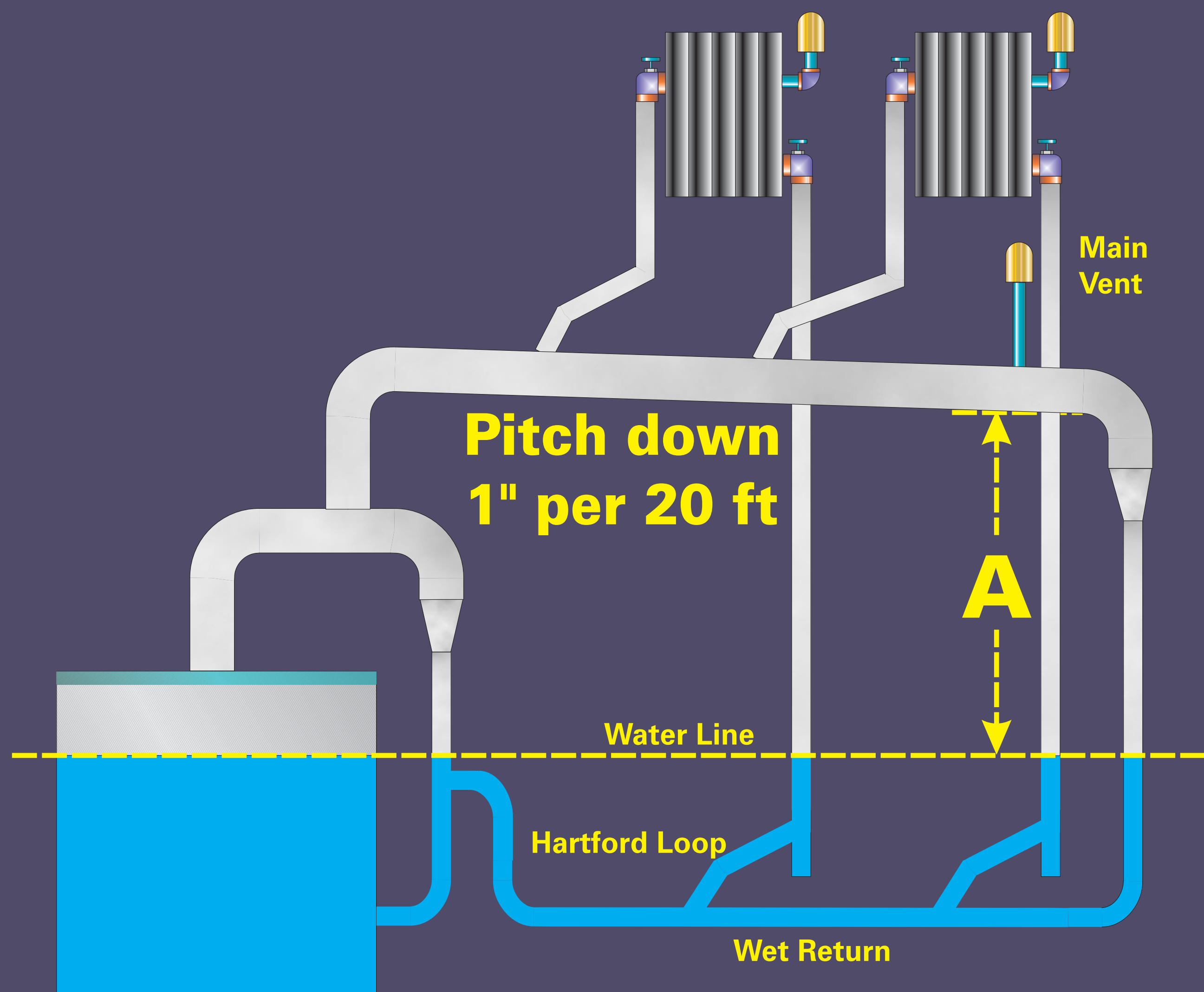


From Hoffman "Basic Steam Heating Systems"

The two pipe downfeed system is similar to the upfeed system. But the main is at the top of the system and steam feeds downward.

Use float and thermostatic drip traps on the steam main and supply risers.

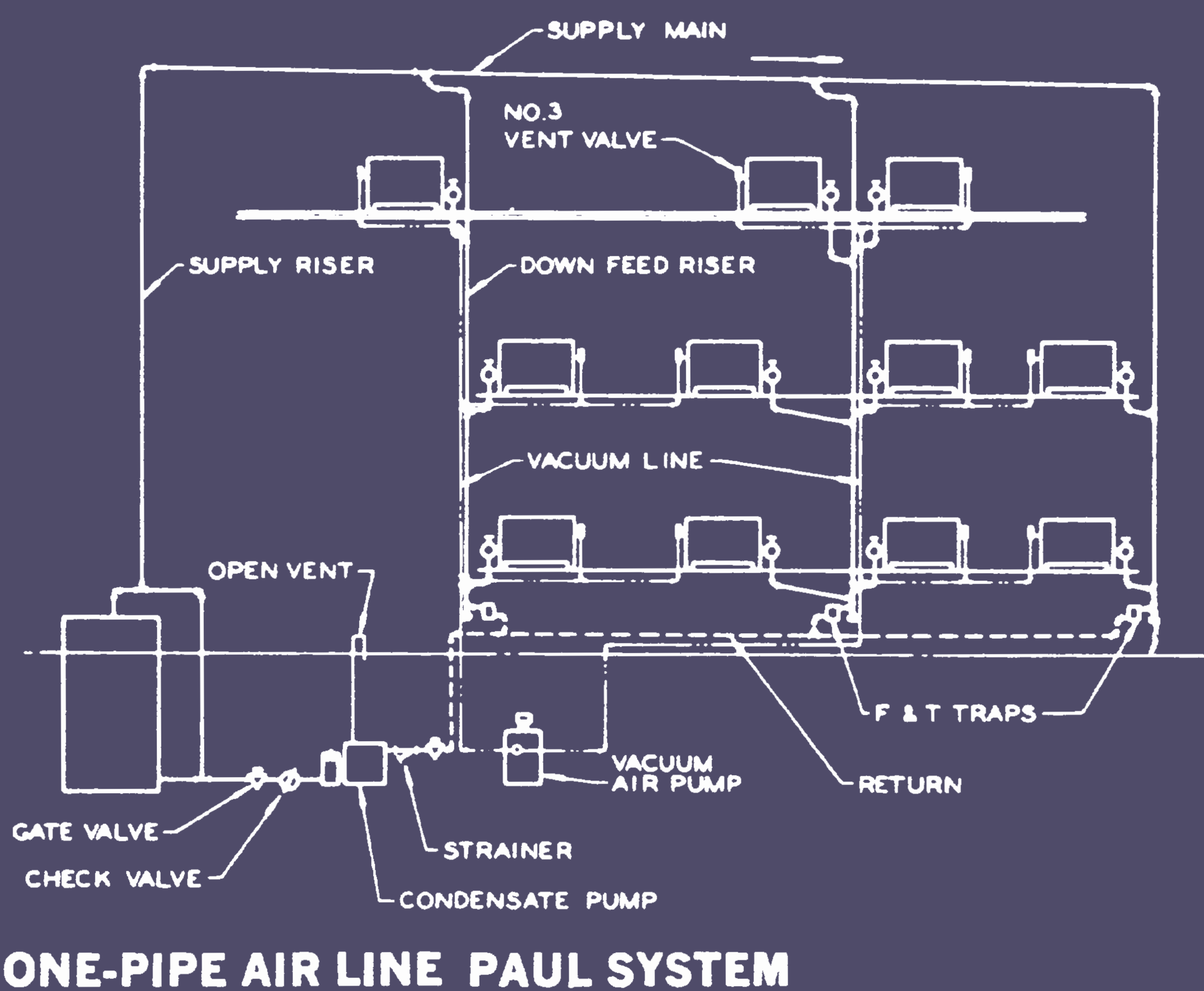
TWO-PIPE WET RETURN SYSTEM WITH NO TRAPS



This two pipe system requires no pump or traps. Each radiator return line is piped individually to the bottom of the system and tied into the wet return. This provides a water seal.

These systems require a Dimension A of at least 28 inches in most cases, the same as for one pipe systems.

ONE-PIPE PAUL SYSTEM

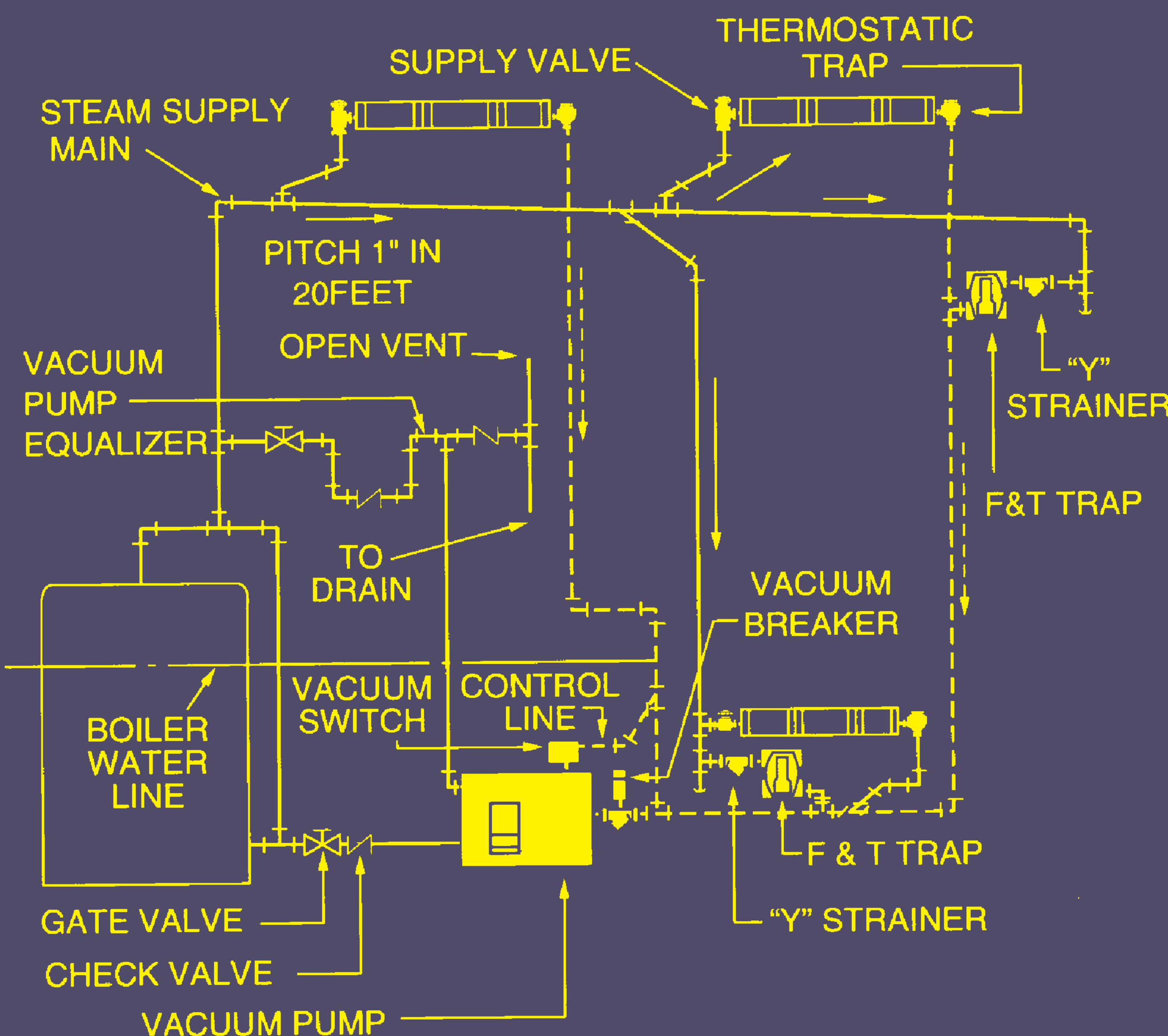


From Hoffman "Steam Heating Systems, Design Manual and Engineering Data"

The One Pipe Paul system works similarly to a one pipe pumped return system. But it uses an air vacuum pump to speed removal of air from the system at the start of the heating cycle. This allows smaller returns, quicker response and more uniform heating.

The air vents on the radiators are called Paul vents.

VACUUM SYSTEM

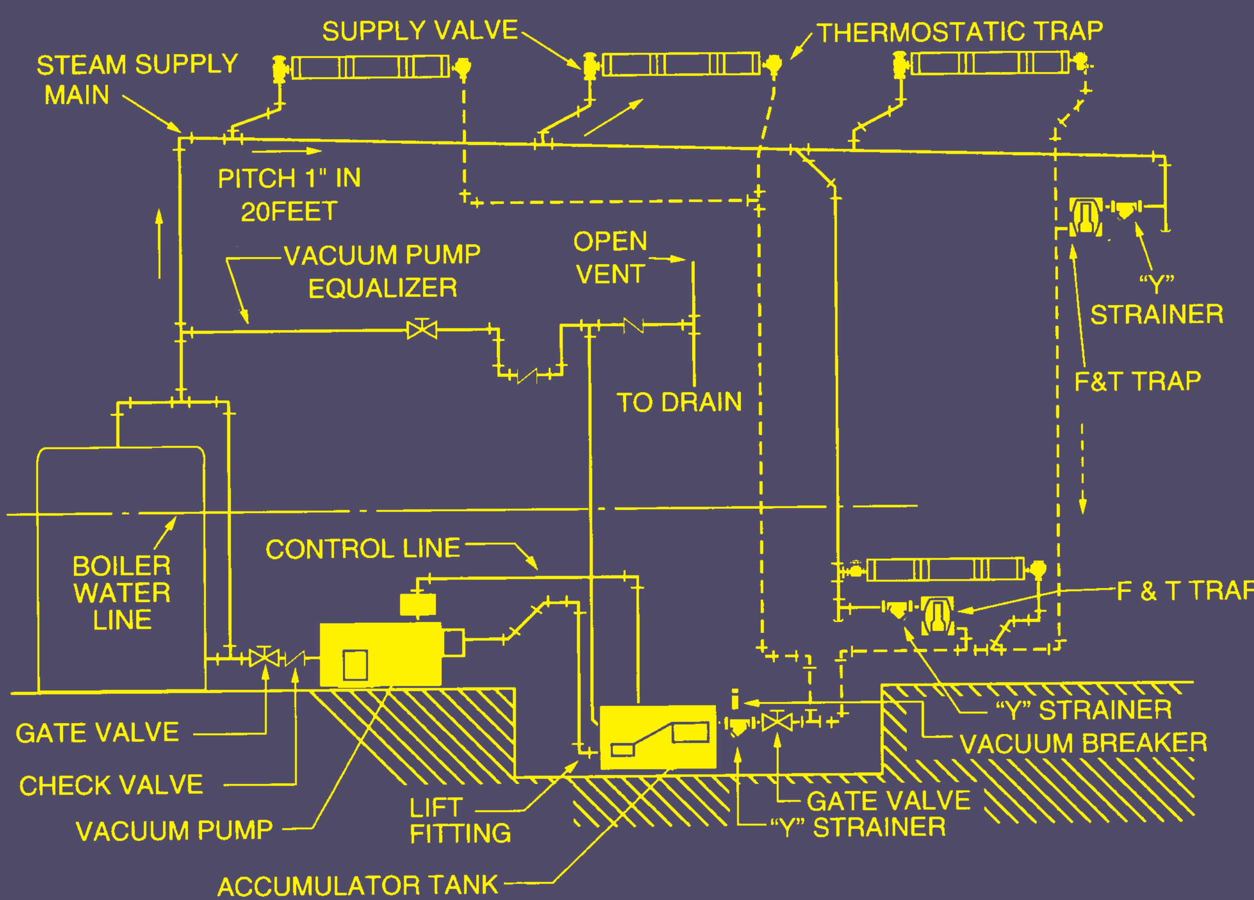


From Hoffman "Basic Steam Heating Systems"

Once a vacuum system, always a vacuum system. This is because the return piping is smaller, made possible because the vacuum pulls the air through quickly.

The system must be air tight and the vacuum pump must pull a vacuum for the system to work correctly. Unless the piping is changed this system cannot be converted to standard pumped return.

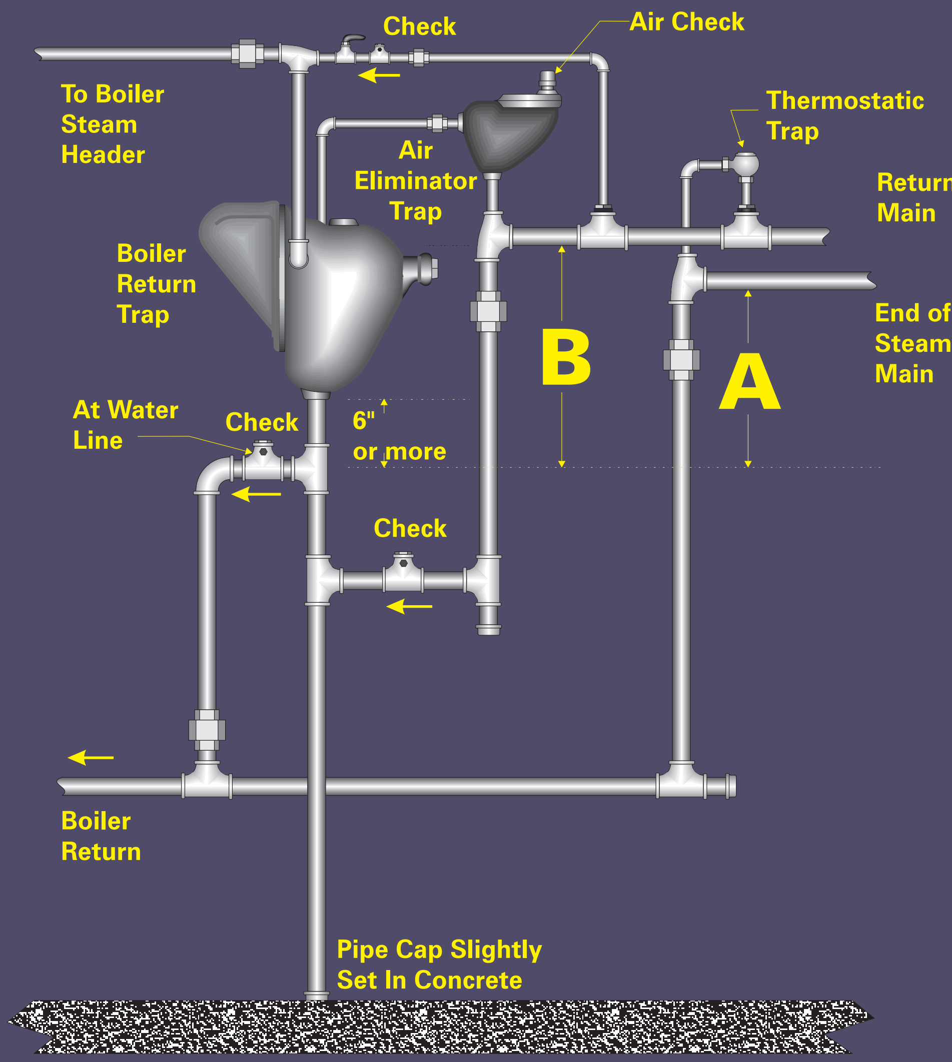
VACUUM SYSTEM WITH ACCUMULATOR TANK



From Hoffman "Basic Steam Heating Systems"

The accumulator tank and lift fitting move condensate from a level below the receiver.

VAPOR SYSTEM ALTERNATING RECEIVER & AIR ELIMINATOR TRAP

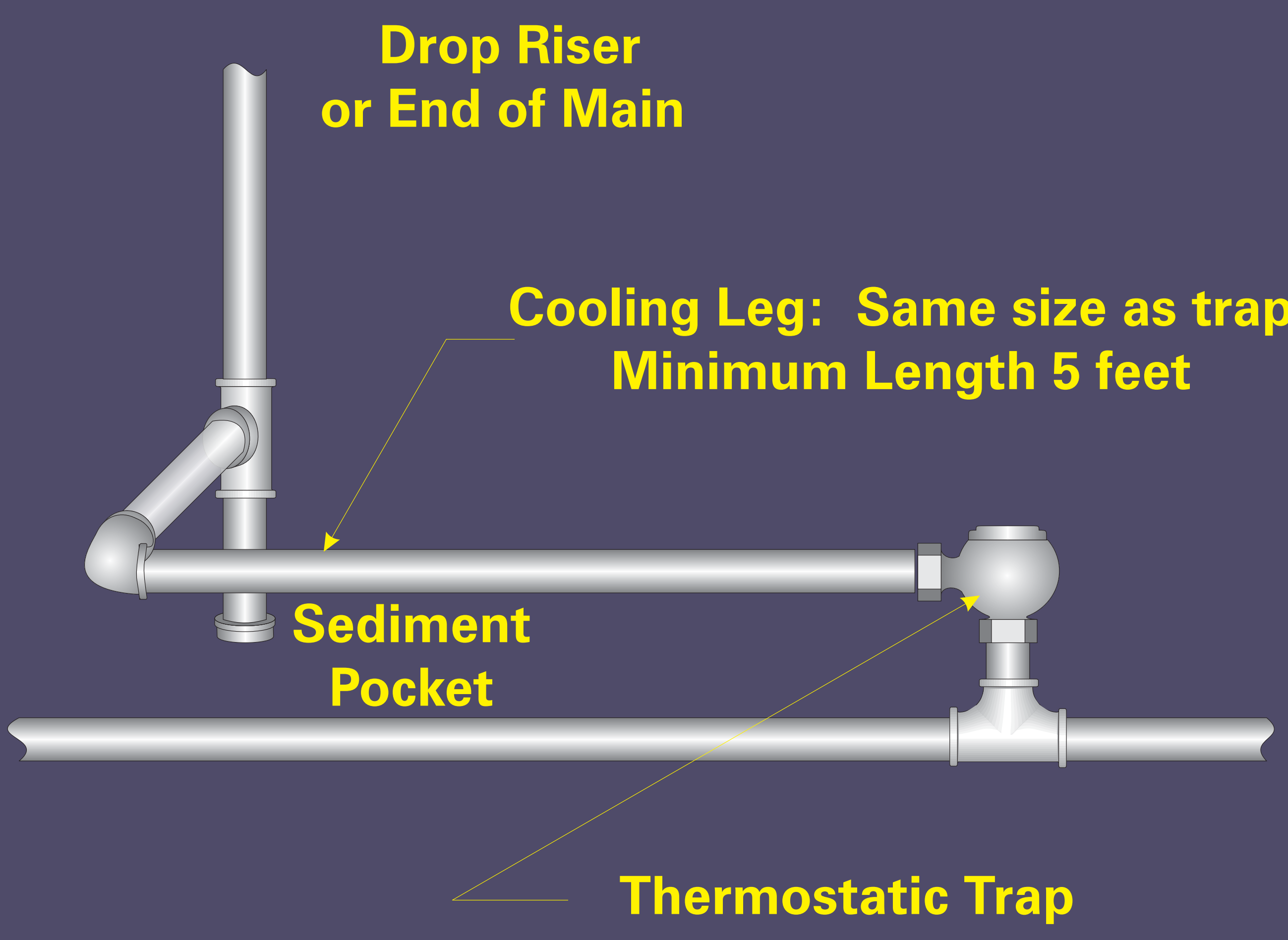


From Holohan "The Lost Art of Steam Heating"

There were many designs of vapor systems in the early part of the century. This one is fairly common and uses an Alternating Receiver and Air Eliminator Trap.

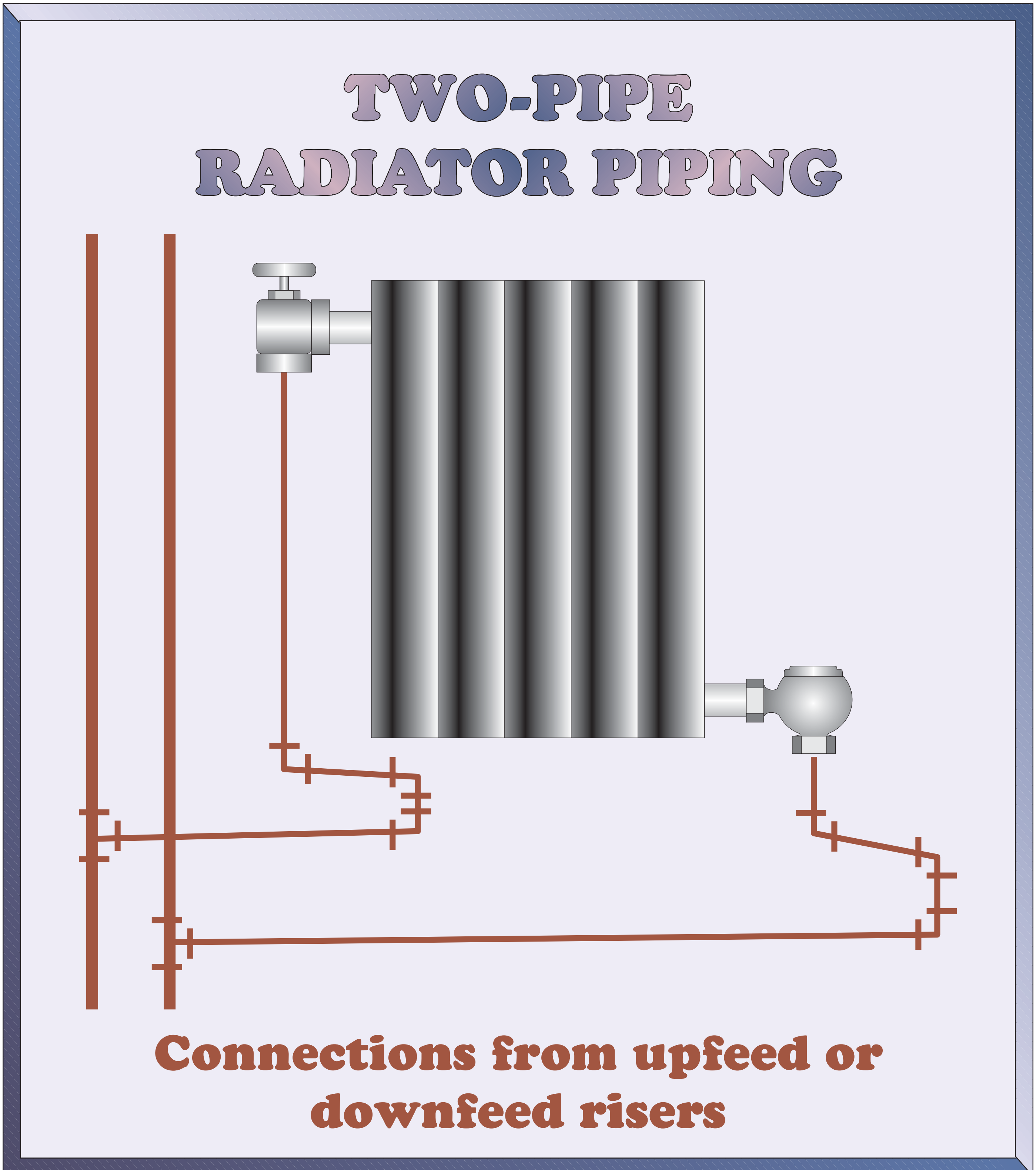
The Alternating Receiver accumulates condensate until its float rises high enough. It then allows steam pressure to balance the return line pressure, letting condensate flow to the boiler. The component heights and piping are critical to operation.

DRIPPING INTO DRY RETURNS USING THERMOSTATIC TRAP TO PROVIDE COOLED CONDENSATE



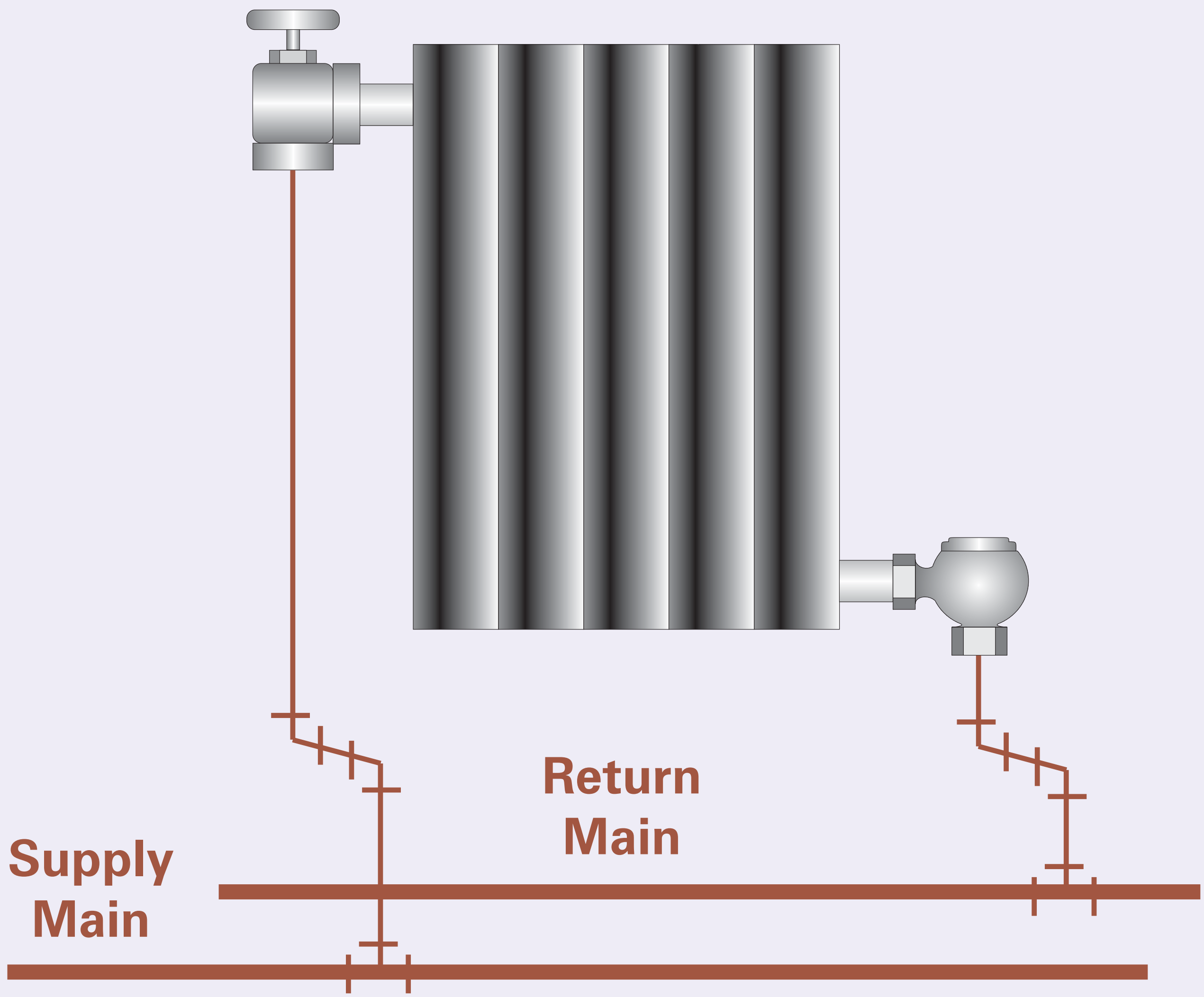
Dripping into a dry return can cause flashing of condensate and water hammer if the condensate is too hot.

You can use a thermostatic trap as a drip trap if you install an uninsulated pipe at least 5 feet long ahead of it. This cools the condensate before it reaches the trap.



Slope the pipes toward the risers. And provide swing joints to allow expansion of the risers and the branch piping.

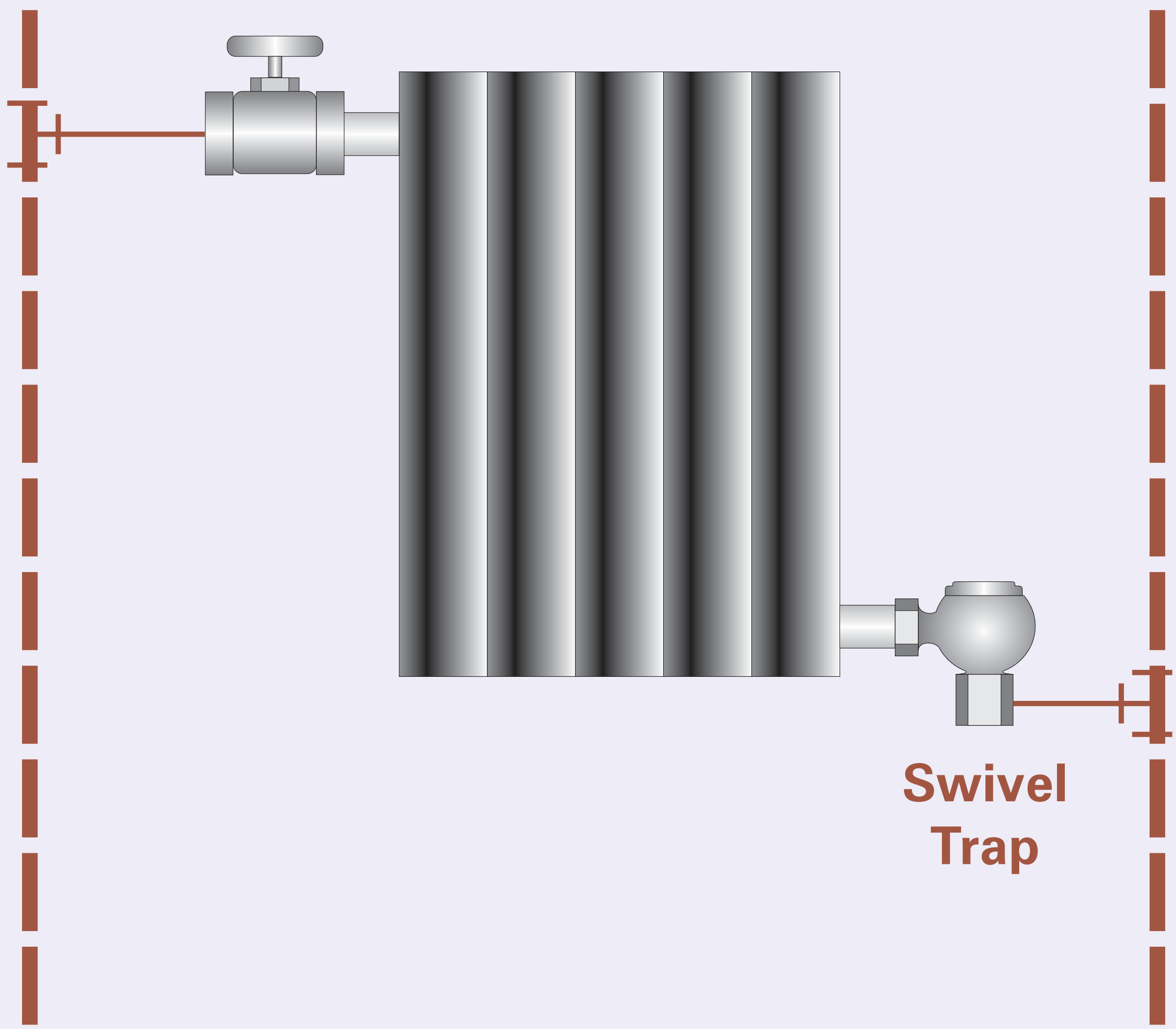
TWO-PIPE RADIATOR PIPING



Connections from horizontal supply & return mains

Slope the pipes toward the risers. And provide swing joints to allow expansion of the risers and the branch piping.

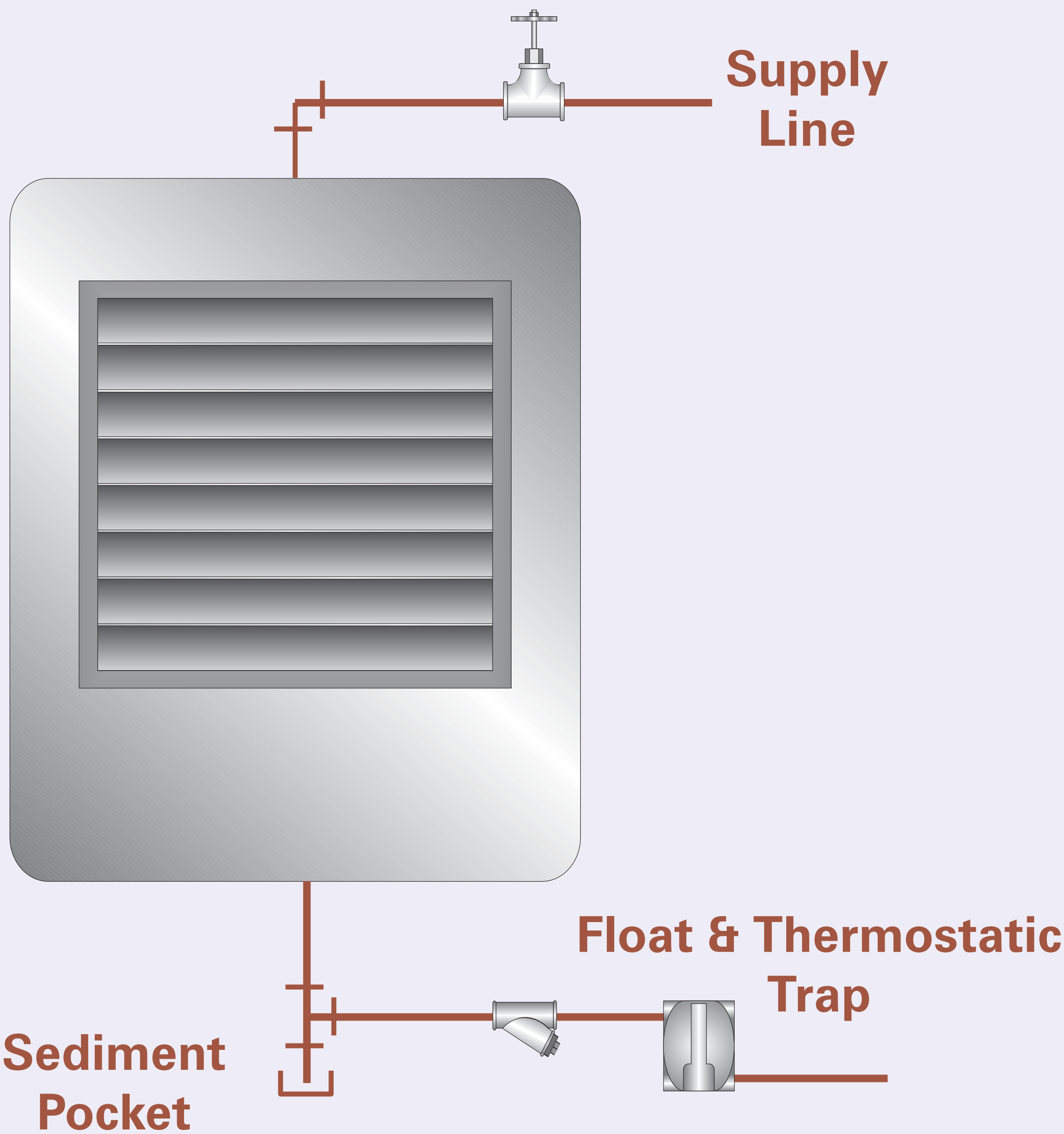
TWO-PIPE RADIATOR PIPING



Connections from upfeed or downfeed risers in wall

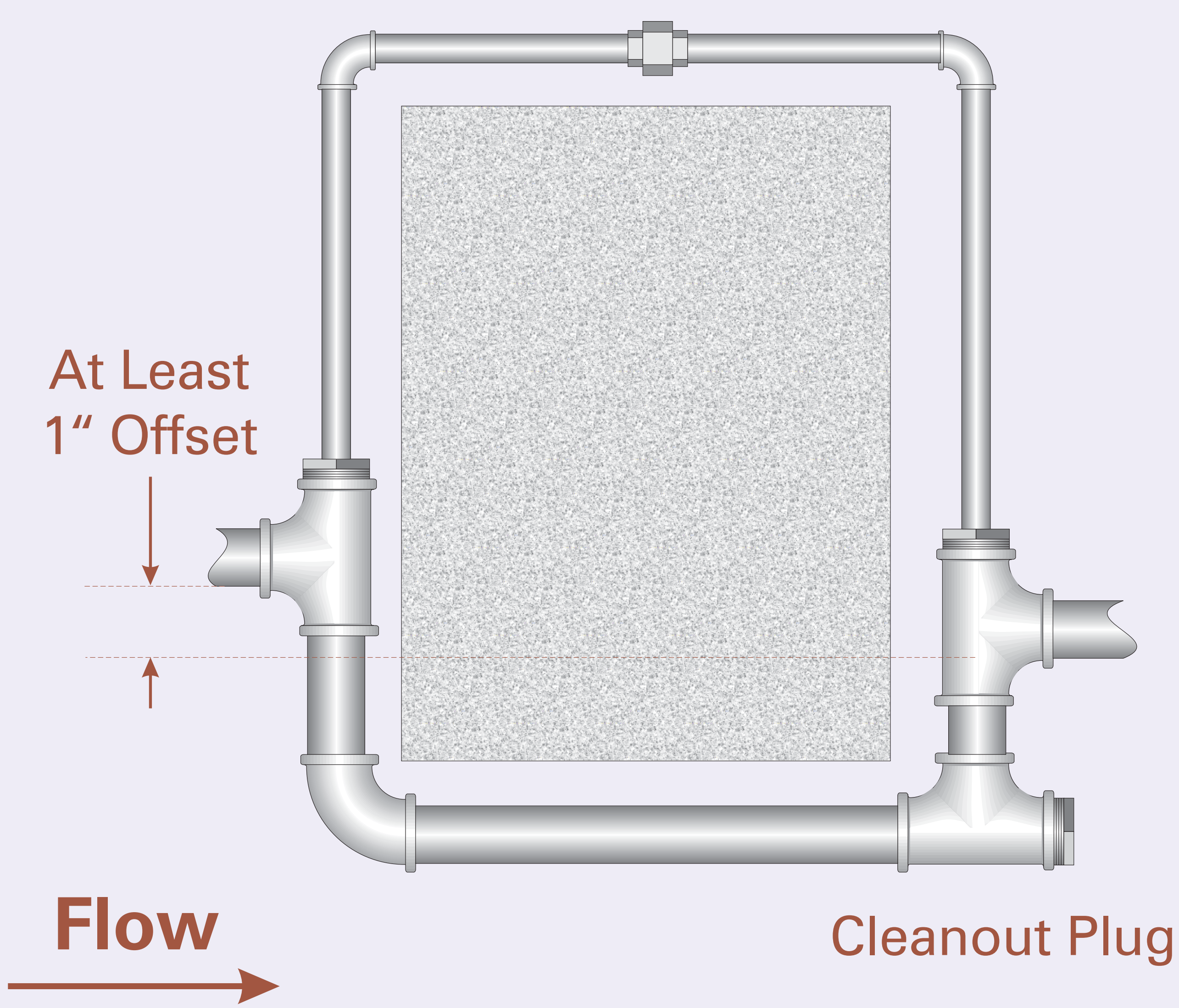
Use swivel traps to simplify piping to risers in the wall.

TWO-PIPE UNIT HEATER PIPING



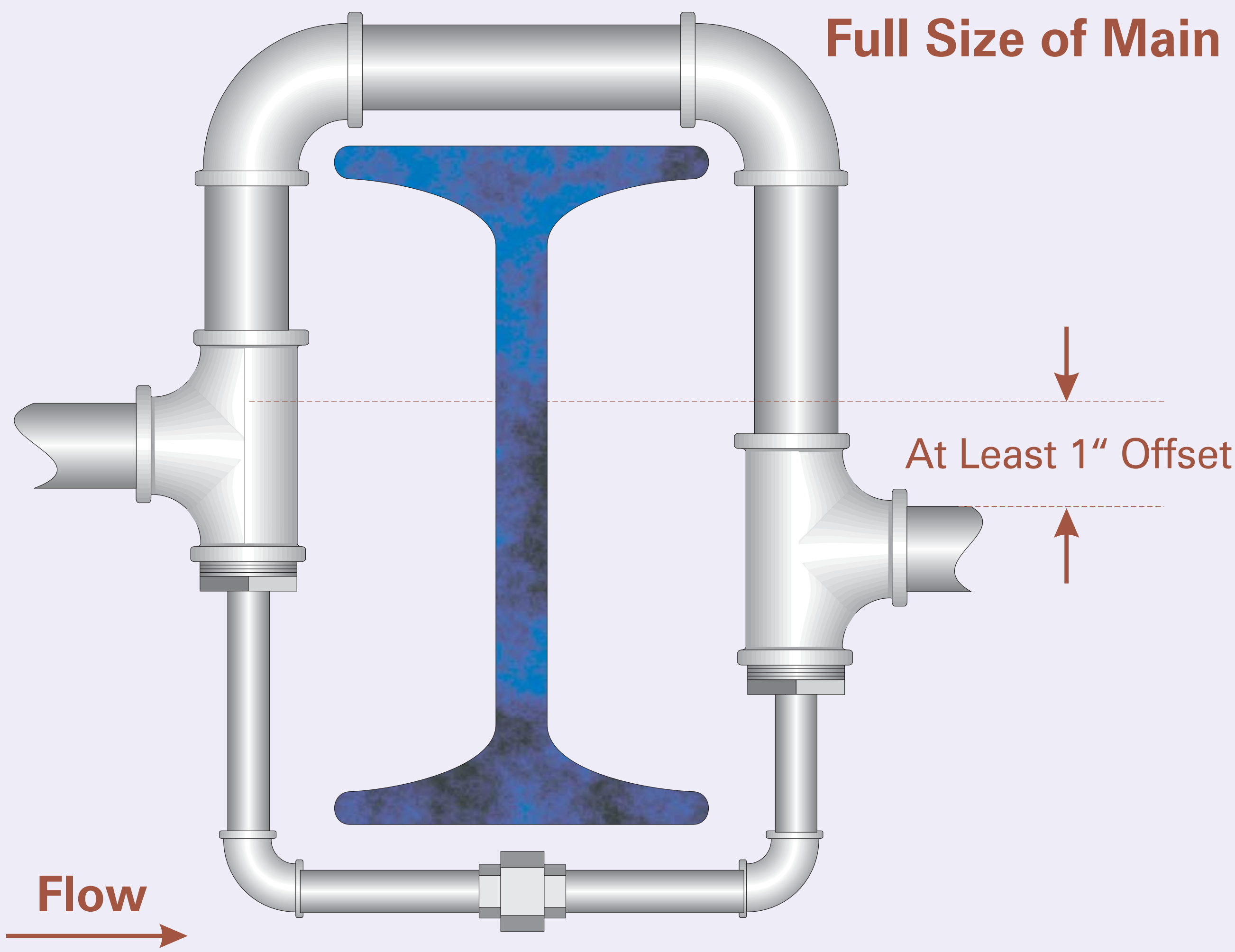
Use float and thermostatic traps on unit heaters and heat exchangers. They drain condensate when the level rises regardless of the condensate temperature and operate well under varying loads.

PIPING AROUND OBSTRUCTIONS
Dry Return Piping



Install the upper pipe as shown to allow air movement through the return. Provide the offset to avoid condensate build up in the line.

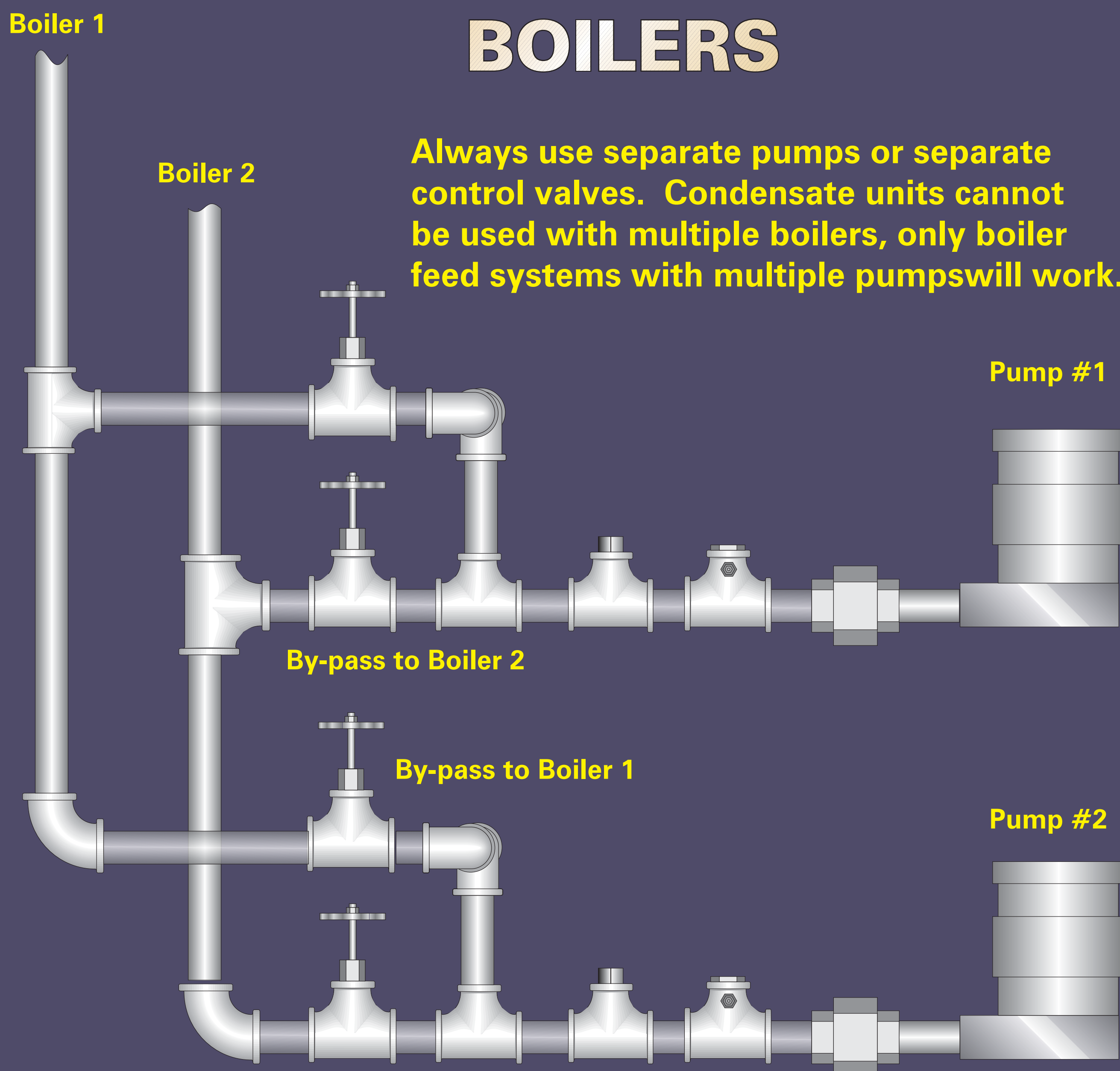
PIPING AROUND OBSTRUCTIONS
Steam Main Piping



Install the lower line with the offset shown to allow condensate to flow through freely.

PUMPING TO MULTIPLE BOILERS

Always use separate pumps or separate control valves. Condensate units cannot be used with multiple boilers, only boiler feed systems with multiple pumpswill work.



Isolate the feed to multiple boilers to assure correct water level control.

CLEANING THE BOILER

- Chemical cleaning – Follow the boiler manufacturer's instructions and use caution to prevent injury from hot liquids and corrosive chemicals
- Allow time on the job to clean and skim the boiler – build this into the quote
- Most of a day will probably be required to skim the boiler – it is often better to allow the boiler to run a couple of days before skimming
- If the boiler isn't cleaned, the system will have problems due to large amounts of carryover, overfilling due to unstable water level, and damage to system components from water hammer and contamination

Install a skim line on every steam boiler and take the time to skim it thoroughly.

Clean the boiler chemically following the boiler manufacturer's instructions.

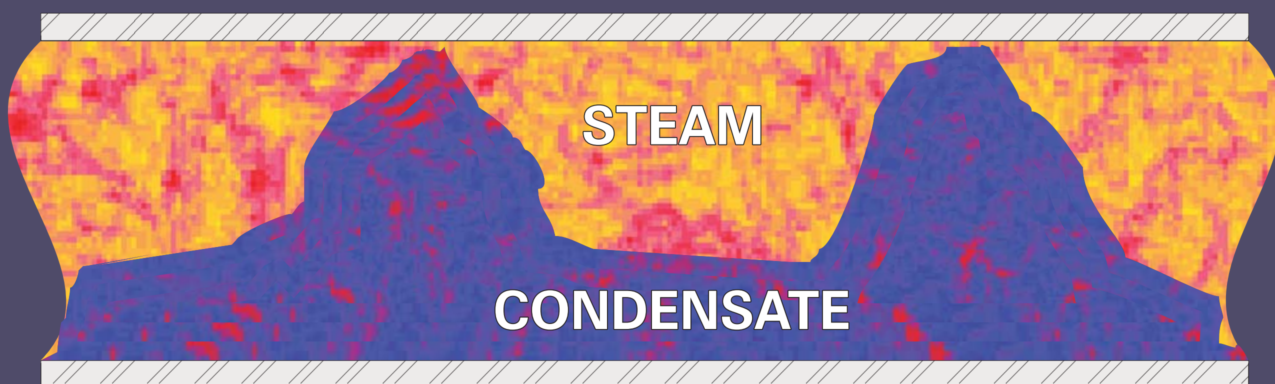
SET THE BOILER STEAM PRESSURE TO JUST HIGHER THAN THE SYSTEM LOSS

- The boiler operating pressure should be as low as possible for best system operation. Set the pressure so the last radiator in the system gets heat – no higher than necessary.
- Older two-pipe steam heating systems were usually designed with pipe sizes which would result in about 2 ounces per 100 feet of pipe pressure loss. One-pipe systems and vapor systems used larger pipes in order to limit the pressure drop even more.
- Higher than necessary pressures can cause problems with water seals in older systems and with systems which need a low "B" dimension.

Most steam heating systems work better at low pressure. Some systems, such as vapor systems won't work any other way.

Set the operating pressure as low as possible.

WATER HAMMER



STEAM TRAPPED BETWEEN WAVES CONDENSES, CREATING A VACUUM

THIS CAUSES THE WATER TO SLAM AGAINST THE PIPE, CAUSING BANGING AND MOVEMENT OF THE PIPING.

Many a steam system has gotten a bad reputation due to water hammer. It is a nuisance and can also damage components and even piping.

These tips might be helpful in locating the causes.

START-UP WATER HAMMER

- Check for sagging steam mains or not enough pitch in steam pipes and returns
- Look for concentric reducers in steam-carrying pipes and returns
- Check drip traps to make sure they are removing condensate and that they have enough static head on the inlet to drain condensate without pressure upstream
- If the new boiler has a water level higher than the old boiler, dry returns may now be partially wetted
- Can be caused by no drip line on the back side of a back-pitched motorized valve

These conditions cause water hammer soon after the boiler fires, mostly due to water standing in the pipes.

MID-CYCLE WATER HAMMER

- Check for clogged returns on gravity systems, causing water to back up the return riser into steam pipes or dry returns
- The boiler may be oversized, causing too high a flow in the steam lines and too much pressure drop, causing water to back up the riser into the steam pipes or dry returns
- Check near boiler piping and boiler water quality – problems here could cause wet steam to be carried to the system
- Check for defective steam traps, failed open, which allow steam to pass into the returns
- One-pipe large radiators may be vented too quickly – use two smaller vents, one mounted above the other

These conditions cause water hammer during the heating cycle, after the system has begun to make condensate.

MID-CYCLE WATER HAMMER

- There might be a long nipple at the Hartford loop, causing water hammer as the water moves up and down at this point
- Make sure the return line to the boiler feed system or receiver slopes continuously down to the tank. A water leg here will cause hammer and will also prevent proper venting of air.
- Make sure a "master" trap has not been added at the receiver or feed system. Double trapping will cause hammer in the pipe between the steam main drip trap and the trap at the tank.
- Pumping into a Hartford loop connection can cause hammer if the feed rate is too high and the equalizer isn't large enough.

Check the return line piping and boiler feed piping carefully.

Use a level to make sure the piping is sloped in the right direction.

MID-CYCLE WATER HAMMER

- Could be caused by no drip on the inlet side of a forward pitched motorized valve
- Pipe insulation may have been removed and not replaced. This will cause excessive condensate loads in the steam piping both at start-up and during operation. Replace the insulation on all pipes except those used for cooling the condensate (such as on drips trapped into thermostatic traps)

Always insulate the steam piping. Steam piping and components were almost always designed based on insulated piping.

Uninsulated piping is an energy waster and may cause excessive condensate loading and excess water in the steam lines.

SHUT-DOWN WATER HAMMER

- The close nipple at the Hartford loop may be too close to the water line, allowing steam to enter the horizontal line as the boiler shuts down and the water level drops. The top of the close nipple should be 2“ below the water line.
- If the pipe insulation is removed in the boiler room, but left in place in the building, the boiler room piping will pull a quick vacuum on shutdown as the steam condenses. The system piping is kept warm by the insulation and cools more slowly. This rapid vacuum will cause lifting of the boiler water into the header and bouncing of the water as well. Always insulate the steam pipes.

The boiler water level drops on shut down. This causes a bouncing water level in the equalizer line. If the Hartford loop connection is too close to the water line the horizontal connection can be exposed to steam during this time. Hammering will occur in the line.

Always insulate the steam piping.

HAMMERING IN THE BOILER

- On wet-base (forced draft or power fired) boilers, check the flame shape. Flame impingement on the sides or floor of the boiler will cause steam pockets and hammering. Placing a fiber blanket on the floor will often reduce or eliminate this problem if the flame is alright.
- Poor circulation in the boiler due to heavy sludge deposits or liming will cause hammer. Blow down the boiler and check water to see if sludge is present. Make sure the system isn't adding too much fresh water.
- Oversized tankless coils can cause a rapid drop and bounce in the boiler water line, causing hammering in the boiler.

Include periodic inspection of the flame and burner as part of the maintenance program for forced draft boilers. Recommend the burner be tuned up annually.

Install a water meter on the make-up line of every steam system. Excess make up water will cause liming and oxygen corrosion.

NO HEAT OR POOR HEAT DISTRIBUTION IN THE BUILDING

- Air may not be venting properly due to non-working air vents, particularly the steam main and riser air vents.
- Steam main and riser drip traps may be failed closed, preventing air elimination.
- Radiator traps may be failed open, causing steam to build pressure in the returns, preventing other traps from working.
- Make sure there are no water legs in the return piping on two-pipe systems.
- On systems which used water seals between the steam lines and returns, the boiler pressure may be too high, causing steam to pressurize the returns.

Check (and test if possible) all system traps, particularly the drip traps.

Make sure the return lines slope toward the receiver with no places for water to pocket.

SYSTEM OR BOILER OVERFILLING OR FLOODING

- The new boiler may be smaller than what it replaced and doesn't have enough storage volume, causing unnecessary feeder operation. A boiler feed system may be necessary.
- Boiler water feed rate may be too fast, causing water level collapse when feeding. Make sure the pump discharge pressure or feeder make-up rate is no higher than needed to keep up with the boiler. An electronic feeder may be needed to control feed rate.
- Foaming in the boiler due to poor water quality or incorrect near boiler piping will cause water carryover to the system and premature low water condition, causing unnecessary make-up.

System flooding often occurs because the boiler steaming time is shorter than than the time it takes for condensate to return from the system. On almost every cycle the water feeder will add fresh water to keep the boiler running. When the condensate does return the boiler floods.

EXCESSIVE BOILER WATER LEVEL BOUNCE

- Water level movement is normal in any steam system, particularly gravity systems, since the return condensate causes the pressure in the returns to vary.
- Water level will bounce excessively if the water is oily or dirty. The boiler must be cleaned and skimmed.
- Incorrect near boiler piping will cause rapid water level movement because of carryover to the header, sloped water lines or excessive velocity in the boiler risers.
- If the feed rate is too high from the pump or feeder, the water level will collapse as the feed comes on.

Check the near boiler piping and make sure the system water and the boiler are as clean as possible.

RAPID CYCLING

- Air vents or traps may not be venting properly, causing air to back up in the system. The boiler will then build pressure against this air pocket and cycle on the pressure control.
- The pressure differential may be too close on the pressure control.
- Water level bouncing can cause the water level control to have nuisance outages. Check water quality and near boiler piping.

If the air doesn't move out of the piping quickly enough, the pressure builds up. This causes the boiler to shut down on limit before heating ever starts.

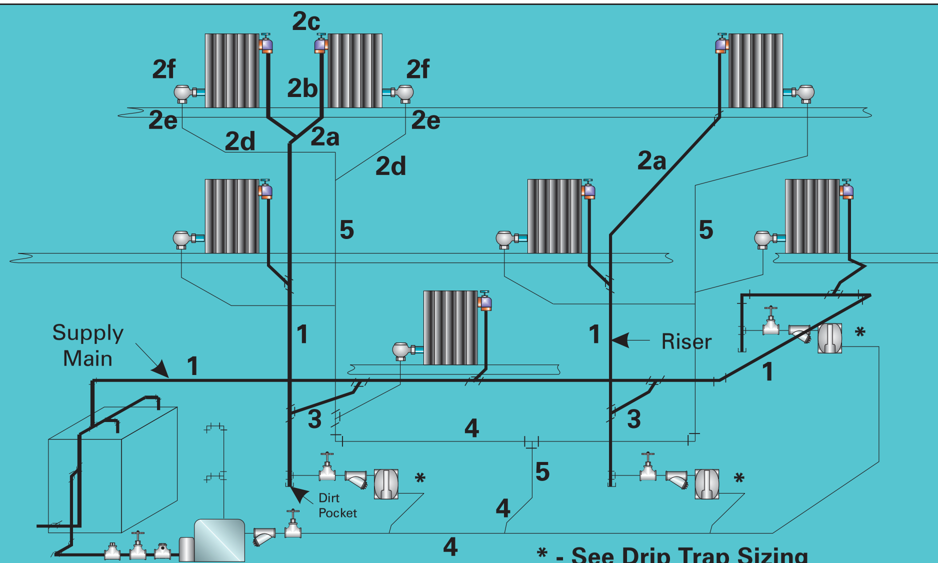
Definitions & Ratings

EDR = Equivalent Direction Radiation
= 240 BTUH per ft^2 EDR

Condensate PPH = EDR / 4

GPM Condensate = 1/2 gpm per 1000 ft^2 EDR
= 2 gpm per 1000 PPH
= 2 gpm per Million BTUH

PPH Steam = Given from & at 212° F
= 970 BTU per Pound Steam
= IBR Gross Output / 970



* - See Drip Trap Sizing

1 - STEAM MAIN & RISER CAPACITY, EDR - 3.5 PSIG PRESSURE							
Pipe Size	1 oz/100 ft	2 oz/100 ft	4 oz/100 ft	8 oz/100 ft	12 oz/100 ft	16 oz/100 ft	32 oz/100 ft
2"	432	648	936	1344	1680	1920	2840
2 1/2"	696	1032	1512	2160	2720	3120	4600
3"	1272	1860	2640	3840	4760	5520	7800
4"	2560	3800	5640	7920	9800	11520	16800
5"	4800	6720	9760	14280	17520	20400	30000
6"	7680	11280	15840	22800	28800	33600	47600
8"	15600	22280	32400	45600	58000	66000	96000
10"	28800	40800	60000	84000	104800	120000	170800
12"	45600	66000	93600	132000	164000	192000	271200

1 - STEAM MAIN & RISER CAPACITY, EDR - 12 PSIG PRESSURE							
Pipe Size	1 oz/100 ft	2 oz/100 ft	4 oz/100 ft	8 oz/100 ft	12 oz/100 ft	16 oz/100 ft	32 oz/100 ft
2"	536	776	1140	1640	2040	2360	3400
2 1/2"	860	1240	1840	2640	3280	3800	5480
3"	1520	2200	3240	4640	5720	6680	9600
4"	3200	4640	6760	9600	12000	13840	19600
5"	5720	8400	12000	17000	21000	24400	34400
6"	9200	13200	19400	28000	34400	40000	56800
8"	19200	28000	40000	57200	70800	82000	118000
10"	35200	50400	72800	104000	128000	148000	208000
12"	54800	78000	113600	160000	198000	230000	324000

2 - CONNECTIONS TO RADIATORS, PIPE SIZE						
Connection:	0-25 EDR	26-75 EDR	76-150 EDR	151-200 EDR	201-400 EDR	401-700 EDR
a - Supply Horizontal Run-out	3/4"	1"	1 1/4"	1 1/2"	2"	-
b - Supply Vertical Line	1/2"	3/4"	1"	1 1/4"	1 1/2"	-
c - Supply Valve Size	1/2"	3/4"	1"	1 1/4"	1 1/2"	-
d - Return Horizontal Run-out	3/4"	3/4"	3/4"	3/4"	3/4"	1"
e - Return Vertical Line	1/2"	1/2"	1/2"	1/2"	3/4"	1"
f - Return Trap Size	1/2"	1/2"	1/2"	1/2"	3/4"	1"

3 - RUNOUTS TO RISERS, CAPACITY IN EDR					
Pipe Size:	3/4"	1"	1 1/4"	1 1/2"	2"
	42.0	83.0	152.4	236.8	460.0

4 - DRY RETURN MAIN CAPACITY, EDR					
Pipe Size	1/2 oz/100 ft	2/3 oz/100 ft	1 oz/100 ft	2 oz/100 ft	4 oz/100 ft
1"	248	284	320	412	460
1 1/4"	520	596	672	868	964
1 1/2"	824	944	1060	1360	1512
2"	1880	2140	2300	2960	3300
2 1/2"	3040	3472	3800	4920	5440
3"	5840	6240	7000	9000	10000
4"	11720	13400	15000	19320	21520

5 - DRY RETURN RISER CAPACITY, EDR					
Pipe Size	1/2 oz/100 ft	2/3 oz/100 ft	1 oz/100 ft	2 oz/100 ft	4 oz/100 ft
3/4"	192	192	192	192	192
1"	452	452	452	452	452
1 1/4"	992	992	992	992	992
1 1/2"	1500	1500	1500	1500	1500
2"	3000	3000	3000	3000	3000

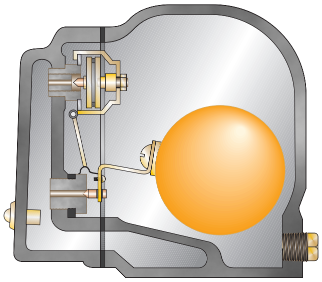
4 - VACUUM RETURN MAIN CAPACITY, EDR					
Pipe Size	2/3 oz/100 ft	1 oz/100 ft	2 oz/100 ft	4 oz/100 ft	8 oz/100 ft
3/4"	168	400	568	800	1132
1"	572	700	996	1400	1976
1 1/4"	976	1200	1707	2400	3392
1 1/2"	1552	1900	2696	3800	5360
2"	3260	4000	5680	8000	11320
2 1/2"	5440	6720	9520	13400	18920
3"	8720	10720	15200	21400	30240
4"	18000	22000	31240	44000	62000
5"	31520	38720	54800	77600	109200
6"	50400	62000	88000	124000	175200

5 - VACUUM RETURN RISER CAPACITY, EDR					
Pipe Size	2/3 oz/100 ft	1 oz/100 ft	2 oz/100 ft	4 oz/100 ft	8 oz/100 ft
3/4"	572	700	996	1400	1976
1"	976	1200	1704	2400	3392
1 1/4"	1552	1900	2696	3800	5360
1 1/2"	3260	4000	5680	8000	11320
2"	5440	6720	9520	13400	18920
2 1/2"	8720	10720	15200	21400	30240
3"	13000	16000	22720	32000	45200
4"	31520	38720	54800	77600	109200
5"	50400	62000	88000	124000	175200

EQUIVALENT LENGTH OF FITTINGS, FEET					
SIZE	ELBOW	TEE - SIDE OUTLET	GATE VALVE	GLOBE VALVE	ANGLE VALVE
1/2"	1.3	3	0.3	14	7
3/4"	1.8	4	0.4	18	10
1"	2.2	5	0.5	23	12
1 1/4"	3.0	6	0.6	29	15
1 1/2"	3.5	7	0.8	34	18
2"	4.3	8	1.0	46	22
2 1/2"	5.0	11	1.1	54	27
3"	6.5	13	1.4	66	34
4"	9	18	1.9	92	45
5"	11	22	2.2	112	56
6"	13	27	2.8	136	67
8"	17	35	3.7	180	92
10"	21	45	4.6	230	112

SIZING DATA EXCERPTED FROM "HOFFMAN STEAM HEATING SYSTEMS" DESIGN MANUAL AND ENGINEERING DATA - ITT CORP - 1981

FULL-COLOR TRAINING GUIDE SERIES



TWO-PIPE STEAM & PUMPED RETURN

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CHTS796 R5 (1/08-1M)