CHAPTER FOUR

Air Out

Why Venting All the Air from the Piping and Radiation Is Important

Steam and air cannot occupy the same space, therefore air must be vented from the radiation and the piping before steam can enter.

- Steam pressure could compress the air, but only with pressures not used in normal heating work.
- Air bound systems waste money trying to heat.
- The rate at which the air is removed is the rate at which the steam enters the radiation.

Fig. 1 Venting should be done at a rate that does not create any back pressure at the boiler, this is especially important with vapor systems.

- Back pressure at the boiler can cause the burner to shut off on the pressure control setting during a run cycle.
- This short cycling of the burner causes uneven heating and high fuels bills.

Fig. 2 Venting needs to be done at both the radiation and the ends of the mains. For one pipe work vent the supply main, while for two pipe work, vent both the supply and the return mains.

- In theory, the main vent on the supply main causes steam to first flow to the end of the main, then into the takeoff to feed the radiation at a uniform rate.
- Once steam is established the length of the main, the farthest radiators will receive steam as quickly as those close to the boiler.

Fig. 3 The ideal air vent, if on the radiator or the piping, will eliminate air from the system at a rate consistent with best results (too fast causes spitting, too slow causes uneven heating) and to close the vent port when steam or water is present.

- Most vents are designed for closure to both steam and water.
- Some "Quick Vents" are designed to close only to steam, not to water. These should be used only at high points of systems where water will not be present.

The ideal burner run cycle during a "call for heat" is one that is not interrupted by the high pressure limit.

- By not removing the air from the system at a fast enough rate, pressure will build up in the system and open the contacts on the high limit to shut off the burner.
- This type of short cycling wastes fuel and causes uneven heating.
- Refer to page 84 for sizing the vent to prevent short cycling.

Fig. 1

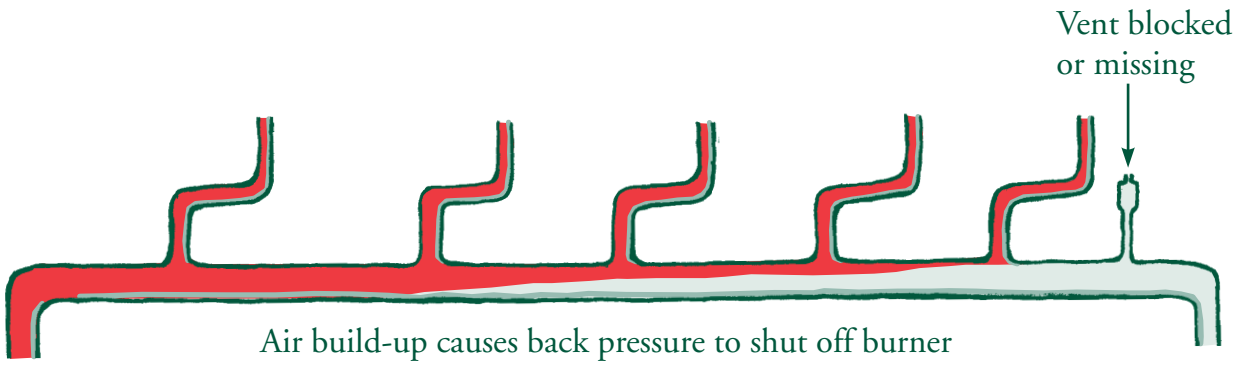


Fig. 2

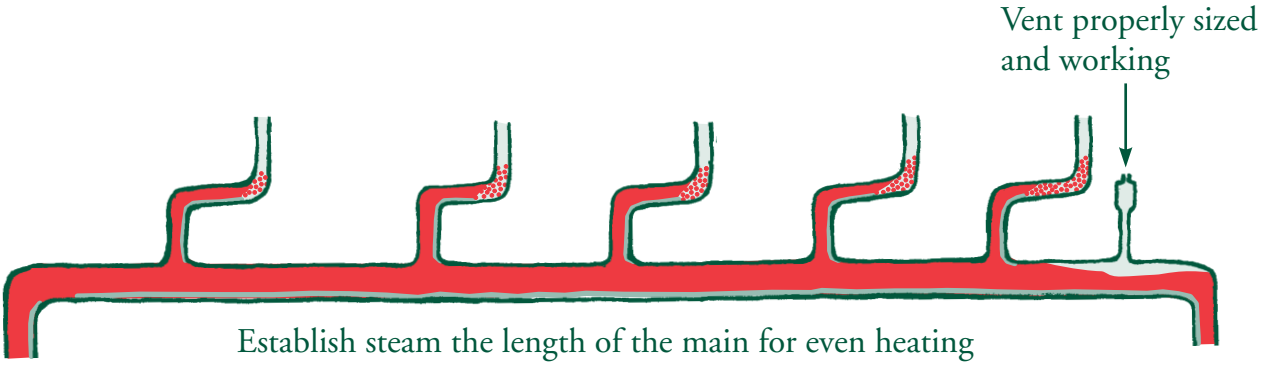
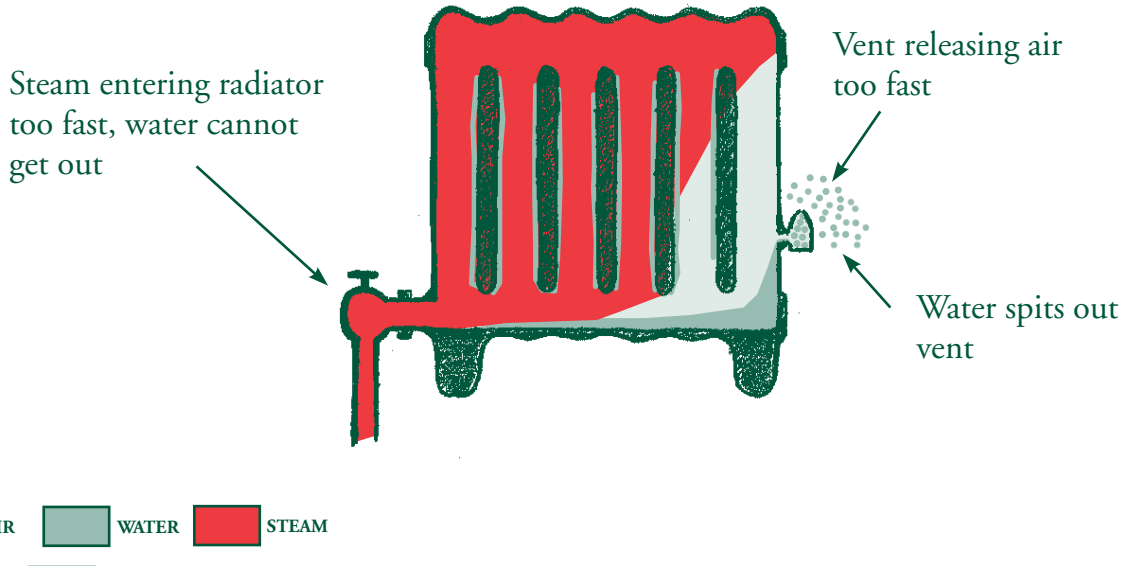


Fig. 3



Follow the Path of Air Out of the System

Air fills the radiation and piping at start-up.

- **Air** must be pushed or pulled **out** of the system so that **steam** can fill it **up**.

Air in the near boiler piping and supply mains is forced to the end of the steam supply main by the flow of the steam.

- **Fig. 1** Air typically leaves the supply main through the main air vent.
- **Fig. 2** Air can also pass to the dry return on two pipe systems by a radiator trap installed above the main.
- **Fig. 3** End of supply main F+T traps can be used to pass air to a vented condensate, boiler feed, or vacuum unit.

Air in the run outs and upfeed risers is forced into the radiation.

- **Fig. 4** In a one pipe radiator the air is forced through an air vent to atmosphere or through an air valve to a vacuum pump or central venting point.
- **Fig. 5** In a two pipe radiator the air is forced through the trap to the dry return, where it is vented to atmosphere through a main vent or to a vacuum pump.

In systems with a vacuum pump, the air is drawn to the vacuum unit and vented to the atmosphere.

- Vacuum units do a great job of air removal, therefore creating better steam distribution.
- Vacuum units pull the air quickly through the mains and radiation to allow the steam to flow quickly and evenly.

Follow the Path of Air Out of the System

Fig. 1

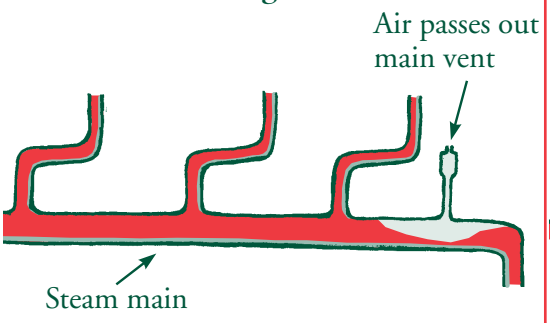


Fig. 2

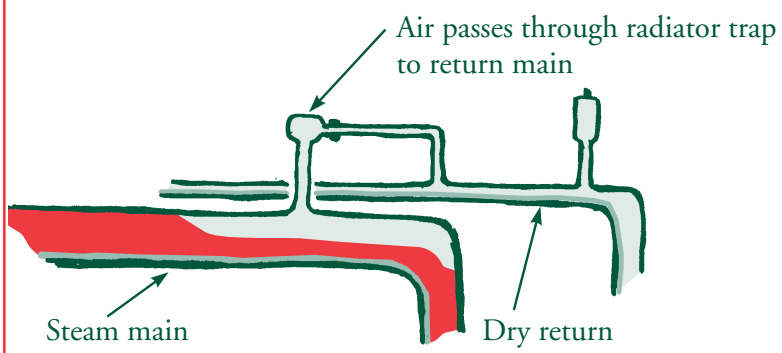


Fig. 3

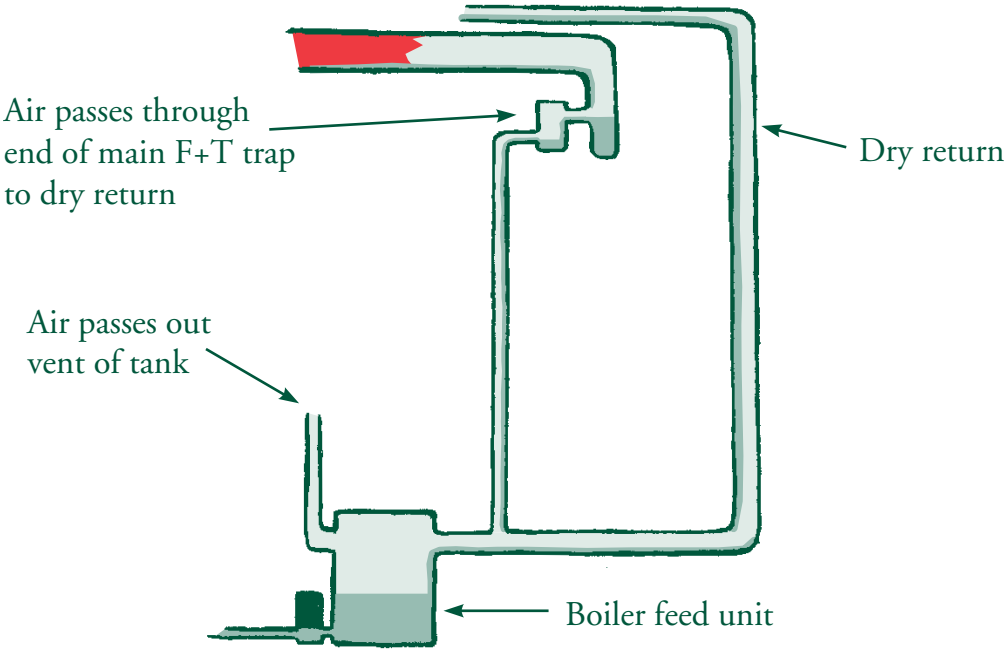


Fig. 4

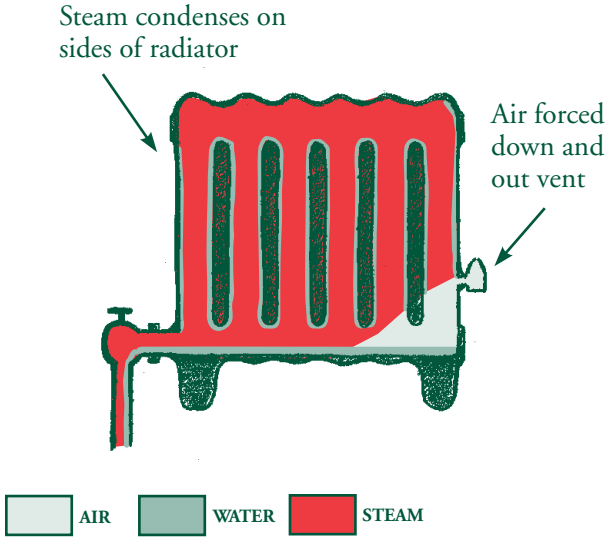
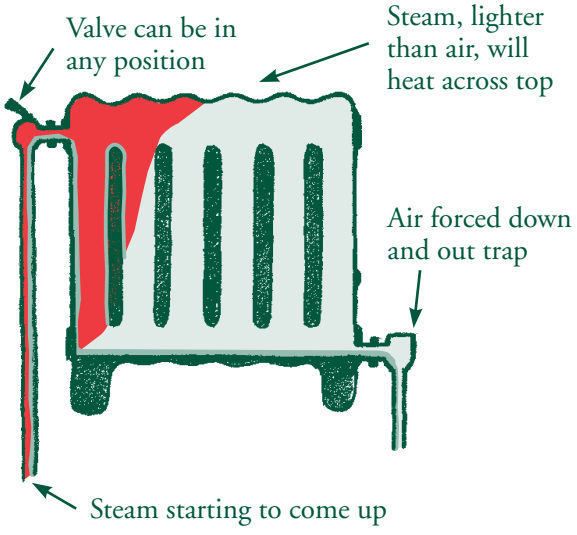


Fig. 5



Venting One Pipe Steam

Fig. 1 One pipe steam systems need vents at both the radiators and the ends of the steam main to allow even heating.

- Using vents on the radiator alone can cause radiators closest to boiler to heat faster than those radiators farthest from the boiler.
- If the thermostat is located near the boiler, the far ends will be cold.
- If the thermostat is located away from the boiler, the area closer to the boiler will be too hot.
- If the main vent is not large enough, uneven heating will result. Refer to page 84 for main vent sizing,

The ideal automatic air vent for a radiator on a one pipe steam system will eliminate air, close instantly for steam, and not allow water to leak or spit.

- The vent should be open to allow air to pass freely from the radiator.
- At the presence of steam, the vent should instantly close the vent port, containing the steam in the radiator.
- As this steam condenses in both the body of the vent and the radiator, the vent should not allow this water to escape through the vent port.
- The tongue of the vent allows the water to flow out of the vent.

Fig. 2 Too fast a venting rate of the radiator vent can force water to the vent end of the radiator, because the velocity of the steam is entering the radiator too fast.

- Forcing water to the wrong end of the radiator keeps it from flowing out of the radiator.
- Too much water can close the vent with its float action, preventing any more air to leave or steam to enter.
- The high velocity of too fast a venting rate can cause any water present to be picked up and vented out with the air instead of flowing out of the radiator valve.

Fig. 1

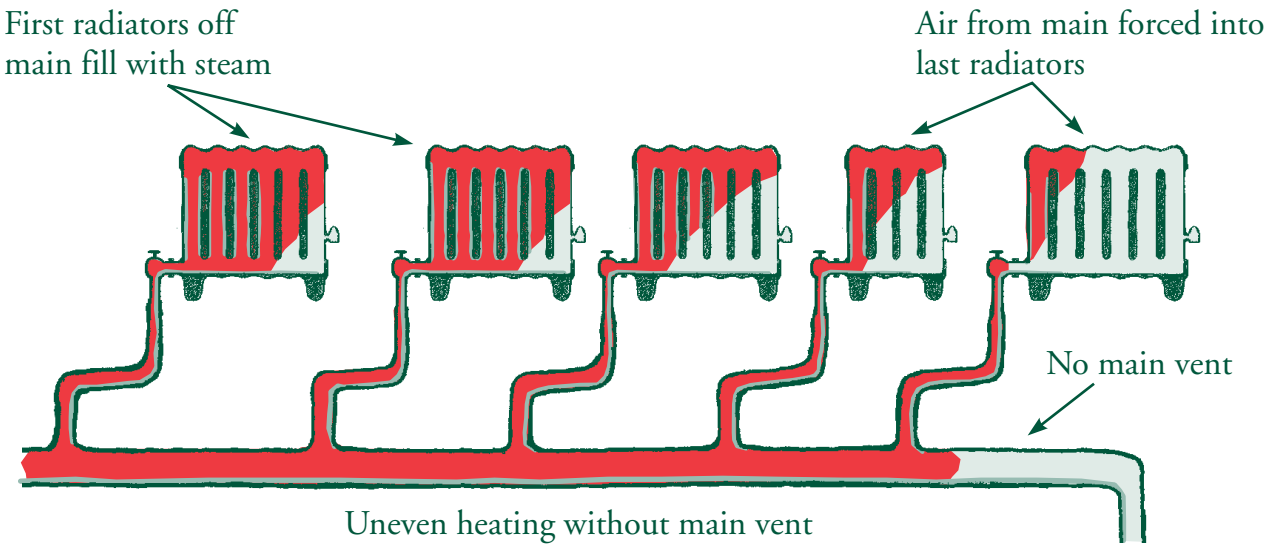
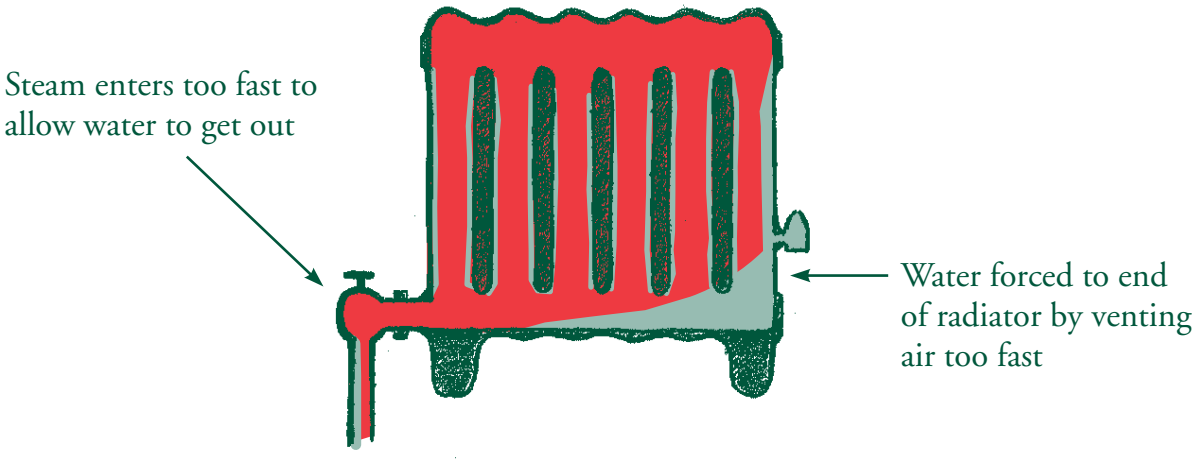


Fig. 2



AIR WATER STEAM

Venting One Pipe Steam, continued

Some vents are available with an adjustable vent rate feature.

- The vent port size can be made smaller to slow the venting rate, or made larger to speed up the venting rate.
- Adjustment can be made to compensate for location or size of the radiator.
- A large radiator may need a faster venting rate than a smaller radiator.
- A radiator at the end of the main may need a faster venting rate than a radiator at the start of the main.

Fig. 1 Radiator vents have a rating called drop-away pressure.

- The drop away pressure is the steam operating pressure that the vent can open against.
- If the steam pressure in the system is greater than the drop away rating, the vent will remain closed and no more steam will enter.
- Adjustable or quick vents can have a low drop-away pressure. Be careful with their application.

Fig. 2 One pipe steam systems with cast iron radiators work best if all the radiator vents are the same model from the same manufacturer venting at the same rate.

- A consistent venting rate proportions the steam flow throughout the supply piping
- Large radiators can be drilled and tapped to have two vents.
- With two vents, twice the volume of air is removed, but at the same rate as the rest of the system.
- Two vents can prevent water from spitting, while filling the radiator with steam.

Fig. 3 The venting rate can be controlled by a thermostatically controlled air vent.

- The actuator reacts to the temperature of the room.
- It will keep the vent open, allowing steam flow into the radiator, when the room cools down.
- It will shut off the vent, stopping the flow of steam into the radiator, when the thermostat is satisfied.

Fig. 1

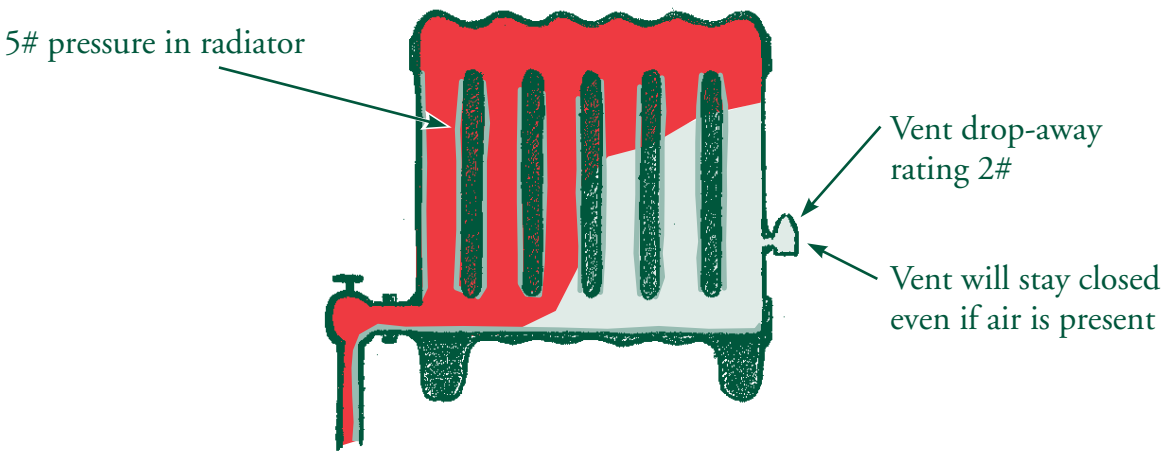


Fig. 2

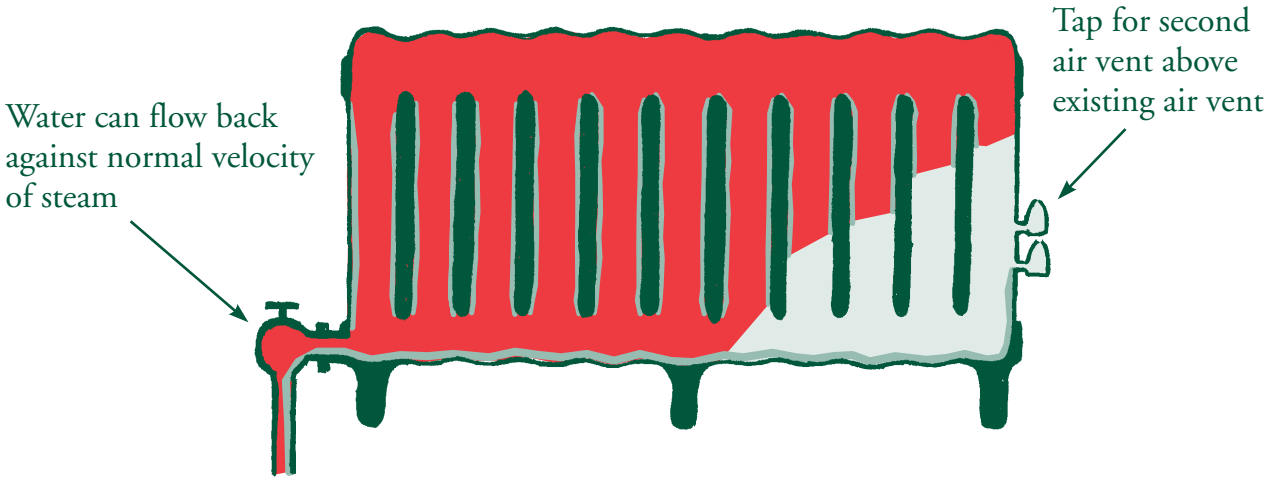
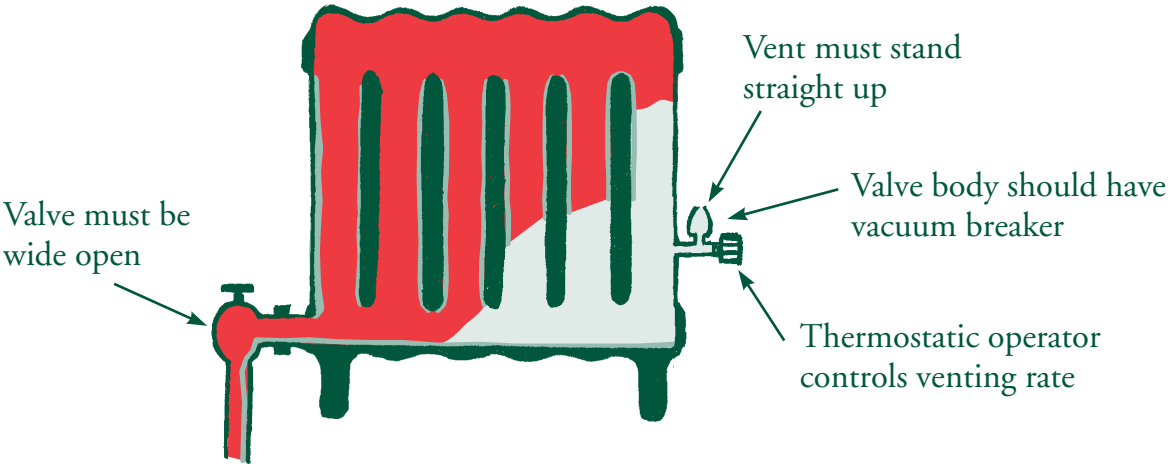


Fig. 3



AIR WATER STEAM

Venting One Pipe Steam, continued

Fig. 1 Vents used on coal-fired systems had a built-in check valve to prevent air from re-entering the system.

- The system would go into a vacuum as the steam condensed and closed the check valves.
- The vacuum would allow the boiler to continue making steam as the coal fire died down during the night. See page 169 for vacuum /temperature relationships.
- Today's systems don't use the vacuum vents because they operate with burners that are on-off, which prevent the formation of a vacuum at burner shut-off.

Fig. 2 The old coal-fired systems were slow to make steam.

- The air had more time to leave the system since the steam came up slowly.
- Modern boilers produce steam more quickly, so in order to heat evenly, more main vents may need to be added to the system.
- See page 84 for vent sizing guidelines.

Fig. 3 One pipe steam up flow systems in tall buildings will have vertical risers that feed many radiators, often several per floor.

- This vertical riser is similar to the horizontal mains in the basement in that it needs a main air vent.
- The top of the riser air vent will allow steam to flow up the length of the riser to fill it.
- Steam will then be available both at the top and bottom of the building at about the same time, giving more even heating.

Fig. 1

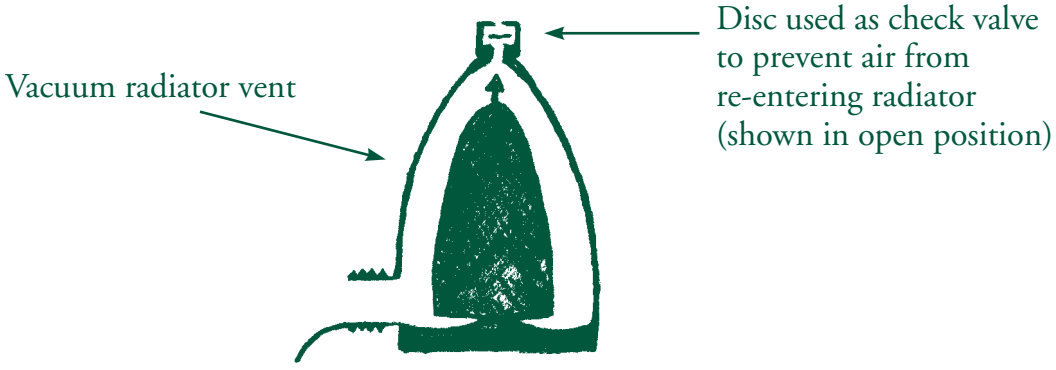


Fig. 2

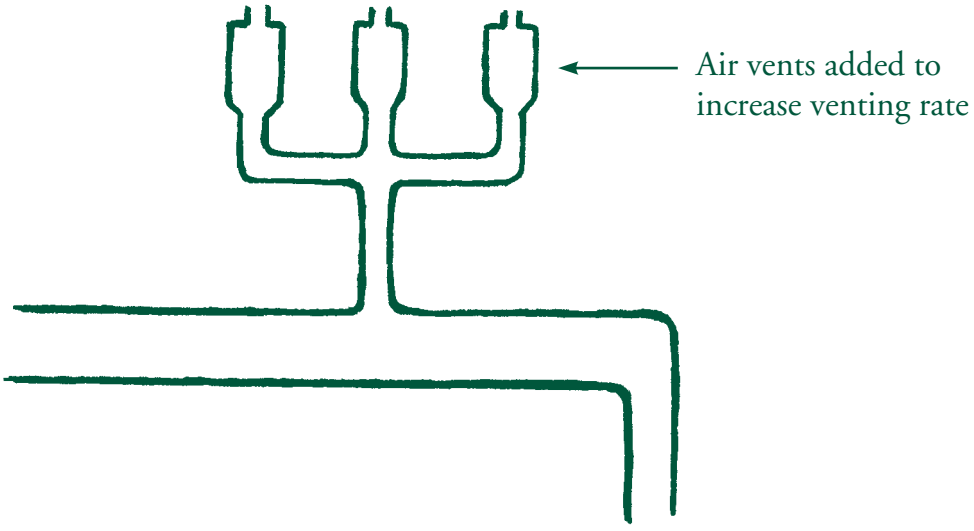
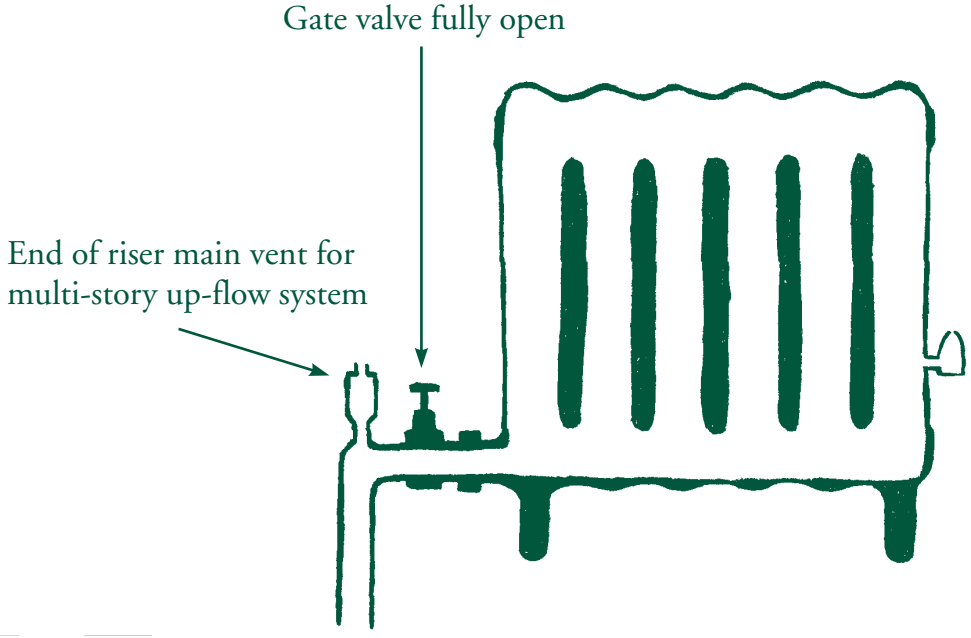


Fig. 3



Venting Two Pipe Steam

Fig. 1 The end of steam main air vent in two pipe systems are just as important as in one pipe systems.

- The end of the main vent gets steam to the radiation takeoff farthest from the boiler at about the same time as the radiation takeoff closest to the boiler.
- Without an end of main vent, pressure can build up in the boiler since the steam has less space to occupy because the air is blocking steam flow in the piping.
- Short cycling, uneven heating, and high fuel bills will be caused by removal, blockage or under sizing of the main vent.
- Refer to page 84 for main vent sizing.
- Air vents are sometimes removed because they're leaking and replaced with a pipe plug. Look at the end of all mains to follow the path of the air. If you find a roadblock like a pipe plug, remove and replace with the proper size air vent.

Fig. 2 Some two pipe steam mains use radiator style traps at the end of the supply main to vent the air over to the return main.

- These traps will be located above the mains, connecting the supply and the return mains.
- Air and steam, not water, travel from the end of the supply main to the trap.
- The trap passes the air and closes at the pressure of steam to prevent steam from entering the return line.
- On these types of systems, air passed to the return main flows all the way back through the dry return to be eliminated from the system at the main vent located in the boiler room.

Fig. 3 Air in the radiator of the two pipe system passes through the radiator trap or vapor device to the return line.

- Air will be vented from the system at the end of the return main with a main vent where the dry return ends at its connection to the wet return.

Fig. 1

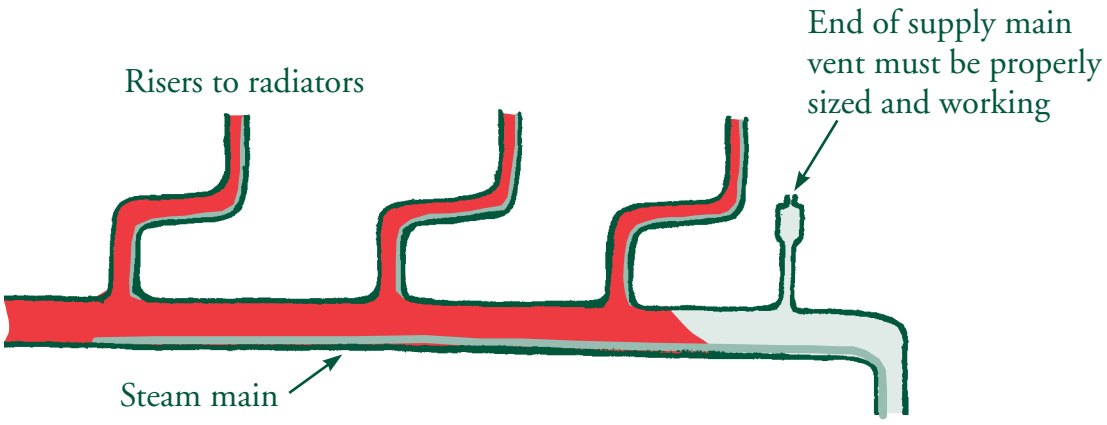


Fig. 2

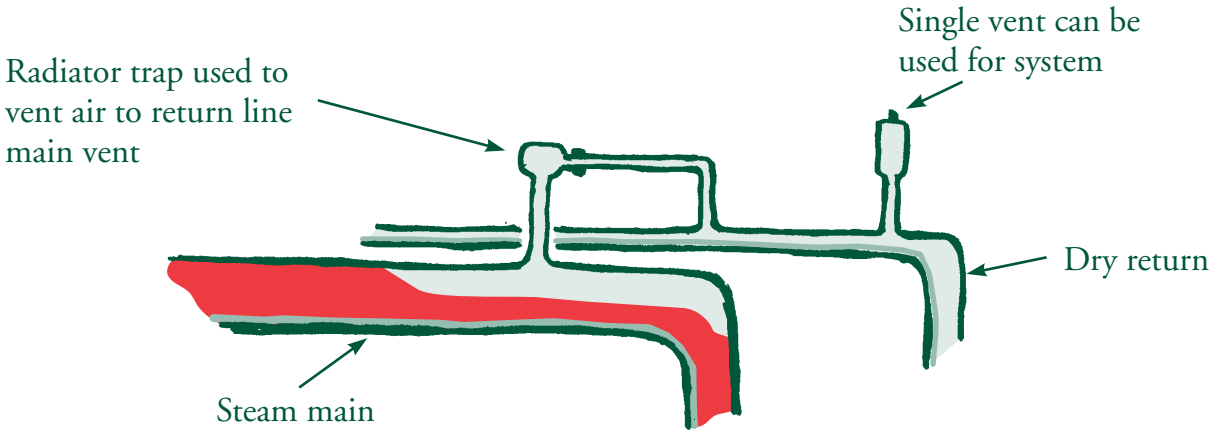
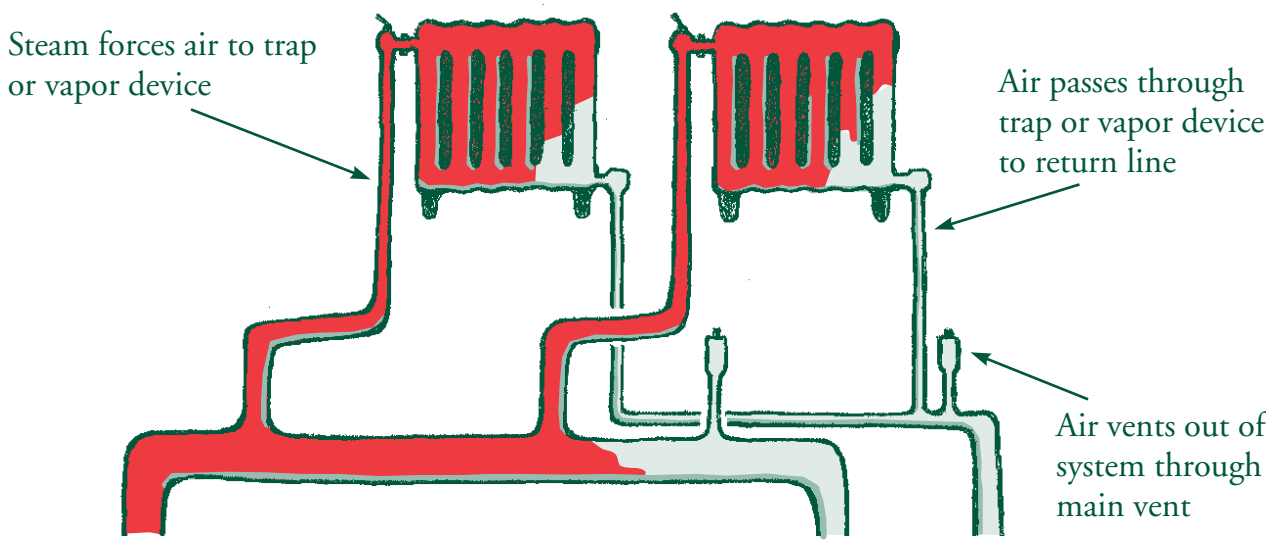


Fig. 3



AIR WATER STEAM

Venting Vapor Systems

Vapor systems, operating on ounces of pressure instead of pounds of pressure, require a large main venting capacity.

- If any back pressure from slow removal of air from system occurs, the pressure in the boiler will quickly rise above the pressure control high pressure setting.
- This nuisance shut off will result in poor steam generation, uneven steam distribution, and high fuel bills.
- Modern steam vents do not have the same venting capacity as vents made specifically for vapor systems.
- **Fig. 1** Adding a second or third main vent at the same location will increase the venting rate, keeping pressure from building up in the system.
- See page 84 for vent sizing guidelines.

Fig. 2 Vapor systems were typically two pipe systems with vapor devices instead of traps.

- Air passes out of radiator through the vapor device to be vented from the system at a main vent.
- The radiator inlet valve only allows as much steam in the radiator as it can condense. No steam should pass through the vapor device.

Some old vapor systems had dry returns connected to the chimney, without using any main vent.

- The end of the return main would be piped through a radiator in the ceiling of the boiler room.
- The purpose of the radiator was to condense any moisture or vapor left in the air.
- The pipe would then be carried into the chimney to induce a slight vacuum on the return from the draft of the chimney.
- The vacuum would pull the air out of the system to speed up the flow of steam, resulting in better economy and more even steam distribution.

Fig. 1

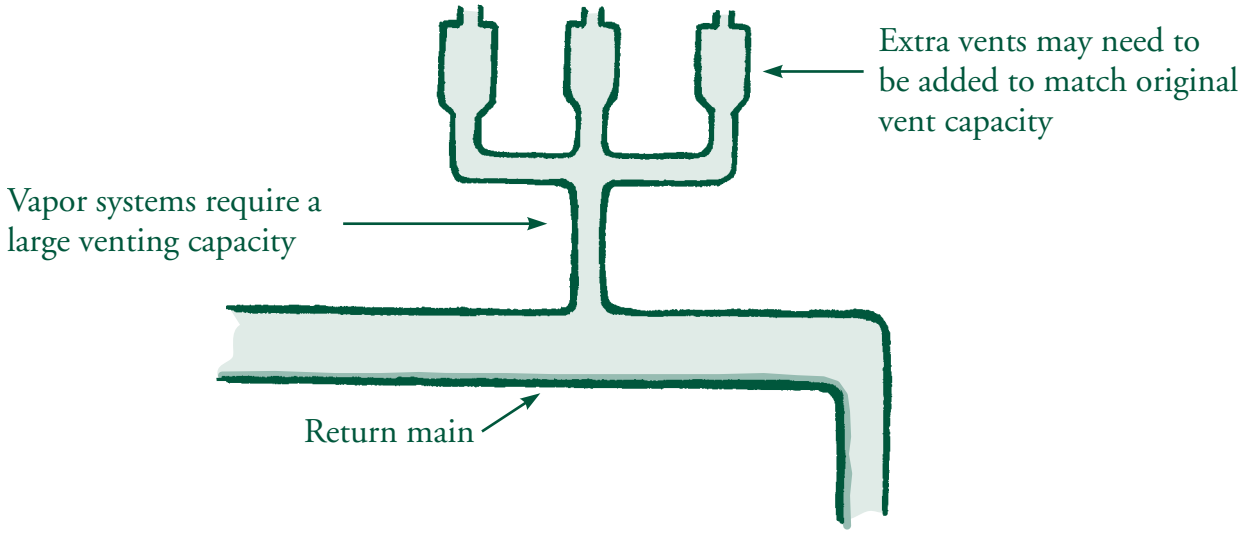
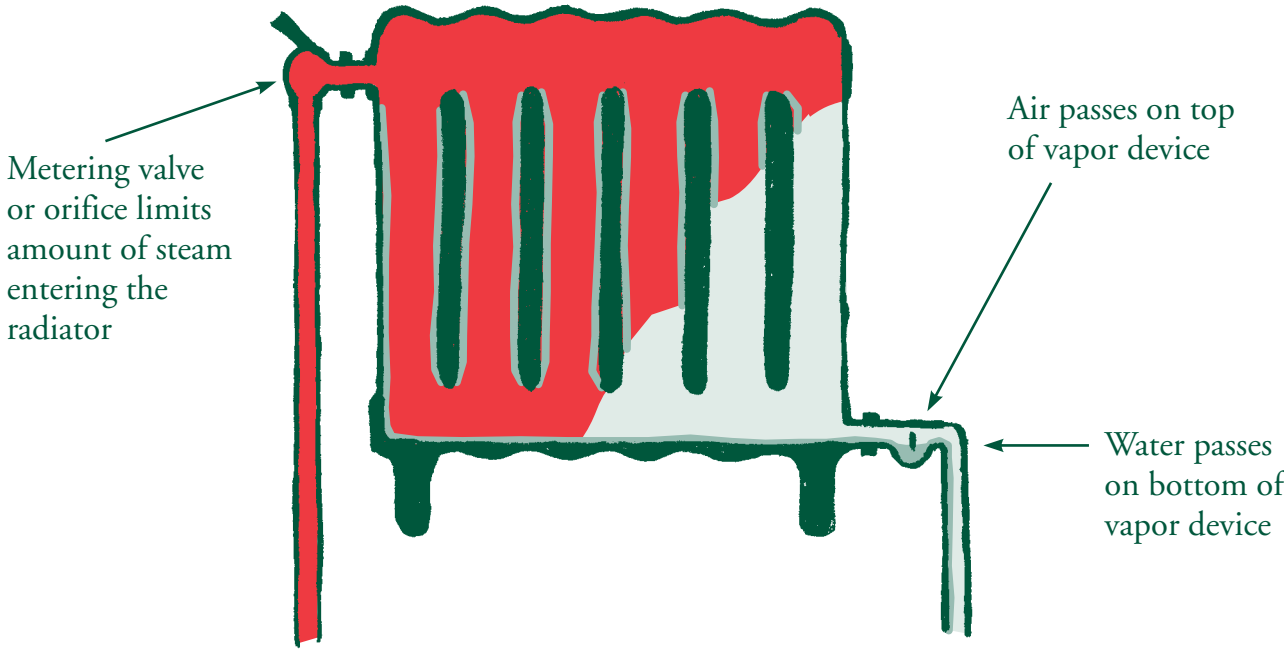

Extra vents may need to be added to match original vent capacity
Vapor systems require a large venting capacity
Return main

Fig. 2


Metering valve or orifice limits amount of steam entering the radiator
Air passes on top of vapor device
Water passes on bottom of vapor device
AIR
WATER
STEAM

Traps as Air Vents

Fig. 1 Thermostatic (radiator) traps are used as the supply main vent in some two pipe systems.

- The trap is piped between the supply main and dry return.
- Usually it's right up against the ceiling and hasn't been serviced for years.
- If it's stuck closed, the radiation off that main will not heat properly.
- If it's stuck open, steam gets into the return side and causes water hammer and uneven heating.

Fig. 2 F+T traps are used as the supply main vent when using vented (open) receiver tanks on condensate pumps and boiler feed pumps.

- The thermostatic element in the F+T trap passes air through to the vented tank.
- The piping from the discharge side of the F+T trap to the inlet of the receiver tank must pitch downhill.
- Watch out for water traps between the F+T trap and the inlet to tank, air cannot pass through the water.
- Install air vent on discharge side on F+T if water flows into receiver tank through a water trap. See page 163, Figure 2.

Don't trap multiple end of supply mains with one trap.

- Always use a separate trap for each main.
- Unequal steam pressures where multiple mains combine will create uneven circulation and heating.

Bucket traps make poor air vents.

- Bucket traps are designed for process work and do a poor job of venting air at start up.

Fig. 3 Radiation needs to be trapped individually.

- Air passes through radiation and then through trap.
- Use air vent on discharge side of radiation but before trap and check valve when lifting condensate.

Fig. 1

Radiator trap used to vent air from supply main to main vent on return

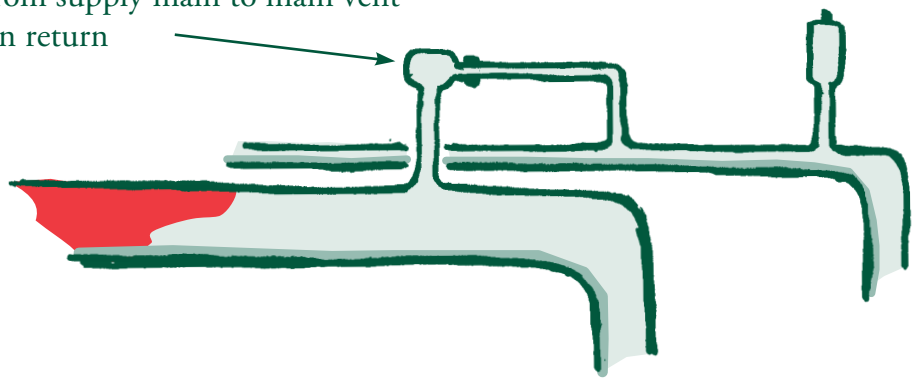


Fig. 2

F+T traps used to vent air from supply main to vent of receiver tank

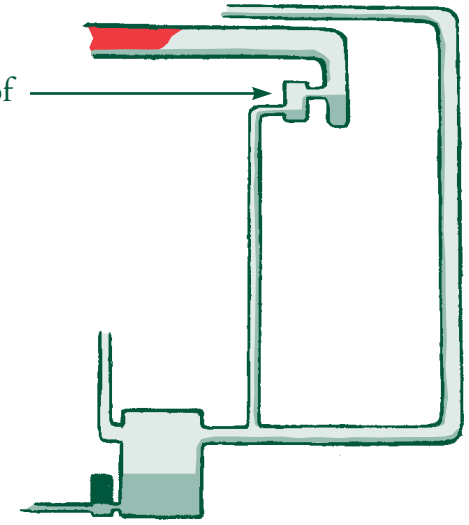
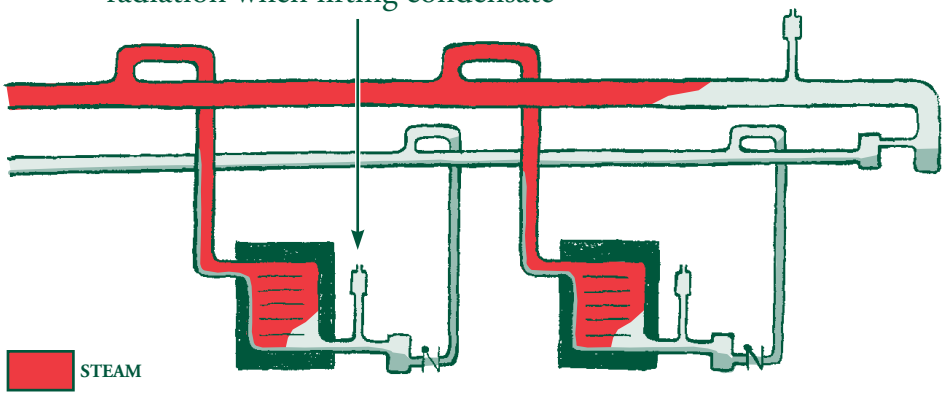


Fig. 3

Air vent required on each piece of radiation when lifting condensate



Using Vacuum for Air Removal

Negative pressure in a steam system, a vacuum, can be highly effective for air removal.

- The negative pressure draws the air from the system ahead of the steam.
- The negative pressure is applied to the return side after the traps or air valves.

Vacuum can be applied to either a one pipe or two pipe system.

- **Fig. 1** The vacuum on a one pipe system is applied to the discharge side of a special air vent called an air valve.
- A 1/4˝ or 3/8˝ line extends from the air valve through the building to a central vacuum unit in basement.
- **Fig. 2** The vacuum on a two pipe system is applied to the discharge side of the traps.
- The return pipes can be sized smaller than with a gravity return system because the negative pressure helps overcome the pressure drop in the return line.

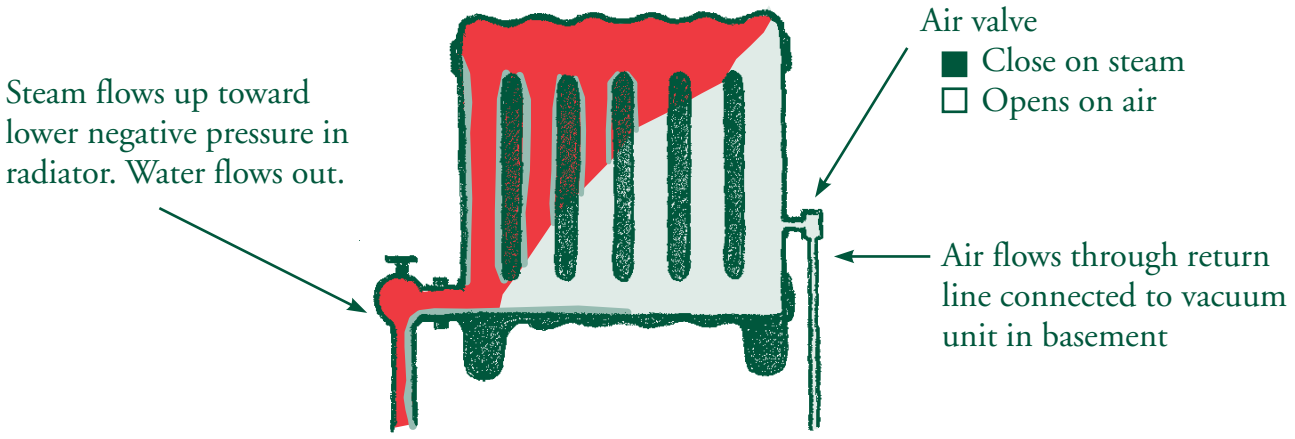
Vacuum can be naturally induced.

- The condensing action of the steam inside the radiation creates a natural vacuum that draws in more steam.
- The draft of the chimney was used for a naturally induced vacuum in some systems.

Electrically driven pumps have been designed to mechanically induce a vacuum.

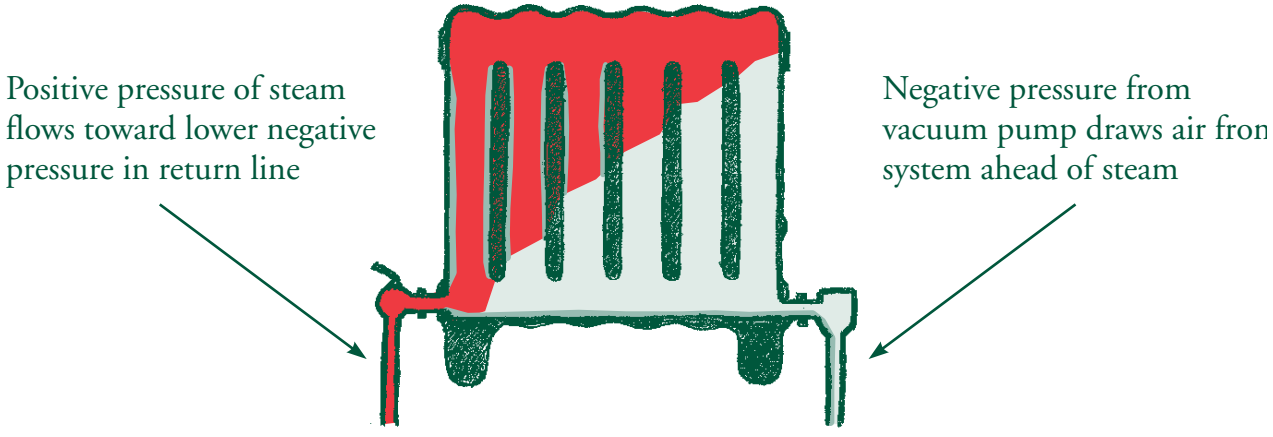
- The amount of vacuum can be adjusted and is controlled by a vacuum switch on the pump unit.
- Air is vented out of the unit to atmosphere through an open pipe.

Fig. 1



One pipe radiator at start of steam cycle

Fig. 2



Two pipe radiator at start of steam cycle

AIR WATER STEAM

Sizing and Piping Main Air Vents

Main air vents have rated capacities that need to be matched to system size to be able to vent all the air from the main.

- Check with manufacturers specs for air removal ratings in Cubic Feet per Minute (CFM).
- Venting rates of main air vents have changed through the years.
- If using a single vent on a one pipe system, it must be able to relieve the air capacity of the whole supply piping system.
- If using a single vent on a two pipe system, it must be able to relieve the air capacity of the supply piping system and the radiation.
- If multiple vents are used on multiple steam mains, each must be able to relieve the capacity of that main.
- Using more than one vent at one location may be required to provide even heat.

Refer to Fig. 1 for help determining the air capacity of the mains.

- Measure the pipe size and length of the main.
- Find the capacity at the intersection of the pipe size and length.
- Divide the approximate capacity by the venting rate of the vent being used to estimate how long it will take to clear the main.
- Refer to the example on the opposite page to see the effect the number of vents makes.

Fig. 2 All supply main air vents should be piped to protect them from water hammer damage.

- Vents should be located after the last takeoff but at least 15˝ before the end of the main.
- Vent should be at least 6˝ above the main.
- If the only tapping available is at the end of the main, protect the vent from water hammer by installing elbows between main and vent.

Fig. 1

How to Size Main Vent

Air Capacity of Black Pipe (in cubic feet)

	Length							
Pipe Size	25	50	75	100	150	200	250	300
1½	0.36	0.71	1.07	1.42	2.13	2.84	3.55	4.26
2	0.58	1.17	1.75	2.33	3.50	4.66	5.83	6.99
2½	0.83	1.66	2.49	3.32	4.98	6.64	8.30	9.96
3	1.28	2.57	3.85	5.13	7.70	10.26	12.83	15.39
4	2.21	4.42	6.63	8.84	13.26	17.68	22.10	26.52
5	3.47	6.95	10.42	13.89	20.84	27.78	34.73	41.67
6	5.02	10.04	15.06	20.08	30.12	40.16	50.20	60.24
8	8.87	17.73	26.60	35.46	53.19	70.92	88.65	106.38

Shaded areas require more than 4 minutes to vent all air with typical main vent at rate of 1.4 cubic feet per minute.

Example of Vent Sizing

- A 4″ main 200 feet long contains 17.68 cubic feet of air.
- One common main air vent passes 1.4 cubic feet of air per minute.
- 17.68 cubic feet divided by 1.4 cubic feet per minute equals about 13 minutes.
- Three vents at 1.4 cubic feet per minute equals 4.2 cubic feet of air per minute.
- 17.68 cubic feet divided by 4.2 cubic feet per minute equals about 4 minutes.

Fig. 2