

Drawing 23

Shown above and on pages 63 and 64 are drawings of two-pipe vapor air vent systems. These drawings show steam systems in two two-story buildings. One system has a dry return and the others are modified systems with wet returns. These steam systems are governed by the same rules as one-pipe steam systems. Two-pipe vapor vent systems typically operate at 4 to 16 ounces of steam pressure. Low operating steam pressure was made possible because these steam systems were designed with large steam and return pipes. The larger piping permitted the steam systems to operate at low velocities (steam flowing less than 15 to 25 feet a second). Additionally, larger radiators were used because steam temperatures at one pressure 1 psig or less range from 212 to 215 degrees.

To keep the steam velocity in a steam piping system low, system designers designed the steam heating systems with low pressure drops. Low pressure drops permitted steam to circulate with steam pressures as low as 4 ounces. Remember, a building that requires 1,000 EDR of steam needs 250 pounds of evaporated water per hour or 4.16 pounds of evaporated water per minute to heat the building. Each pound of water (steam) at 0 psig occupies 25 cubic feet of space. When a steam piping system is designed, the operating pressure usually will not exceed twice the pressure drop. A piping system with an eighth of a pound pressure drop needs $\frac{1}{4}$ of a pound (4 ounces) of steam pressure to overcome the frictional resistance of the piping. The cubic feet of steam supplied to heat a building is a finite number and the total cubic feet of steam is calculated to heat a building on the coldest days of the year.

A tip: to help recognize if an old steam system can operate at a pound or less steam pressure, a steam main looks much larger than needed, and the building is equipped with large radiators. This tip is the beginning of an exercise or a reverse engineering project. See the example:

Example: A building has a steam boiler and a $2\frac{1}{2}$ -inch steam main with $1\frac{1}{4}$ -inch riser and operates at 1-2 psig. The boiler supplies 1,000 EDR or 250 pounds of evaporated water (steam) at a velocity of 40 feet per second or 2,400 feet per minute. This building has a total heating load of 700 EDR (radiators) plus 300 EDR of steam to overcome the heat loss and the frictional resistance of the piping. Additionally, in some old steam heating systems, steam riser and return

piping were usually 1¼-inch pipe or greater, and the radiator inlet and outlet piping connections were 1 inch or larger. Larger piping held more cubic feet of steam and permitted a steam system to operate at low velocities.

Steam temperatures vary in steam systems. Suppose a steam system operates at 2 psig, suppose the burner for a boiler is set to shut off at 2 psig and start again at 0 psi, the temperature of the steam will vary from 212 to 219 degrees F. If this heating system *was a gravity return steam vacuum system*, operating steam pressure would vary from about 15 inches Hg to 2 psi. This would result in steam temperatures fluctuating between 180 and 219 degrees Fahrenheit. Due to the lower steam temperatures, larger radiators were needed. In this gravity vacuum system, the added radiation increased the heating load nearly 300 EDR for the radiators, plus 50 EDR for the piping pickup factor. By increase from 1,000 to 1,350 EDR, the 2½-inch steam main must be changed to 3 inches.

To control boiler operating steam pressure, a pressure controller is needed. In the very late 1800s, pressure controllers were mechanical devices. Mechanical devices were used because most buildings did not have electricity. Two methods were used to control steam pressure at the boiler:

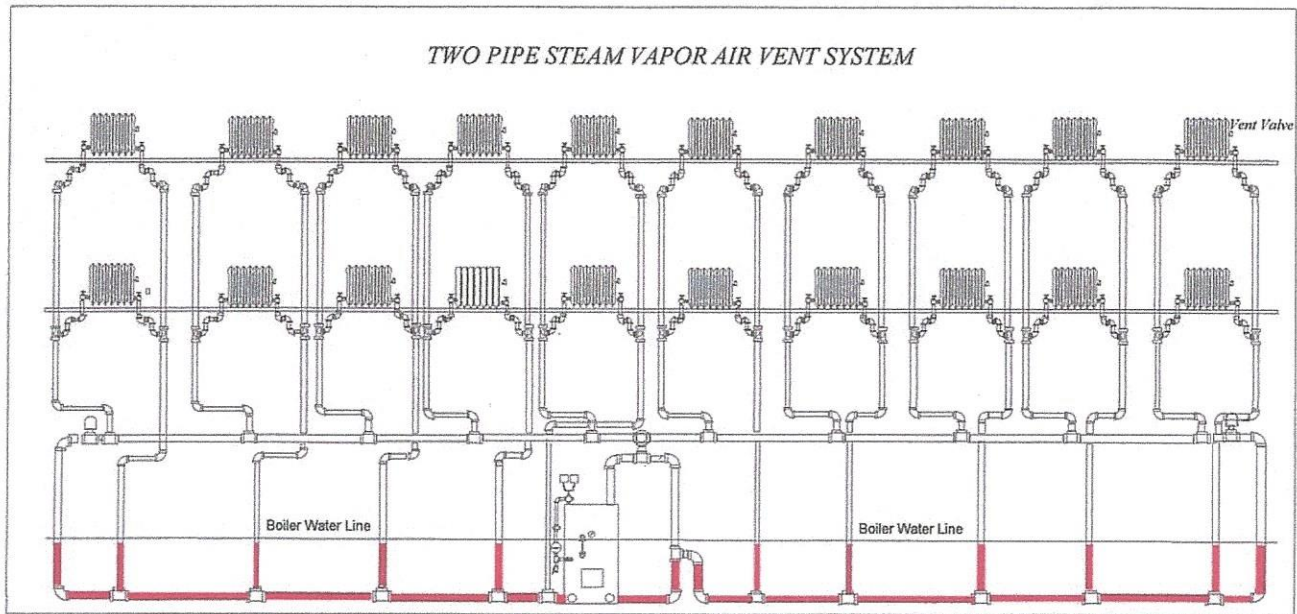
A cylindrical open condensate receiver was installed with the boiler trim. The bottom of the receiver was piped to the bottom tap of the boiler. This receiver was equipped with a heavy copper ball, chain, and linkages connected to an air supply damper at the bottom of the firebox. When the boiler made steam pressure, water was pushed out of the boiler into the receiver. The copper ball in the receiver rose, the chain slackened, and the air inlet damper dropped, which, in effect, automatically banked the coal fire. That action restricted air flow into the firebox and caused the coal fire to cool. Because less heat was supplied to the boiler, the steam pressure dropped. Two boiler companies that used this type of contrivance were the VECO (Vapor Engineering Company) and the Broomell Company.

A balanced steam pressure regulating valve was installed on the steam main or into the top of the boiler. This steam regulator had a lever, weights, and a chain connected to a damper at the firebox. By adjusting the position of the weights on the lever, steam pressure could be set. The valve floated between 0 pressure and the set point; the action of the moving lever and chain connected to the air damper at the primary air inlet of the firebox and would bank the coal fire. The balanced pressure regulator maintained steam pressure at or below the set point.

All the drawings in this book have modern-type near boiler piping, including a Hartford loop. This representation is to remind everyone that the near boiler piping was modified from its original form. All near boiler piping must be installed as recommended by the boiler manufacturer. Additionally, for the sake of brevity, most of the drawings are made from an altered master drawing.

Look at the drawings. The connections at the radiators are smaller than the steam and return risers. Additionally, each radiator has two shut-off valves and a vent valve. See the placement of the radiator vent valves. Each vent valve is installed at the *return side of the radiator* and about 1/3 below the top of the radiator.

In the drawings on pages 63 and 64, the steam mains and dry returns were not reduced in size. Since the steam mains and dry return piping are large, the boiler operating steam pressure may be set low. Problems can occur in vapor systems when steam pressures are set high and particularly in two-pipe steam vapor vent systems.



When a boiler produces steam and steam enters the steam piping, air and steam vapors flow into the steam main, steam risers, heating elements, return risers, and the wet or dry return piping. Air is released by the steam main, main vent valves, and radiator vent valves. Heat circulation in a building usually occurs before steam pressure registers the pressure gauge. When steam piping and radiators heat up and the steam pressure reaches the set point, steam can flow out of the radiators and into the return risers.

Steam flows up and down the return risers because a zone of lower pressure is created as the radiator vent valves release air. The source of the steam in the return risers is the unspent steam from the radiators and the pressurized dry return, as shown in the drawing on page 61.

In two-pipe vapor air vent systems, when steam pressure is kept below 1 pound and the vent valves operate properly, the system will provide quiet and uniform heating throughout the building. Unfortunately, mechanical equipment, vent valves, valves with levers and linkages, dampers, pulleys, and chains need repair or replacement. When this ancillary equipment is not maintained, the operation of the heating system degrades. In addition, when oil replaced coal as a fuel, many steam systems (not all) became noisy and steam did not circulate properly.

Problems occurred in many steam systems when coal boilers were converted to gas- and oil-fired units. Oil burner and gas burner conversions were installed by many contractors. Unbeknown to many of them, making steam quickly with the new burners would cause problems in the steam systems. Additionally, many contractors servicing the steam systems did not know how steam systems worked. Unqualified service technicians made adjustments and repaired the steam systems, and as problems in the buildings worsened, even more unneeded adjustments, repairs, and changes were made to make the steam systems operate properly.

Two-pipe steam vapor systems were expensive installations, especially the one shown where separate steam risers and returns serve different floors. In the early days of steam heating, the steam heating or boiler installation contractor would do the heat loss calculations, design, and install the steam system. Many general contractors and home owners shopped for better prices. Contractors that did heat loss calculation and design, which specialized in vapor systems, could not compete with