Methods for controlling one and two pipe systems for comfort, even temperature distribution and energy savings.

or

Living with a Steam Heating System, a Guide for New Yorkers (but not engineers)

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Abstract:

Many buildings in larger cities have existing one and two pipe steam heating systems. Of those, the majority have control problems, leading to uneven heating, high fuel costs, and water hammer. This paper will discuss state of the art systems, best practices, troubleshooting, maintaining a comfortable environment and energy savings.

One pipe steam systems allow for condensate and steam to travel throughout the system within the same pipes. As the boiler creates steam it travels through and up the pipes to the radiators where it warms the space and condenses. This condensate then travels back down the same pipe(s) back to the boiler. The pipes and radiators are all pitched back towards the boiler to allow this system to operate on gravity.

State of the Art Controls for One Pipe:

In order to make a one pipe steam system operate well, the steam flow must be **balanced**.

Adjustable air valves (figure to the right and below) must be installed at each of the radiators. This way, radiators closest to the boiler can have a smaller opening on the air valve while radiators farther from the boiler can have a larger opening. This allows steam to flow more evenly throughout the system as radiators closest to the boiler won't overheat while radiators farther from the boiler won't under heat. These air valves can be used to shut off the steam to unoccupied rooms. If the air valve is completely closed off, no steam will enter that radiator. Air valves operate using a bellow filled with an alcohol water mixture that flashes to a gas at 180 F. Set by the manufacturer at this temperature so that air can escape, but when steam is present at 212 F, it changes to a gas, expanding the bellow which closes the valve. Air valves should be checked every three to five years as they may fail and are essential to making the system operate correctly.

Automatic Adjustable Air Valves

Honeywell Braukmann and Danfoss are two widely available air cushion control valve brands available for one pipe heating systems. These can be set for varying temperatures from room to room. While more expensive than the simple air valves, these actually sense the room temperature, not merely the amount of steam in the radiator. Control is noticeably better and these are a better quality product than the simple air valves. See the photos below.

Boiler control for One Pipe Steam:

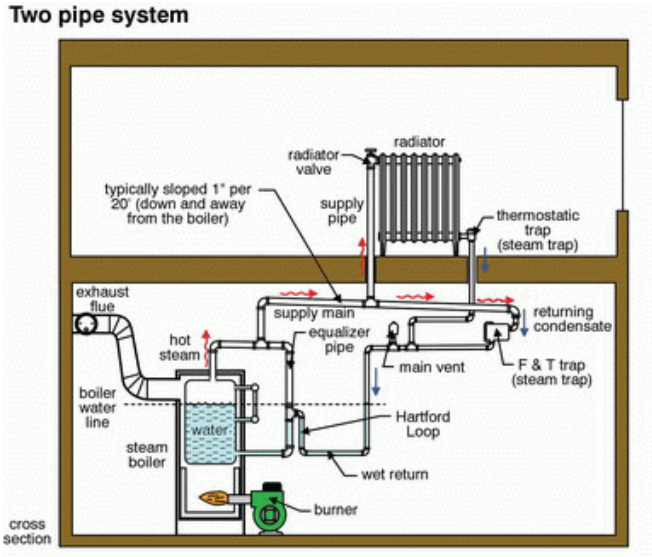
The boiler is usually controlled by a single thermostat which provides poor control, particularly in townhouses. The thermostat will only take into consideration the temperature of the floor or room in which it is located. For example, if the thermostat is located on the first floor near the boiler, then it will read the temperature of that floor. Steam will reach those radiators first, heating the floor quickly. This means that the thermostat will turn off the boiler before the steam can completely heat the radiators on the floors farthest from the boiler, leading to cooler temperatures on those floors. In order to fix this problem, it is suggested that temperature sensors are placed on multiple floors with an averaging thermostat. This allows for a more even distribution of heat.

Larger one pipe steam heating systems may require the use of a Heat Timer Control.

State of the Art Control for Two Pipe Systems

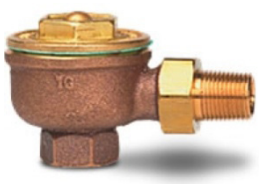
Two pipe steam systems have supply lines for steam and separate return lines for condensate. If the system is working correctly only minor quantities of condensate will be present in steam lines. The key to even and comfortable heating is once again a balanced flow of steam to radiators and condensate return to the boiler.

As the boiler creates steam, it travels through the supply pipe and reaches the radiator, where it gives off heat and condenses. It then returns to the boiler through the return line. Return lines are pitched like one pipe systems so that the condensate can operate via gravity. The supply lines are also pitched leading to the return line. There are some systems that have condensate pumps or vacuum pumps that facilitate the movement of steam and condensate, however most systems will have pitched pipes as seen below.



Steam traps

In order to control the flow of steam and condensate, these two fluids must be kept separate. The usual method is to install a steam trap on the outlet of each radiator. This device allows air and water to exist the radiator, but not steam. If the traps do not work, the system cannot be controlled.



The internal element of a failed trap can be replaced easily by a plumber. If you live in an apartment, the Landlord should do this. Of course if your traps have failed, then it is reasonable to assume that all traps in the building must be checked.

Trap function can be checked by using the Tempilstick. It is a temperature sensitive stick which melts at a specific temperature. So, if you are using one that melts at the temperature of the steam in your system and place it at the outlet side of the radiator trap and it melts, then you know that there is steam on that side of the pipe. This means that either that trap has failed, or a nearby trap has failed. Either way, if the system is old it would be wise to replace all of the thermostatic radiator traps.

Now that steam and water have been separated, we can move on to controlling the radiators.

For control over temperature two pipe steam systems make use of thermostatic radiator valves (TRV). TRVs monitor the temperature near the radiator and they are attached to the steam supply pipe. The temperature can then be manually set by the occupant; the settings are usually displayed numerically with a temperature range corresponding to each increment. When the desired temperature has been reached, the valve will close the supply of steam to the individual radiator. The same manufacturers Honeywell Braukmann and Danfoss offer quality products.

If the radiator is installed in an enclosure the capillary tube model must be used.

Boiler Control for 2 pipe systems

Use a Heat Timer or similar. No thermostats allowed. The Heat Timer control will monitor the outdoor temperature, condensate return rate, can be programmed and is generally the best solution for controlling this 19th century technology.

The Radiator Cozy, Another Idea

Radiator Cozy is a proprietary insulating enclosure developed by Radiolabs that wraps around the radiator (figure to the right). This enclosure works with both one and two pipe steam. In particular, Cozy works well for larger, one pipe systems with oversized boilers, since thermostatic radiator valves are likely to work poorly in those situations. However, it is preferable to prevent steam from entering into the radiator in the first place, rather than allowing the steam to enter the radiator and then keep the heat/steam confined within it. Cozy uses several simple technologies to achieve its desired effect. Basically, the thermal enclosure that wraps around the radiator traps the heat within the radiator and a temperature sensor will tell the small fan to blow the hot air out once the temperature reaches below a specified point. Additionally, Cozy has the option of connecting through a Smartphone or a device connected to the internet to gain additional information about the system. This data is useful as it describes which rooms are overheating, under heating, and overall efficiency of the system. More information can be found at radiatorlabs.com.

Trouble shooting:

If following the above guidelines does not get the system to where it is operating in a satisfactory manner, something is probably not right. Here is a primer, but there are resources given at the end of the paper. Failing all else our office can design a replacement hot water heating system for your building.

Troubleshooting One Pipe Systems:

As steam heating systems age, heating issues occur and over time changes have been made to the system. The prevention of heat loss is a priority in both one and two pipe steam heating; the pipes should be properly insulated. When properly insulated efficiency will improve as less heat is escaping from the system meaning steam will be hotter when it reaches the radiators additionally reheating condensate will require less energy.
When dealing with trapped condensate in a one pipe system ensure all the pipes and

radiators are pitched back towards the boiler. Over time hangers supporting the pipes can become loose or worn out. Radiators themselves can burrow into the floor causing them to level out and leaving behind some amount of condensate after each cycle. Another problem faced within the pipes is when a blockage is formed happening in both one and two pipe systems. Over time rust, calcium and magnesium can build up inside of the pipes. In some cases the pipes can be cleaned but it is often necessary to replace these pipes.

As previously mentioned air valves should be checked regularly. These valves are likely to fail open which in this case steam will enter the room via the valve, which is also noisy. If the valve is to fail closed it will prevent the radiator from heating. The air inside of the radiator becomes trapped inside and steam will be unable to enter. Keep a few spares on hand.

Troubleshooting Two Pipe Systems:

If a few radiators fail to heat up, this is likely due to a failed thermostatic radiator trap. If it fails in the closed position, then the air and condensate are unable to leave the radiator, so the steam cannot enter. The fix is simple; you only have to replace the failed thermostatic radiator traps.
If the traps fail open then water hammer results, the famous clanking of the pipes or radiator, even far away in the system. Go trap patrol during the summer, and replace all traps in the building.

Just as one pipe have air valves on the radiators to remove air from the system; two pipe steam needs a way of removing air from its system. This can be done in a few ways, and it's worth mentioning nearly all two pipe systems do not vent the individual radiators. Do not install one-pipe steam vents on the radiators as this may fix the cold radiators, but will cause many more problems in the future. Instead, depending on the setup there are various venting configurations, from a single vent on the main line to multiple vents on the risers. A good understanding of different types of two pipe systems will allow one to determine the type of venting needed. Consult a knowledgeable plumber or an engineer.

Water hammer is a common occurrence with steam heating and is the loud clanking sounds that can be heard in the pipes and radiators. This is caused by steam entering the condensate and suddenly changing from vapor to liquid causing impressive banging to occur. Commonly called water hammer, this problem must be addressed by professionals. Recommended measures to start alleviating this problem:

- Go on trap patrol and make sure all traps are functional.
- On large systems make sure that condensate return pumps and boiler feed units are adequately sized.
- Ensure that the air can leave the system when steam is being supplied.

- Ensure all piping is properly pitched and 'dripped' (provided with a means to remove condensate), especially horizontal steam mains and vertical steam risers.
- If wet condensate return piping is present, this is a prime suspect in preventing a free flow of condensate back to the boiler due to clogging. Have a plumber cut out a short length of pipe to check.
- Have steam boiler professional check the boiler controls, operations and condensate return arrangement at the boiler.

Much has gone unmentioned in this introduction to steam heating system control. Should your interest be piqued, there are many resources available that can help you become an expert in the arcane and disappearing art of designing, operating and maintaining steam heating systems.

Sources

1. Holohan, Dan. *The Lost Art of Steam Heating*. Bethpage, NY: D. Holohan, 2006. Print.
2. Moore, Brian W., P.E. "THE LOCOMOTIVE." *Low Water Cutoffs – What Can I Do to Prevent A Low Water Condition?* The Hartford Steam Boiler Inspection and Insurance Company, n.d. Web. 06 July 2016.