

SteamTeam®

Bell & Gossett®
McDonnell & Miller™

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Replacing a steam boiler - successfully!

When an existing steam boiler fails, the adventure of installing a new one begins. Here are a few keys to successful replacement.

Asking the Right Questions

Step one is to find out why the old boiler failed:

- Was it an 80 year boiler on its last leg?
- Were the controls installed properly?
- Were the controls maintained as the manufacturer recommended?
- Was the boiler bringing in large amounts of fresh water?
- Is your customer familiar with a steam system's nuances, or a new homeowner who doesn't know that steam boilers require "hands on" attention?

Answer these questions before you install the new boiler. Otherwise, boiler failure will happen again and the homeowner's steam system will quickly become your steam system!



**McDonnell & Miller
WFE UniMatch Water Feeder**

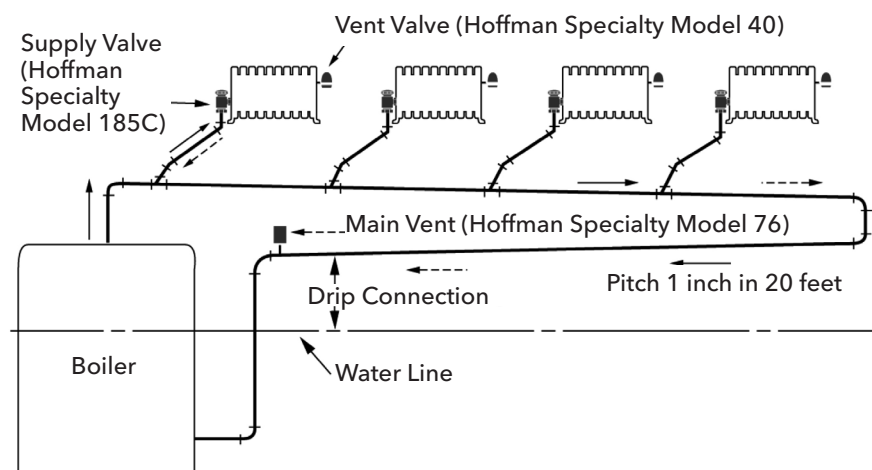


**McDonnell & Miller
Series PSE-800**

Understanding Hydronic vs. Steam Heating

The new boiler's capacity to produce steam must match the existing system's capacity to condense steam—a fact that trips up many contractors. Remember, steam systems provide heat much differently than hot water systems.

- In a hydronic system, the boilers, pipes and radiation are filled with water. The boiler heats the water, which circulates out to the radiation, gives off heat to the room, and drops a few degrees in temperature. The water then returns to the boiler to be heated and recirculated.



Typical steam system with dry return

- In a steam system, all the pipes and radiators are filled with air. The system's only water is in the boiler and in any piping below the boiler water line. The boiler adds latent heat—a measurement of energy not sensed by a thermometer—to the water until it becomes steam and heads out into the system. Here's the thing: This steam wants to change back into water. When it does, it gives back the latent heat that turned the water into steam—right where the hot steam enters cold pipes and radiators.

Sizing the Replacement Boiler

To heat every radiator in the house, the boiler has to produce enough steam to fill the piping network and all the radiators. Thus, successful replacement requires that the new steam boiler is sized according to the amount of radiation connected to the piping system. Walk through the house with a clipboard, add up the EDR ratings of every radiator, and you'll know the exact size boiler required for this home.

Why not just read the old boiler's rating plate? You're putting your reputation in the hands of the installer who came before you. Many homeowners believe that buying a new steam boiler gives them a new steam system. If they continue to have problems caused by the incorrect size of the old boiler, they won't be happy. And they'll blame you.

Avoiding Oversizing

An oversized replacement boiler forces too much steam into the piping system, creating velocity problems, spitting steam vents, water hammering, and short cycling. The homeowner doesn't know anything about boiler sizing. All he knows is that the boiler keeps cycling on and off, the radiator vents are spitting water all over the walls and floor, and the house sounds like it might explode.

Take the time to properly size the replacement steam boiler, and you can keep your customer calm and happy—and complete the job successfully.

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Top 10 mistakes contractors make with steam heating systems



- #10 They think they're working on just part of the system.** You're never working on just part of a steam system. When you touch one part, you affect all the other parts. Think big! *Think System.* You may be there only to replace the boiler, but when that new boiler won't heat the building, *you'll* get the call.
- #9 They remove the insulation.** Steam is a gas that quickly condenses into a liquid when it hits cold pipes. If a pipe is insulated, the steam is five times less likely to condense. Whoa! If you want the steam to reach those far-off radiators, you have to insulate those pipes.
- #8 They don't figure the time it takes to clean the system.** Steam systems are wide open to the atmosphere and constantly corroding. That corrosion works its way down into the boiler, making the water line bounce and surge—leading to water-level problems and equipment failure. If you're installing a new boiler, include time to clean the system in your price—or you'll end up doing it for free.
- #7 They underestimate the importance of the vacuum pump.** That vacuum pump let the original engineer undersize every pipe, valve and fitting in the building; thanks to a pressure-to-vacuum differential across the system, the steam moved quickly from the boiler to the radiators. Without the vacuum pump, though, you're forced to run higher-than-normal pressure. That leads to uneven heating, high fuel bills, water hammer and equipment failure. If there's a vacuum pump and it's broken, we can help. Domestic Pump makes a fine line of vacuum pumps, and our rep will be glad to accompany you to that problem job.
- #6 They line-size steam traps and PRVs.** Why do contractors do this? Because it's easy! The trouble is, it doesn't work very well. Valves should be the same size as the lines they're piped into. They will always be smaller. If you line-size a trap or a PRV, it will just barely open during operation. That leads to "wire-drawing" (erosion of the metal seat) and premature death. If you're not sure of the size, call your McDonnell & Miller/Hoffman Specialty rep.

#5 They oversize the replacement boiler. Oversized boilers short-cycle, creating high fuel bills, equipment failure and angry customers. The only correct way to size a replacement steam boiler is to measure all the radiation in the building. The boiler's ability to make steam has to match the system's ability to condense steam. Don't size a new boiler based on the size of the old one. That boiler may date from the days of coal firing and could well be twice as large as it should be. Why leave all that money on the job? Take the time to measure the radiators.

#4 They don't think like air. Where there is air, steam will not go. You should always walk through the system and imagine yourself as air. Could you get out of those pipes? If you can't get out, neither can the air. Trapped air leads to uneven heating and high fuel bills. Air is one of the simplest problems to diagnose. Ask your counterman to show you the complete line of Hoffman Specialty air vents. Each box holds a solution.

#3 They install one-pipe steam vents on two-pipe steam radiators. When thermostatic radiator traps fail, the steam moves into and pressurizes the return lines. That traps air in the radiators, keeping them from heating. If you install an air vent on that two-pipe radiator, the air will get out, and the radiator will heat, for sure! But since there's steam in the return lines (because of the failed traps), the condensate won't get back to the boiler until the end of the cycle. That leads to severe water hammer, and water level problems at the boiler.

If you want your steam traps to last longer, ask your counterman about Hoffman Specialty Bear Traps. We build them for the long run.

#2 They try to use just one steam trap for the whole system. Steam traps belong on every two-pipe system that has dry returns, and on any system that has a condensate or boiler feed pump. The traps keep the steam from entering the return lines, going a long way toward balancing the steam distribution. If you try to get by with just one big trap at the inlet to the condensate or boiler feed pump, you'll have a building that never heats well.

#1 They get frustrated and raise the steam pressure. Most buildings will heat beautifully with no more than 2 psi steam pressure—based on *pipe size*, not building size. The correct steam pressure for the job was set on the day the original engineer sized the piping system. If you have to run the pressure higher than 2 psi you probably have trapped air or failed steam traps.

Bonus!

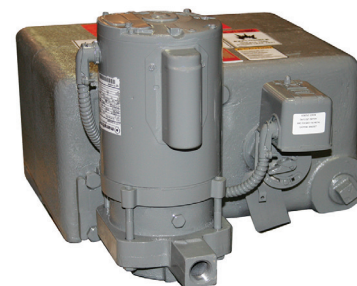
They don't call their McDonnell & Miller/Hoffman Specialty rep! Who knows more about steam heating than the representatives for McDonnell & Miller/Hoffman Specialty? We've been in the business since the days this stuff was thought up. Hey, we helped think it up! If you're having a problem, do the smart thing and call us first.

Steve Almgreen
Assistant Product Line Manager -
Steam Products

Condensate pump start-up and balancing

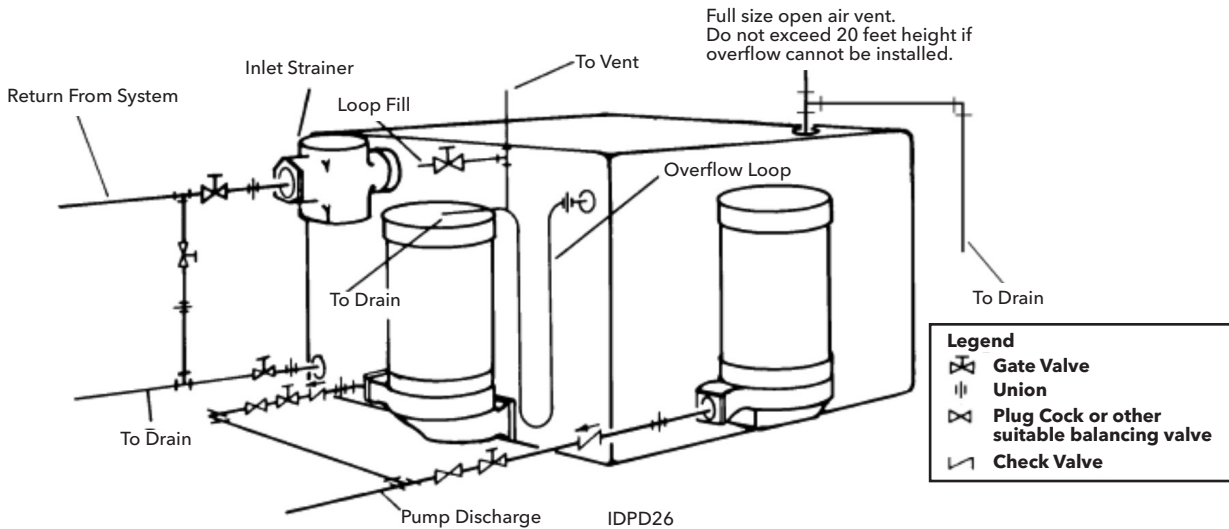
Domestic® Pump often gets requests to clarify piping diagram and start-up instructions, especially the need for each pump to have a union, a gate valve, check valve and plug cock, as shown below. Here's the reasoning behind our recommendations.

- The union is the point where the condensate equipment and the rest of the system meet.
- The check valve prevents problems like these:
 - Condensate flowing backward from the boiler or from vertical piping when the pump is not operating.



**Hoffman Specialty®
Watchman WC-6-20B**

- One duplex-unit pump pumping into the discharge of the other pump, causing recirculation problems.
- The gate valve, or isolation valve, lets you service the unit in isolation from the rest of the system.
- The plug cock, or other suitable balancing valve, balances the pump.



Elementary piping diagram

Contractors often want to know exactly what a “plug cock” is and why it needs to be installed. We also get questions about seals failing (usually due to cavitation).

The plug cock is simply some sort of balancing valve. The term originally referred to a square-headed steam cock or other balancing valve typical of steam systems from the 1940s and 50s. Today, you can use any good-quality balancing valve with a low Cv, such as the Bell & Gossett Circuit Setter.

In *The Lost Art of Steam Heating*, here’s what author Dan Holohan says about condensate unit piping and plug cocks.

Put a gate or ball valve after the check valve so you’ll be able to service the pump or the check valve without having to drain the boiler. Then, install a lubricated plug cock or other suitable balancing valve after the service valve. The plug cock pulls in the reins on the pump and keeps the check valve from chattering. You need it because manufactures size most condensate pumps to move more water at 20 psig. That’s because a low pressure boiler can operate up to 15 psig. If the boiler operates at pressure less than 50 psig, you have to pump into it with a pressure equal to the operating pressure, plus 5 psig. So if your boiler is running at 2 psig, your pump should discharge at 7 psig. If the boiler operates at its maximum 15 psig pressure, you’ll need a 20 psig pump to get in. That’s why they make them that way.

The problem, however, is if we let the pump do what’s it’s capable of doing, the pumped flow of return condensate will be much too fast. It will have the check valve chattering like a machine gun. The lubricated plug cock adds resistance to the flow and stops the chattering. If you had a heating boiler operating at 2 psig, you’d throttle the plug cock until you induced about 13 psig of pressure drop in the line (you need 7 psig to enter the boiler at the proper rate. The plug cock eats up the rest). You don’t necessarily need a pressure gauge to do this; just listen to the check valve. When it stops chattering, you’re probably at the right point.

You can’t throttle with a gate valve because when closed part way, the gate hangs perpendicular to the flow of water. It will rattle back and forth and eventually shake itself off its stem. Besides, you shouldn’t use your service valve to throttle because someone will invariably close it to service the pump and then reopen it to its full open position. That sets your check valve to chattering again.¹

That’s sound theory. Let’s look at the practical side. People unfamiliar with pumps tend to think impeller vanes scoop the water into the pump discharge and into the system. Actually, the impeller or pump wheel “slaps” the water, throwing it to the edge of the pump casing and out the discharge. That creates a low pressure zone in the impeller’s eye, or inlet of the impeller. Because high pressure always flows to low pressure, more water rushes into the impeller eye to fill the void.

In steam systems, we also need to consider net positive suction head (NPSH), defined as the net positive pressure that causes a liquid to flow through the suction piping to a pump and enter the impeller's eye. NPSH is simply the minimum suction required to prevent flashing of the fluid in the pump.

There are two values for NPSH.

- NPSHR (R for required), a function of the pump design, is how much NPSH is **required** to keep the fluid from flashing to steam inside the pump.
- NPSHA (A for available), is what's **available** for the pump to use.

In vented condensate systems, the NPSHA value is a function of several things:

- Positive static head, or water column, of condensate above the pump's impeller eye
- Vapor pressure of the fluid
- Minus the piping friction loss of the water column piping into the pump.

Remember that vapor pressure is also related to temperature. Typically, the vapor pressure of condensate decreases as the temperature goes up.

Totaling the positives and negatives reveals available NPSH, which must always exceed required NPSH. If it doesn't, the water in the eye of the impeller will flash back to vapor. This is called cavitation and can damage the pump's internal components.

Domestic Pump and Hoffman Specialty have always been conservative in our pump sizing. The typical pump provided on your product has pumping potential far greater than your requirements. Let's look at a typical 609 PF pump curve.

A pump with a 3-11/16" impeller might typically be selected for the duty point of 15 gpm at 20 psi (i.e. 46 feet of head). Left uncontrolled, or as Dan Holohan puts it, "not reined in," that pump has the potential to pump at a capacity of 32 gallons per minute but will generate only 31 or 32 feet of head, or 13 psi. If you're trying to get water into a 15 psi boiler and have only 13 psi coming out of the pump, nothing moves. Until the boiler pushes out more steam and the volume in the boiler and its related pressure drops, no water can get to where you want it, into the boiler. You need to control the pump.

Put another way, picture a backyard garden hose. With no nozzle in place, the hose will pump 10 gallons a minute, but only your ankles get wet—not your lawn. Installing a nozzle essentially gives you a control valve (i.e. the plug cock or balancing valve). Tightening the nozzle sends less water through the hose but increases the pressure; you can now spray water across the yard to even the farthest corners of your garden.

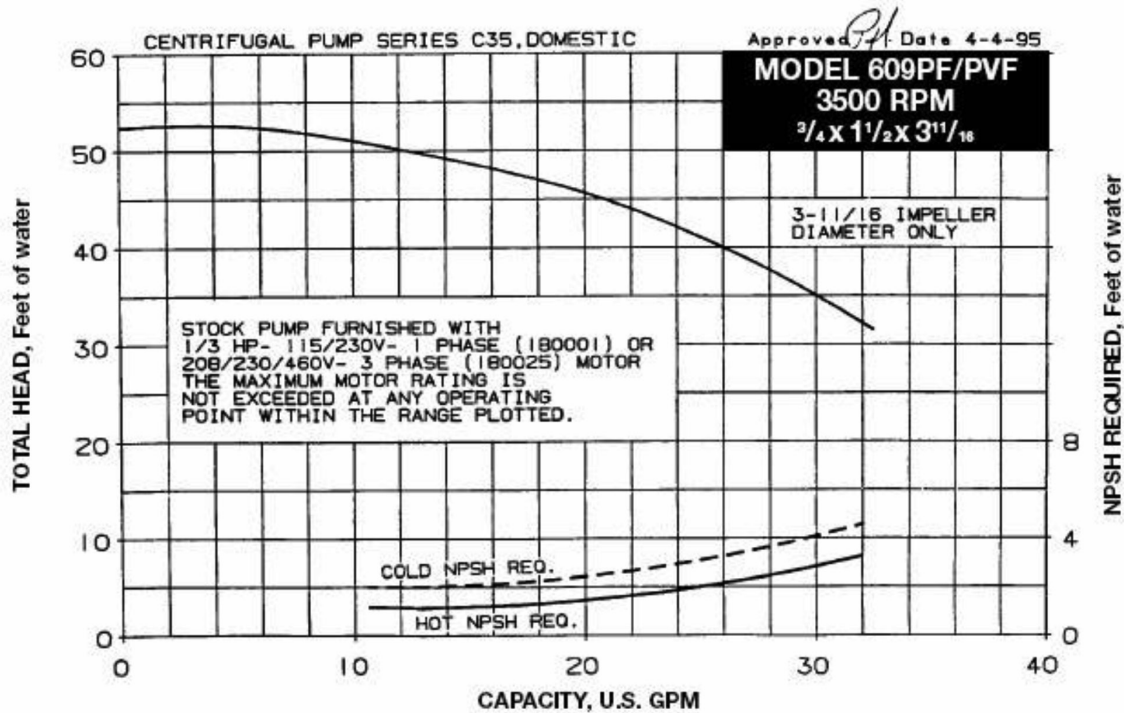
In the same way, the plug cock or balancing valve increases pressure and decreases flow. The pump moves back on its operational curve, preventing deadheading against the boiler's internal pressure or a pressure drop in the pipe between the pump and next piece of equipment. Equally important, the pump moves back on its NPSHR curve, eliminating the potential for cavitation.

Look again at the pump curve and NPSH table above. For a pump rated 15 gpm at 46 ft TDH, the NPSHR is approximately 1 ft. required. But if the condensate is at 212°F, then by the chart there is 0 NPSHA. NPSHA must be greater than NPSHR to stop the water in the impeller from flashing to vapor. So, if your pump remains uncontrolled and the condensate is too hot, then using same 609 PF at 210°F (which has 1.4 NPSHA) and

Temp. °F	Temp. °C	Static Suction Head in Feet (M)										
		0 (0)	1 (.03)	2 (.06)	3 (.09)	4 (1.2)	5 (1.5)	6 (1.8)	7 (2.1)	8 (2.4)	9 (2.7)	10 (3.0)
		NPSH										
212°	100°	0 (0)	1 (0.3)	2 (0.6)	3 (0.9)	4 (1.2)	5 (1.5)	6 (1.8)	7 (2.1)	8 (2.4)	9 (2.7)	10 (3.0)
210°	99.9°	1.4 (0.4)	2.4 (0.7)	3.4 (1.0)	4.4 (1.3)	5.4 (1.6)	6.4 (2.0)	7.4 (2.3)	8.4 (2.6)	9.4 (2.9)	10.4 (3.2)	11.4 (3.5)
208°	97.8°	2.6 (0.8)	3.6 (1.1)	4.6 (1.4)	5.6 (1.7)	6.6 (2.0)	7.6 (2.3)	8.6 (2.6)	9.6 (2.9)	10.6 (3.2)	11.6 (3.5)	12.6 (3.8)
206°	96.7°	4.0 (1.2)	5.0 (1.5)	6.0 (1.8)	7.0 (2.1)	8.0 (2.4)	9.0 (2.7)	10.0 (3.0)	11.0 (3.4)	12.0 (3.7)	13.0 (4.0)	14.0 (4.3)
204°	95.6°	5.1 (1.6)	6.1 (1.9)	7.1 (2.2)	8.1 (2.5)	9.1 (2.8)	10.1 (3.1)	11.1 (3.4)	12.1 (3.7)	13.1 (4.0)	14.1 (4.3)	15.1 (4.6)
200°	93.3°	7.5 (2.3)	8.5 (2.6)	9.5 (2.9)	10.5 (3.2)	11.5 (3.5)	12.5 (3.8)	13.5 (4.1)	14.5 (4.4)	15.5 (4.7)	16.5 (5.0)	17.5 (5.3)
190°	97.8°	12.5 (3.8)	13.5 (4.1)	14.5 (4.4)	15.5 (4.7)	16.5 (5.0)	17.5 (5.3)	19.5 (5.6)	19.5 (5.9)	20.5 (6.2)	21.5 (6.6)	22.5 (6.9)

* Boiling point decreases 1°F (.55°C) for every 500 feet (150M) of elevation above sea level [at 500' (150M) above sea level, boil point is 211°F (99.44°C)].

NPSH table for water at sea level* and atmospherically vented for supply tank



Centrifugal pump Series C35 3500 RPM performance curve

allowing it to run out on its curve to 26 gpm (which is 2ft. NPSHR) will result in pump cavitation. Reining in the pump with the plug cock or balancing valve not only increases the potential discharge pressure, but also moves the pump back to a point on the NPSH curve where the available is greater than the required. Now water can reach the boiler or the next piece of equipment in your system, and your condensate pump performs as it should.

So the next time you're questioned about the system piping, startups and the need for a plug cock in the system, you'll know that the answer is yes, your customer needs it and now you know why.

From the instruction manual section about putting the unit into service:

Throttle plug cock in discharge line until pressure at pump (while pump is discharging) approaches pump rated pressure. Tighten plug nut to secure adjustment.

From the troubleshooting section of the instruction manual:

Condensate Pump Is Noisy

1. The pump is working against a lower pressure than designed for. While pump is discharging, adjust plug cock in discharge line until pressure at pump approaches pump rated pressure.

¹ The Lost Art of Steam Heating, Dan Holohan, 1992, pp. 171-2