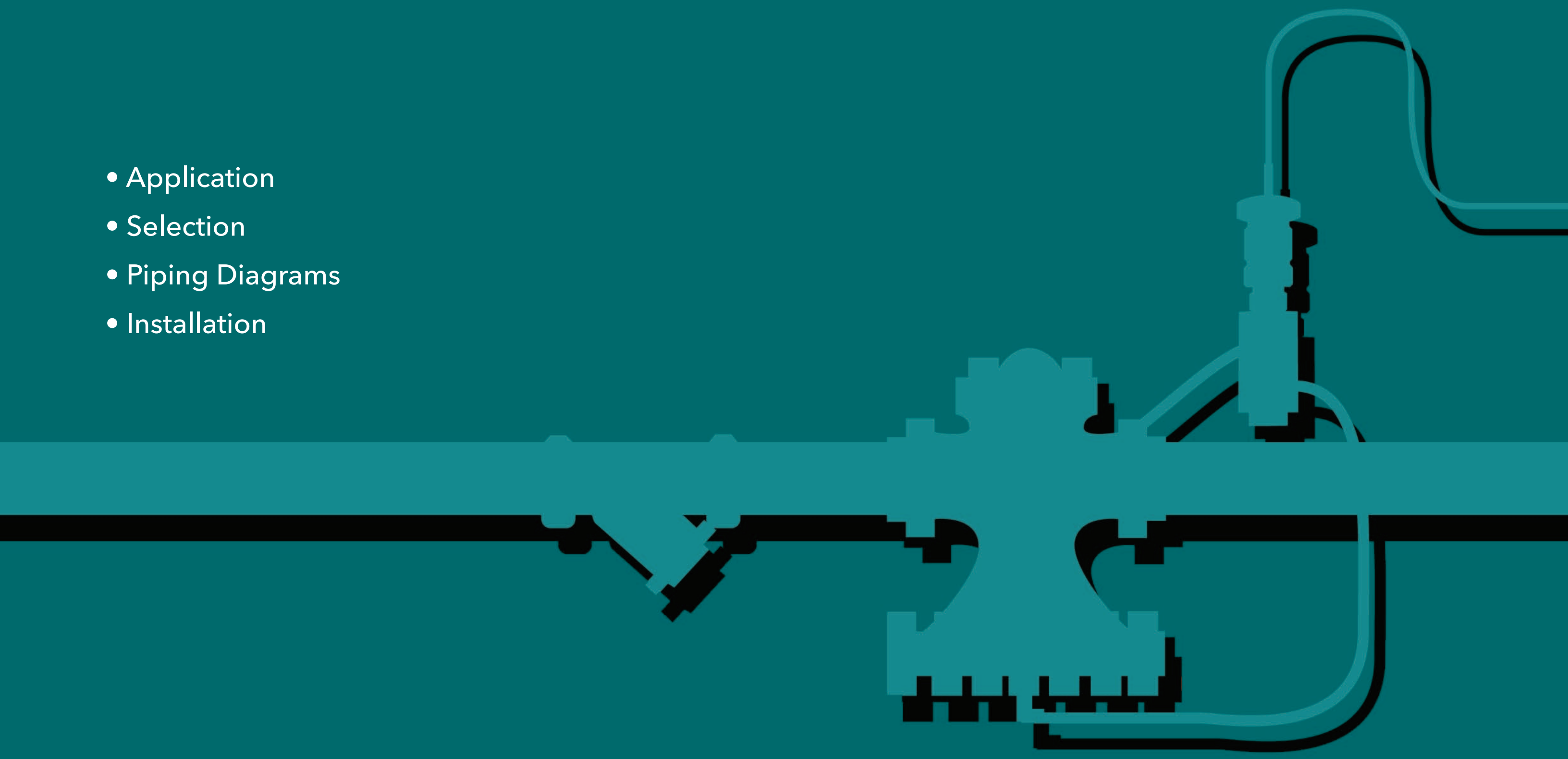
- Application
- Selection
- Piping Diagrams
- Installation



Hoffman Specialty® Temperature Regulators

ENGINEERING DATA MANUAL

HS-501A

Bell & Gossett
a xylem brand

Hoffman Specialty

Engineering Data Manual
Temperature Regulators

Introduction

Chapter 1

Chapter 2

Chapter 3

Chapter 4

Temperature Regulator Functional Requirements

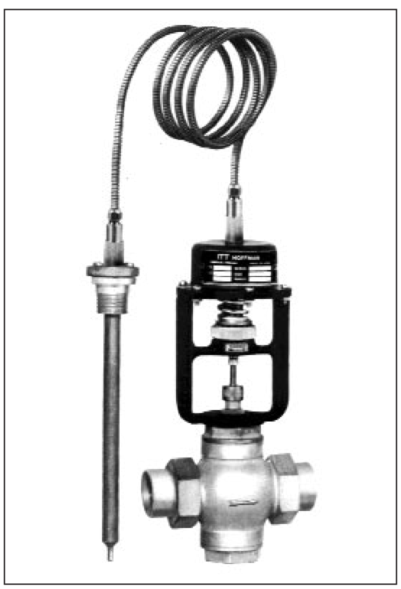
This manual is intended to serve as a guide to the proper selection, sizing and installation of temperature regulators. There are three types of regulators: self-contained vapor tension, pilot-operated and pneumatic-operated. Each has unique benefits and characteristics. Advantages and disadvantages for each type are discussed. The types of temperature regulators are self-contained vapor tension, pilot operated and pneumatic operated. Each has unique benefits and characteristics. This manual is intended to illustrate the system advantages and disadvantages of each type and to serve as a guide to proper sizing, selection and installation.

Temperature regulator installations vary from systems with large storage tanks that change temperature gradually as hot water is drawn off, to instantaneous shell and tube heaters that lack storage tanks and require a fast temperature response time.

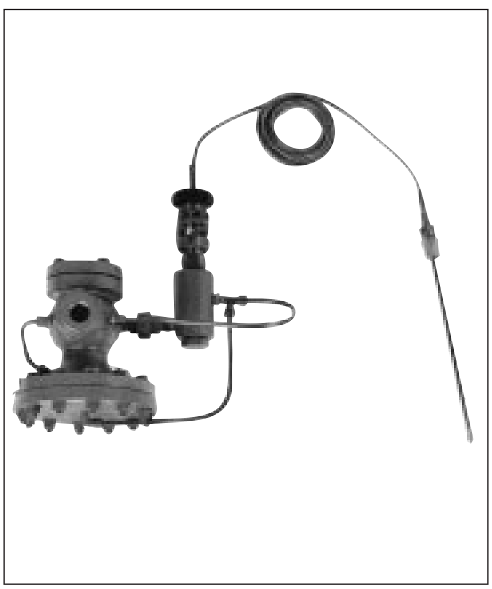
Hoffman Specialty offers self-contained regulators as two-way temperature regulators to control the heating fluids or gases, and three-way valves for mixing or diverting fluids.

Proper regulator selection, location and installation as well as correct sizing of the main valve are necessary to achieve proper temperature control. These steps also will help to maximize the life of the regulator. In addition, to achieve good temperature control, the sensing bulb must be properly located and installed. Other important factors in maximizing overall system performance for steam systems are proper trap sizing, location and installation.

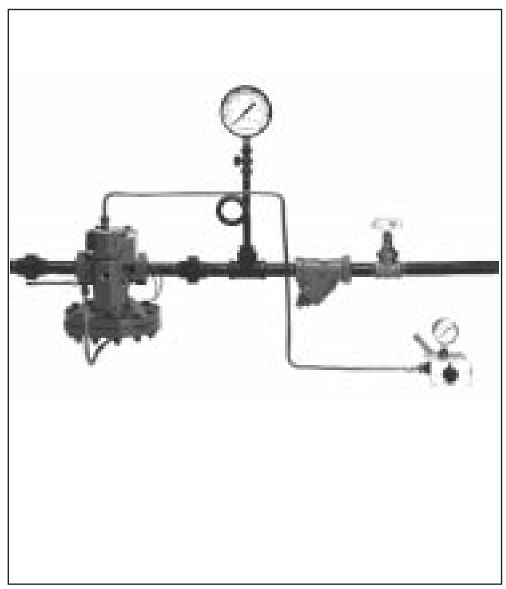
Most complaints of poor temperature control can be traced back to improper selection or incorrect installation.



Self-contained vapor tension temperature regulator



Pilot-operated temperature regulator with main valve and self-contained temperature pilot



Pilot-operated temperature regulator with pneumatic temperature and pressure pilots

Explanation of Terms

Here are definitions of the most popular terms used in temperature regulator control.

Air Venting
At start up, all steam-heated equipment contains air in the steam space. This must be vented before steam can enter. Usually, the steam trap must be capable of venting air, particularly during start-up. Some types of traps are better at venting air than others.

Differential Pressure
There are two concerns regarding differential pressure. The first is differential pressure across the temperature regulator. This may also be referred to as pressure drop across the regulator. It is the difference between upstream supply pressure and the pressure downstream of the regulator. Obtaining good temperature control usually requires sufficient pressure drop to vary the amount of fluid or gas through the valve. **Steam regulators should normally allow a minimum of 50% of the supply pressure drop across the valve.** With a 50% pressure drop, the regulator will utilize its full stroke and limit the condensing load during start-up (close to design condition). Fluid regulators should normally have at least a 10 psi drop except on very low pressure systems. Sizing for low pressure drops on liquid valves increases the valve size and causes hunting (fluctuation) of the valve.

The second concern is differential pressure across the steam trap. There must be a positive differential across the trap under all operating conditions to allow drainage of condensate. If the system design does not provide a positive differential pressure, condensate will back up into the steam space and cause cavitation (referred to as water hammer, defined below). This can destroy regulators, traps and tube bundles.

All steam coils using modulating-type temperature regulators must have gravity drainage from the trap into a vented condensate return system. This should help avoid problems like the ones we discuss next.

Recirculation
On systems without a storage tank, the system water is recirculated (pumped) continuously through the system and heater. Recirculation of the system water acts as a buffer tank and helps prevent sudden temperature changes from occurring at the regulator sensing bulb. A minimum of 20% of system design flow is commonly used to size the recirculating pump.

Water Hammer
If a steam trap drains high temperature condensate into a low pressure wet return, flashing of the condensate may occur. When high temperature condensate at saturation temperature discharges into a lower pressure area, this flashing can create steam pockets in the piping. When the latent heat in a steam pocket is released, the steam pocket implodes, causing cavitation (water hammer). The high forces (estimated to be in excess of 5,000 psi) created by these implosions can damage the bellows, floats and copper tubing used in many steam traps, coils and for system piping.

Induced Vacuum
As steam condenses back into condensate, its volume shrinks. This reduction in volume can create pressures below atmospheric and is often referred to as induced vacuum. An induced vacuum inside a steam space can cause a negative differential pressure across the steam trap and allow condensate to build up. To assure positive differential pressure, a vacuum breaker should be installed in the steam coil or piping so air may enter and relieve the vacuum. Complete condensate drainage under all possible conditions must be provided. This should prevent water hammer and coil freeze-up if condensate is held in the coil by induced vacuum.

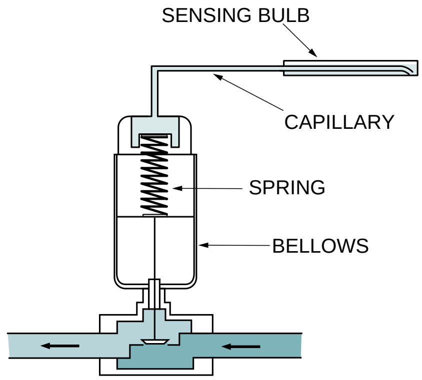
Modulating Loads
In spite of changes in fluid flow rate or changes in initial temperatures, temperature regulators are often required to maintain a close temperature range in the fluid being heated. These changing conditions force the regulator to "modulate" (vary its valve opening) to meet the changing steam load. As a result of this modulating, the steam pressure downstream of the regulator changes. It varies from a high, when the fluid flow is at design conditions and the regulator is wide open, to a lower pressure, perhaps even an induced vacuum, when the regulator is partially closed. Vacuum breakers should be installed to open when the downstream steam pressure drops below atmospheric pressure to allow air to enter the heat transfer device. Thus, they maintain at least atmospheric pressure and assure that condensate continues to drain properly.

Operating Principles and Component Selection

This chapter discusses operating principles for each of the three types of temperature regulators commonly used in HVAC temperature control. The three types are self-contained vapor tension type, pilot-operated type and pneumatic type. Selection of body types and components also is discussed for each of the three regulator types.

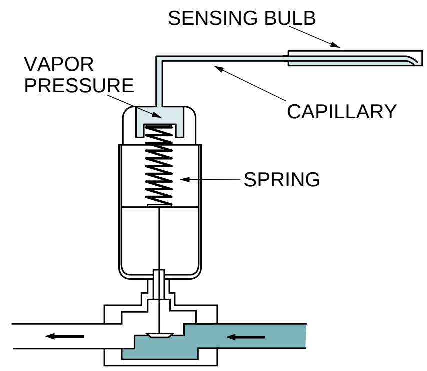
Self-Contained Vapor Tension Type Temperature Regulator

HEATING APPLICATION



Valve in open position. Bulb below set point.

HEATING APPLICATION



Valve in closed position. Bulb above set point.

Operation of Vapor Tension Temperature Regulators

The vapor tension type temperature regulator uses a sensing bulb filled under vacuum with a volatile fluid. This sensing bulb is connected to a bellows by a capillary tube that transmits the fluid to the bellows to operate the valve. The sensing bulb is placed in the fluid where the temperature is to be controlled. The vacuum holds the bellows in a compressed position when the unit is cold. As the temperature increases, the volatile fluid will reach its saturation temperature, begin to boil and create a vapor pressure inside the bulb. This vapor pressure formed in the top of the sensing bulb will push fluid from the bottom portion of the bulb into the capillary tube and bellows. This expands the bellows and closes the valve.

A heating regulator is held open by a spring and is closed by movement of the bellows. When the volatile fluid is below its saturation temperature, the vacuum inside the bulb pulls the bellows away from the valve stem. Different fluids with various boiling points are used to obtain various temperature ranges. Hoffman Specialty Series 1140 temperature regulators, for example, provide 40 degrees F. temperature adjustment for each range. Ranges are available for 40 degrees F. to 220 degrees F.

For cooling applications, the valve plug is initially closed by the spring pressure. As the temperature increases, the vapor pressure in the bulb pushes fluid through the capillary and expands the bellows and opens the valve against the spring force.

Hoffman 1140 temperature regulators are available for both heating and cooling applications. There are several body types available for various applications.

Advantages of self-contained regulators

- Completely self-contained unit does not require external power supply.
- Modulates to handle wide range of system loads.
- Easy temperature adjustment.
- Relatively inexpensive in comparison to other types of temperature control.
- Normally open valve requires minimum pressure drop for low pressure systems.

Disadvantages due to system characteristics

- Primary failure mode is open for heating regulators and closed for cooling regulators.

Primary Applications

- Storage tanks
- Mixing of hot and cold water where constant recirculation can be provided.
- Shell and tube heat exchangers if loads are constant or if buffer tank is used to smooth out load changes.
- Aftercoolers
- Engine jacket cooling
- Air heat coils

Series 1140 Self-Contained Vapor Tension Type

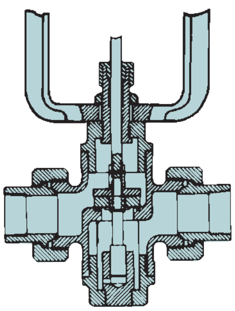
The 1140 Series offers a choice of 7 body styles for heating or cooling. Here is a description of each body type with advantages, disadvantages and primary applications. In most applications, more than one type can be used. If so, economics or availability often determines which valve to specify.

Direct-Acting

(A rise in temperature closes the valve.)

The 01 body code has a single seat composition disc, provides tight shut off and may be used on systems requiring dead end service. This disc provides the best service on water systems which may contain dirt or scale, and it is easily replaced. The valve has a brass seat and should not be used on service where the differential pressure exceeds 50 psi. The 01 body code is the least expensive selection.

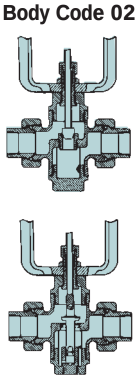
Body Code 01



- **Steam or Water Service—**Positive dead end service
- **Single Seat, Composition Disc, Bronze Trim—** Bronze integral seat
- **Body—**Bronze, union ends
- Maximum Differential Pressure:
  ½″(15mm)—50 psi (3.5 bar)
  ¾″(20mm)—50 psi (3.5 bar)
  1″(25mm)—32 psi (2.2 bar)
  1¼″(32mm)—20 psi (1.4 bar)
  1½″(40mm)—16 psi (1.1 bar)
  2″(50mm)— 8 psi.(.56 bar)

The 02 is a single, stainless steel seat that also provides tight shut off and is good for dead end service. The stainless steel seat provides long life and is recommended for steam service. The single seated valve limits the maximum pressure differential, particularly on larger sizes. When the differential pressure rating is exceeded, the actuator may not have enough power to close the plug against the system pressure.

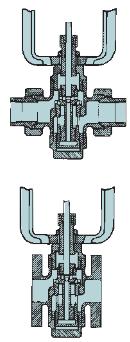
Body Code 02



- **Steam or Water Service—** Dead end shut-off, where higher temperatures and pressures prevail
- **Single Seat, Stainless Steel Trim—**½″ (15mm)–Removable stainless steel seat and cone disc. ¾″(20mm) through 2″(50mm)–Integral stainless steel seat ring and bottom guided stainless steel seat disc
- **Body—**Bronze, union ends
- Maximum Differential Pressure:
  ½″(15mm)—125 psi (8.6 bar)
  ¾″(20mm)— 60 psi (4.2 bar)
  1″(25mm)— 32 psi (2.2 bar)
  1¼″(32mm)— 20 psi (1.4 bar)
  1½″(40mm)— 16 psi (1.1 bar)
  2″(50mm)— 8 psi.(.56 bar)

The 03 uses a balance piston to provide tight shut off against high differential pressures.
The balance piston is designed for steam service only. Results will be poor on water service, as it takes a long time for water to bleed from the balance chamber. The 03 is preferable for high pressure steam systems requiring tight shut off (dead end service).

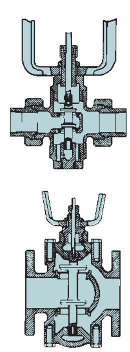
Body Code 03



- **Steam Service—** Dead end service up to full allowable body steam pressure
- **Balanced Single Seat, Stainless Steel Trim—**Removable stainless steel seat, disc and balancing piston
- **Body—** ¾″(20mm) through 2″(50mm)–bronze body, union ends
- Maximum Differential Pressure:
  ¾″(20mm)— 250 psi (17.2 bar)
  1″(25mm)—200 psi (13.8 bar)
  1¼″(32mm)—200 psi (13.8 bar)
  1½″(40mm)—200 psi (13.8 bar)
  2″(50mm)—150 psi.(10.3 bar)

The 05 is a double-seated valve with stainless steel plug and seat. Double-seated valves do not have a tight shut off. The allowable leakage rate on a new double seated valve is .01%. Double-seated valves allow high capacity as they provide two flow paths around the seats, but they should not be used on systems that may overheat due to seat leakage. They also are pressure balanced and may operate against high differential pressures. The 05 may be used on steam or water service.

Body Code 05



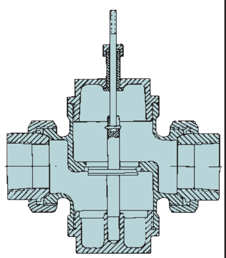
- **Steam or Water Service—**
- **Double Seat, Stainless Steel Trim—**Stainless steel seat rings and stainless steel center-guided plunger.
- **Body—**¾″(20mm) through 2″(50mm)—bronze, union ends. 2½″(65mm) through 4″(100mm)—Iron body, flanged, faced and drilled for 125 lbs. (8.6 bar) standard.
- Maximum Differential Pressure:
  ¾″(20mm)—250 psi (17.2 bar)
  1″(25mm) — 1½″(40mm) — 200 psi (13.8 bar)
  2″(50mm)— 150psi (10.3 bar)
  2½″(65mm) — 4″(100mm) — 125 psi (8.6 bar) (iron body, flanged)

Reverse-Acting

(A rise in temperature opens the valve.)

The 02R is a single seated reverse-acting valve for cooling applications. The stainless steel seat provides long life. This is a good selection when differential pressures are within the limitations shown in the description.

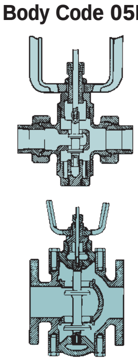
Body Code 02R



- **Steam or Water Service—** General cooling service where dead end shut-off is required
- **Single Seat, Stainless Steel Trim—**Stainless steel seat ring and bottom-guided stainless steel disc
- **Body—**Bronze, union ends ¾″(20mm) through 2″(50mm)
- Maximum Differential Pressure:
  ½″(15mm)—125 psi (8.6 bar)
  ¾″(20mm)— 60 psi (4.2 bar)
  1″(25mm)— 32 psi (2.2 bar)
  1¼″(32mm)— 20 psi (1.4 bar)
  1½″(40mm)— 16 psi (1.1 bar)
  2″(50mm)— 8 psi (.56 bar)

The 05R is a double-seated valve with a stainless steel plug and seat. The allowable leakage rate on a new valve is .01%. Double-seated valves should not be used in no flow conditions, and they do not have a tight shut off.

Body Code 05R

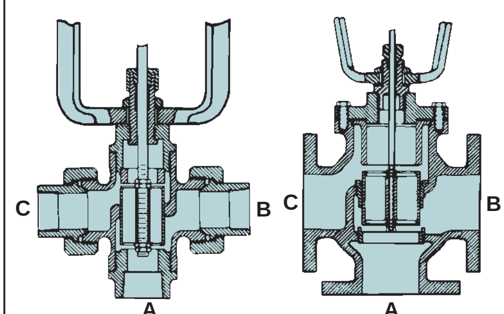


- **Steam or Water Service—**
- **Stainless Steel Trim—** Stainless steel center guided plunger
- **Body—**¾″(20mm) through 2″(50mm)—bronze, union ends. 2½″(65mm) through 4″(100mm)—Iron body, flanged, faced and drilled for 125 lbs. (8.6 bar) standard
- Maximum Differential Pressure:
  ¾″(20mm)—250 psi (17.2 bar)
  1″(25mm) — 2″(50mm)— 200 psi (13.8 bar)
  2½″(65mm) — 4″(100mm)— 125 psi (8.6 bar) (iron body flanged)

Three-Way Mixing or Diverting Valves

The 06 three-way valve may be used as a mixing or diverting valve on water systems. The valve has 3 ports, each designated A, B or C. Port "A" on the bottom of the valve is the mixed water outlet. Port "B" is the hot water inlet, and port "C" is the cold water inlet. A sliding cylinder is used to direct flow from the hot or cold port. When 06 is used as a mixing valve, hot water enters port B and flows under the cylinder. Cold water enters port C above cylinder. The cylinder has openings to allow flow through the piston into the mixed port A. The blended temperature exits through the bottom opening. When used as a diverting valve, fluid enters through A. If it is below the set point, it discharges under the cylinder to B. If above the set point, it exits through the cylinder to C. As the valve modulates within the control range, fluid may discharge through both side openings.
The 06 provides tight shut off and may be used where dead end service is required.

Body Code 06



- **Water Service Only**
- **Nickel Plated Piston, Bronze Trim—**Sliding piston with nickel plated surface and bronze seating surfaces
- **Body—** ½″(15mm) through 2″(50mm) —bronze, union ends, bottom connection screwed
  2½″(65mm) through 4″(100mm)—Iron body, flanged, faced and drilled for 125 lb. (8.6 bar) standard
- Maximum Differential Pressure:
  ½″(15mm) — ¾″(20mm)— 250 psi (17.2 bar)
  1″(25mm) — 2″(50mm)— 200 psi (13.8 bar)
  2½″(65mm) — 4″(100mm)— 125 psi (8.6 bar)

Pilot-Operated Temperature Regulator

Pilot-operated main valve with liquid expansion temperature pilot

A pilot-operated valve has a separate main valve. The main valve is a normally closed device. It is opened by a temperature pilot which loads steam pressure on the main valve diaphragm. This force pushes against a spring and the main valve opens.

The temperature pilot used on the Series 2000 valve, for example, operates on the liquid expansion principle. It has a fluid-filled sensing bulb connected to a bellows by a capillary tube. As the fluid inside the bulb is heated, it expands and is transmitted through the capillary to a bellows. The bellows expands to operate the pilot valve.

Advantages of pilot-operated main valves

- Pilot-operated valves may be combined with pressure pilots or solenoid pilots to provide multiple functions or safety overrides.
- Modulate to handle wide range of system loads.
- Response time is somewhat faster than vapor tension types due to smaller bulb.
- Liquid expansion pilot has a wide range temperature adjustment.
- Operate against high differential pressures.
- Provide in excess of 100 degrees F over temperature protection in temperature pilot.

Disadvantages

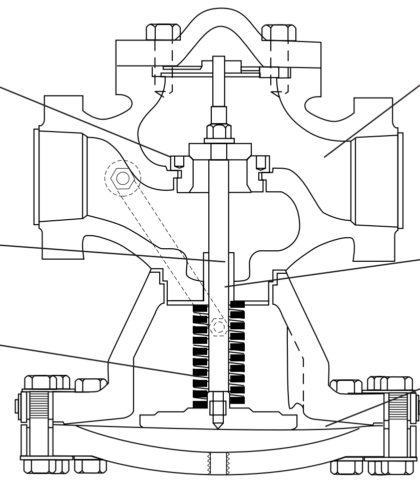
- Normal failure mode of pilot is fail open, while failure mode of main valve is closed. System can be protected by solenoid overrides wired into aquastats, flow switches or auxiliary contacts.
- Used on steam service only.
- Require higher pressure drops to open main valve than self-contained regulator.

Primary Applications

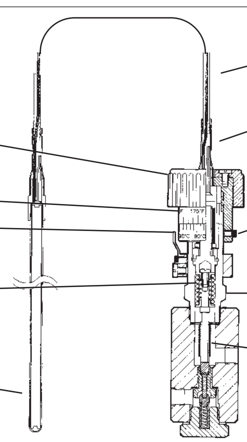
- Storage tanks
- Shell and tube heaters where loads are constant or where buffertank is used to smooth out load changes.
- After coolers
- Applications requiring pressure and temperature control.
- Applications requiring solenoid pilots to override for automatic shut down and start up.
- Where safety overrides are required.

The Hoffman Specialty Series 2000 line includes 27 main valves with 14 pilots and hundreds of possible combinations to cover a wide range of temperature, pressure and capacity options.

Selection of Pilot-Operated Temperature Regulator



The main body of the pilot-operated valve is a single-seated, normally closed design. The valve is held in the closed position by a spring and opened by applying steam pressure to the 2-ply stainless steel diaphragm. Main valves are available in 1/2" through 6" sizes. Each size has a choice of three port and seat sizes to meet system conditions. Full port provides maximum capacity. Port and seat sizes may be interchanged in the field to meet changing conditions.
There are several types of pilots that may be used separately or in conjunction with other pilots to operate the main valve.
The main valve is designed for steam service only.

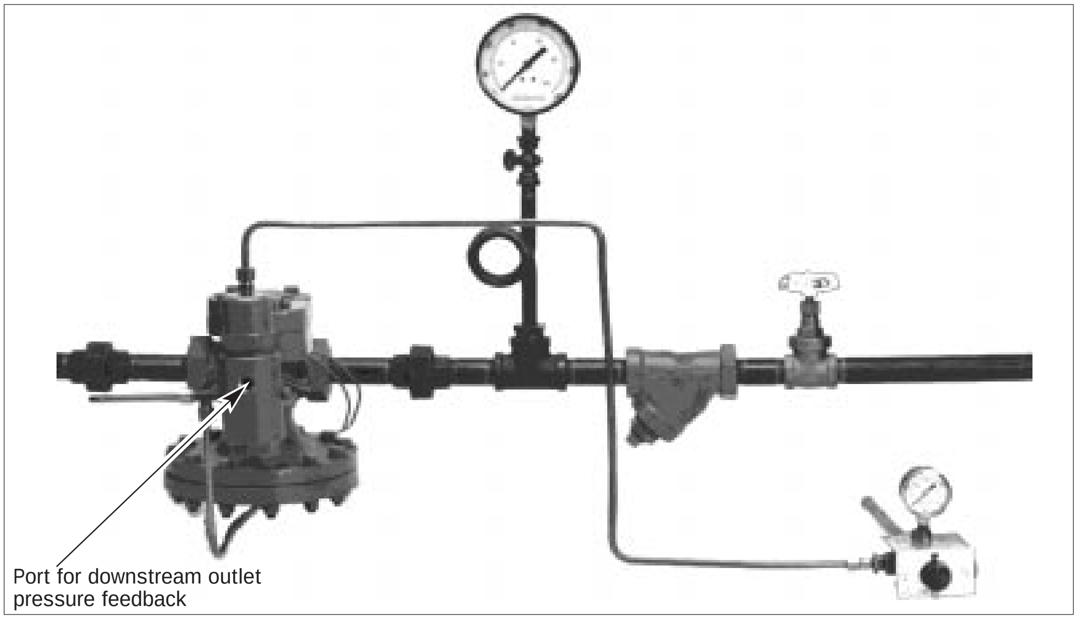


A self-contained temperature pilot controls the main valve. The temperature pilot operates on the liquid expansion principle. The pilot valve controls steam flow from the upstream supply side of the main valve to the diaphragm of the main valve. Temperature adjustment is made by turning the adjusting knob. The temperature pilot may be used in conjunction with a spring pressure pilot to control both temperature and pressure. It also may be used with a solenoid pilot to provide automatic shut-down when over-temperature occurs. Normal failure of the temperature pilot is to fail open.

When the temperature or pressure pilot closes, steam flow to the diaphragm is shut off. The steam trapped on the main valve diaphragm bleeds off through a **bleed orifice,** allowing the main valve to close.

The pilot responds more positively and faster than the self-contained vapor tension type regulator.

Pneumatic-Operated Temperature Regulator



Operation

Pneumatic temperature pilots open or close with a modulated air signal to the regulator. As the brass bulb heats or cools, it expands or contracts to operate a valve controlling the air signal. These pilots provide fast response to a minimum temperature change. The pneumatic air pilot should be used where close temperature control is critical.

Pneumatic temperature pilots may be used with diaphragm valves to control temperature only. Or, they may be used with the Hoffman Specialty Series 2000 pilot operated valves to provide both temperature and pressure control.

Advantages of pneumatic-operated valves

- Selection of components can provide either fail open or fail closed design.
- Provide fast response over a minimal temperature change.
- Easily adjusted.
- No limit to fixed length of capillary.
- Not affected by ambient temperature.

Disadvantages

- More costly than self-contained valves.
- Will not operate if air supply is interrupted.

Applications

- Storage tanks
- Instantaneous heaters
- Duct heaters
- Shell and tube heat exchangers
- After coolers
- Engine jacket cooling
- Process temperature control

Selection of Pneumatic-Operated Temperature Regulators

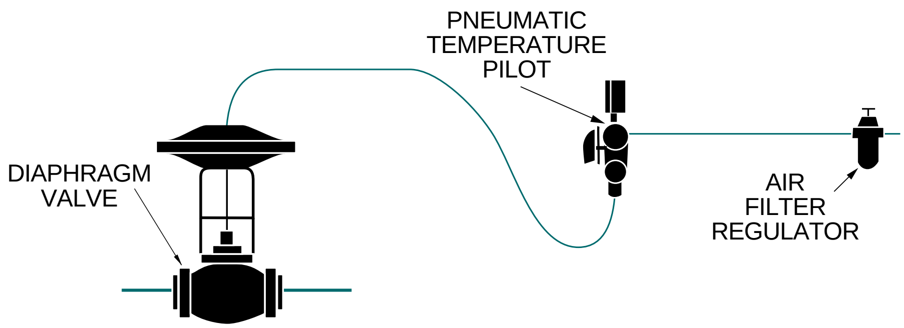
This type of regulator is recommended when rapidly changing load conditions occur. When a Hoffman pneumatic air pilot is used to control a Hoffman Series 2000 main valve, it is normally used in conjunction with a pneumatic pressure pilot such as a Hoffman Model AP-1A.

The pneumatic temperature pilot regulates temperature through the use of a bimetal sensing device. When supplied with an 18 psi air signal, it provides a 3 to 15 psi output supply. The air supply signal to the air pilot may be up to 36 psig. With a 36 psig signal, the output supply will be from 6 psig to 30 psig.

Combining a temperature pilot and a pressure pilot also controls downstream pressure. The pressure downstream of the main valve is connected to the downstream pressure feedback port on the air pressure pilot. Feedback is sensed on the underside of the diaphragm, and air supply pressure is connected to the top of the diaphragm. The air pressure pilot begins to open with 9 psi air loading pressure, and the downstream pressure is limited to air loading pressure minus 9 psi. The maximum output steam pressure with a 15 psi air supply to the pilot is 6 psig. By increasing the air signal to 30 psig, the maximum steam output from the main valve (Series 2000) is 21 psig. A Series 2000 valve using a 315 PNT and an AP-1A supplied with a 18 psig signal will stroke from fully open to fully closed within an accuracy of 5 degrees F.

When downstream steam pressures of more than 21 psig are required, an AP-4A pneumatic pressure pilot may be used. This is because the AP-4A begins to open at 9 psig of air pressure.

Using a Series 2000 valve with a 315 PNT and an AP-4A, outlet pressures up to 84 psig can be obtained. This is calculated as follows: Subtract the 9 psi spring force from the air signal and multiply by the 4:1 ratio produced by the AP-4A with a 15 psi signal. The pressure limit in this example is air supply (15 psi) minus spring force (9 lbs.) times the ratio (4:1) equals 24 psi outlet steam pressure.



A pneumatic air pilot may be used with a diaphragm control valve to maintain temperature. The diaphragm valve is not a pressure limiting device and can be used when high pressures are required on critical temperature applications.

By selecting normally open or normally closed diaphragm valves and properly connecting the direct or reverse-acting supply port, systems can be designed to fail open or fail closed for either heating or cooling applications.

Four-Step Method for Sizing Temperature Regulators

Step 1.
Determine the heating medium to be used (steam, water, etc.) and measure the available supply pressure. Note that the system design operating pressure often is not the available pressure at the regulator. This is important particularly on low pressure systems that may have significant friction loss in the piping. Pressure readings should be taken near the regulator installation site.

Note:
On steam regulators, system efficiency and temperature control are improved by operating at a low steam pressure. When the system load is to be heated to less than 200 degrees F., use a 15 psig or lower steam supply. Install a steam pressure reducing valve, if necessary. Low pressure steam will minimize the condensate temperature discharged from the steam trap and will reduce the flash steam losses in the return system. This will improve the life of the condensate return pump and seal, and it will improve the temperature control. Because of the wide temperature difference between the steam and the medium being heated, temperature variations increase when a higher pressure/higher temperature steam supply is used. Re-evaporation of flash steam losses are reduced approximately 1% for every 10-degree reduction in condensate temperature. The operating cost to heat water to 180 degrees F. to use 5 psi steam is approximately 12% less than using 100 psi steam, unless the energy in the flash steam is recovered.

Step 2.
Select an outlet pressure. **There must be a pressure drop across the temperature regulator.** Then the heating coils can be sized based on this outlet pressure. For best control on steam regulators, the pressure drop should be at least 50% of the supply pressure to allow for good modulation of the valve (for example, 90 psi supply steam should be reduced to 45 psi or less). Temperature regulators controlling liquid flow should have a 10 to 20 psig pressure drop for optimum control.

Step 3.
Determine load requirements. The capacity may be calculated using the "Helpful Hints" on page 15. Note that steam regulator sizes are based on pounds per hour. Liquid regulators are based on gallons per minute flow rate.

The capacity requirement should be based on maximum expected load requirements. Then the regulator should be sized as close to this actual requirement as possible. Oversized valves will have greater temperature variations and often tend to hunt. **Safety factors should not be included in calculation of actual load conditions.**

Step 4.
Select the temperature regulator. Things to consider include capillary lengths, supply pressure, dead end service, allowable response time and allowable temperature variation. Also consider what type of application is required – heating, cooling, mixing or diverting. Select a standard temperature range that will operate close to the mid-point on the regulator. For vapor tension type regulators, it is better to operate in the upper 50% of the range rather than the lower 50%. Liquid expansion and pneumatic regulators operate equally throughout their entire temperature ranges.

Note:
Self-contained regulators or pilots may require 10 to 80 seconds to respond to a temperature change. This will vary depending on size, range and degree of change, although this is usually not a problem on systems with a storage tank. On systems without a storage tank, this can cause momentary temperature fluctuations until the regulator stabilizes to a changing condition.

Pneumatic regulators respond faster and hold a closer temperature range. However, like the other types, they do not have an immediate response. The design of critical applications should always include a system storage tank to act as a buffer. Also, make sure the sensing bulb material is compatible with the medium being controlled, and consider specifying a separable well. (A separable well allows the sensing bulb to be removed from the system fluid stream without draining the system itself. Separable wells are optional and must be ordered separately).

Helpful Hints and Formulas - Approximating Steam Loads

- Heating water with steam (Lbs./hr. required = GPM divided by 2 x temp rise degrees F.)
- Heating fuel oil with steam (Lbs./hr. required = GPM divided by 4 x temp rise degrees F.)
- Heating air with steam coils (Lbs./hr. required = CFM divided by 900 x temp rise degrees F.)

Sizing a Regulator – An Example

A shell and tube heat exchanger is required to increase the temperature of 40 GPM water from 40°F. to 120°F. Available steam supply is 100 psig. Select a temperature regulator.

Step 1.
Determine medium and available supply pressure. All required data has been collected.

Step 2.
Select operating pressure of heat exchanger. This should be at least one-half of the steam supply (or 50 psi). However, at 50 psi, the condensate temperature from the trap will be approximately 298°F. having about 9% flash loss. Heating the water to 120°F. utilizing low pressure steam will save flash losses. Choosing a 5 psi heat exchanger will drain condensate at 227°F. and flash loss will be only about 1.5%. While this may require a larger heat exchanger, the saving in energy can pay back initial cost in a short time. By using low pressure steam, the temperature regulator and steam trap will be less expensive and often will recapture the additional cost of the heat exchanger.

Step 3.
Determine load requirements.
Estimating the steam load using the helpful hints (above) GPM/2 x temperature rise = lbs./hr., or 40/2 x 80 = 1600 lbs./hr. steam required.

Step 4.
Select actual temperature regulator.
To control the 120°F. temperature and limit the steam to 5 psig in the heat exchanger shell, choose a Series 2000 regulator with temperature and spring pilots.
A Series 2000 with one-inch main valve size will pass 1850 lbs./hr. of steam with 100 in and 5 psi out. Refer to Hoffman Specialty's General Catalog, HS-900, which provides capacity tables to assist with proper selection.

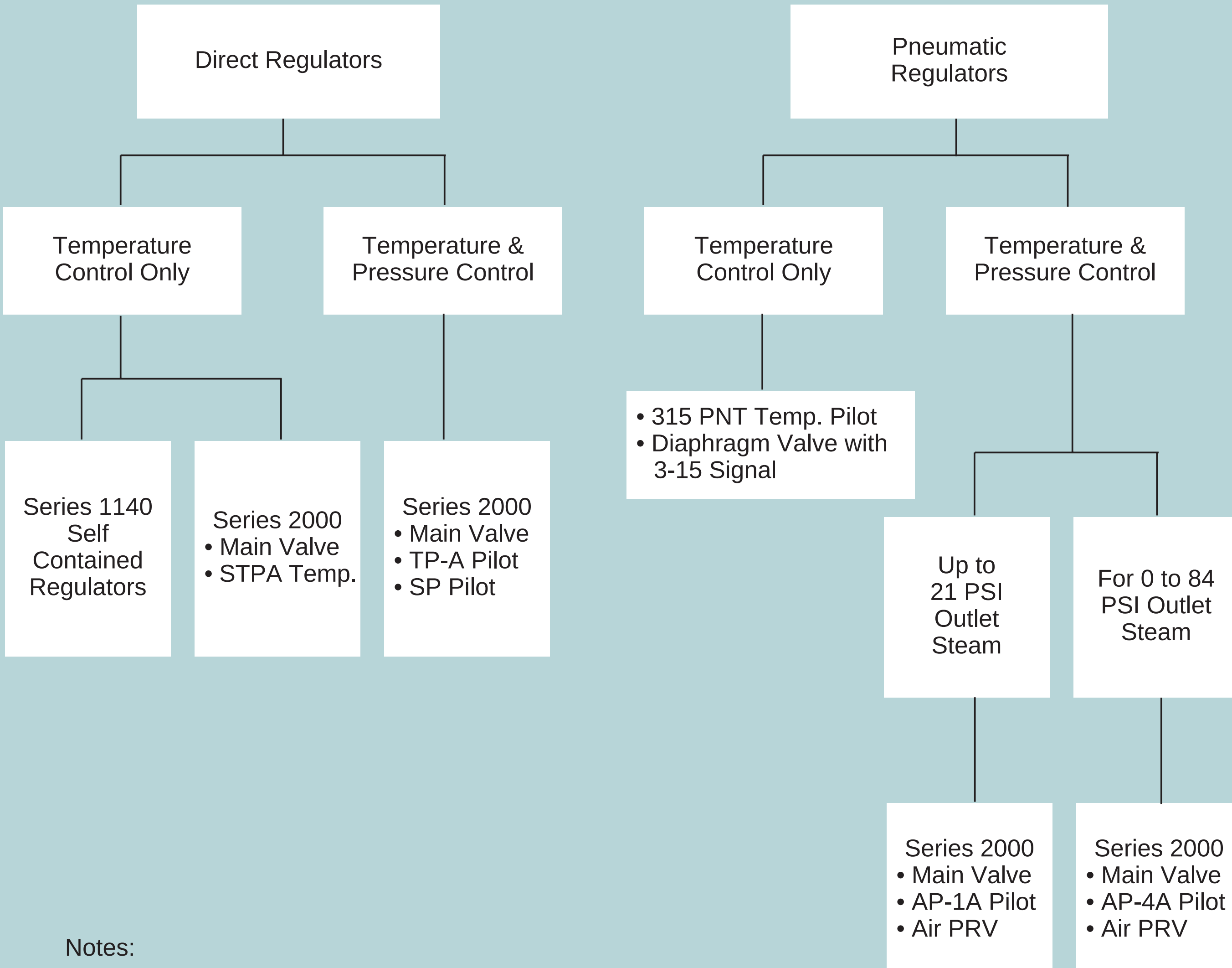
Since the heat exchanger shell is limited to 5 psi, use a trap rated for 15 psi differential. This should be based on a minimum load of 1850 lbs./hr. at 1/2 psi differential pressure. A safety factor of 1.5 times the calculated load should be applied to the steam trap. This will assure complete drainage of the condensate under all operating conditions and during heavy start-up loads. This could be a 2-inch model FT015H (actually this trap will pass 3150 lbs./hr. at 1/2 psi differential).

If ignoring the energy savings from reduced flash, use a 1-inch Series 2000 main valve with temperature pilot only. In this case, the pressure in the heat exchanger shell is not limited and could reach 100 psi. The trap then must be able to operate with 100 psi differential. Use a high capacity 2-inch model FT125X steam trap.

A Model 1140 temperature regulator could be used and not limit the pressure in the heat exchanger shell. A 1 1/4 inch 1140 with 03 body code will pass 2220 lbs./hr. With the 1140, a trap able to operate with 100 psi differential is required. The high capacity 2-inch model FT125X F&T trap can also be used.

Note:
Assume a steam cost of $7.50 per 1,000 lbs. and a load of 1400 lbs./hr. in the above selection. The comparable savings between 50 psi steam flash at 9% and the 5 psi flash loss of 1.5% is $0.79 per hour. This could amount to $6,898.00 per year, based on continuous operation of the unit.

Temperature Regulator Selection Guide



Notes:
1. Maximum pressures shown for pneumatic regulators are based on 36 psi supply to the 315 PNT which will result in a 6-30 psi output signal.
2. All Series 2000 valves may have solenoid pilots added for override safety control.

How to Determine Pounds per Hour of Condensate

1. **Steam heats a liquid indirectly through a metallic wall.**
   - Cooking coils
   - Storage tanks
   - Jacketed kettles
   - Stills

   Lbs./hr. condensate =

   $$\frac{Q_l \times 500 \times S_g \times S_h \times (T_2\text{-}T_1)}{L}$$

   When:
   Q_l = Quantity of liquid being heated in gal/min
   S_g = Specific gravity
   S_h = Specific heat
   L = Latent heat in Btu/lb.
   500= Constant for converting gallons per minute to pounds per hour.
   T_2 = Final temperature
   T_1 = Initial temperature

2. **Steam heats air or a gas indirectly through a metallic wall**
   - Plain or finned heating coils
   - Unit space heaters

   Lbs./hr. condensate =

   $$\frac{Q_g \times D \times S_h \times (T_2\text{-}T_1) \times 60}{L}$$

   When:
   Q_g = Quantity of air or gas in ft^3/min
   D = Density in lb/ft^3
   S_h = Specific heat of gas being heated
   T_1 = Initial temp.
   T_2 = Final temp.
   L = Latent heat in Btu/lb.
   60 = Minutes in hour

3. **Steam heats a solid or slurry indirectly through a metallic wall**
   - Clothing press
   - Cylinder driers
   - Platen presses

   Lbs./hr. condensate =

   $$\frac{970 \times (W_1\text{-}W_2) + W_1 \times (T_2\text{-}T_1)}{L \times T}$$

   When:
   W_1= Initial weight of product
   W_2= Final weight of product
   T_1 = Initial temp.
   T_2 = Final temp.
   L = Latent heat in Btu/lb.
   T = Time required for drying (hours)

   Note: 970 is the latent heat of vaporization at atmospheric pressure. It is included because the drying process requires that all moisture in the product be evaporated.

4. **Steam heats a solid through direct contact**
   - Sterilizers
   - Autoclaves

   Lbs./hr. condensate =

   $$\frac{W \times S_h \times (T_2\text{-}T_1)}{L \times T}$$

   W = Weight of material being heated in lbs.
   S_h = Specific heat of material being heated
   T_1 = Initial temp.
   T_2 = Final temp.
   L = Latent heat Btu/lb.
   T = Time to reach final temp. (hours)

Properties of Saturated Steam

The Properties of Saturated Steam table shows the relationship between temperature and pressure. The table also provides Btu heat values of steam and condensate at various pressures and shows the specific volume of steam at various pressures.

Definitions:

Saturated Steam: Pure steam at the temperature corresponding to the boiling point of water.

Pressure Psi (Gauge): Gauge pressure expressed as lbs./sq. in. The pressure above that of atmosphere. It is pressure indicated on an ordinary pressure gauge.

Sensible Heat: Heat which only increases the temperature of objects (as opposed to latent heat). In the saturation tables, this is the Btu remaining in the condensate at saturation temperature.

Latent Heat: The amount of heat expressed in Btu required to change 1 lb. of water at saturation temperature into 1 lb. of steam. This same amount of heat must be given off to condense 1 lb. of steam back into 1 lb. of water. The heat value is different for every pressure-temperature combination shown .

Total Heat: The sum of the sensible heat in the condensate and the latent heat. It is the total heat above water at 32° F.

Specific Volume cu. ft. per lb.: The volume of 1 lb. of steam at the corresponding pressure.

See Properties of Saturated Steam table on the following page.

Properties of Saturated Steam

STEAM BELOW ATMOSPHERIC PRESSURE

Vacuum Inches of Mercury	Saturated Temp ° F.	Specific Volume cu. ft. per lb.	Heat Content Btu per lb. Saturated Liquid	Heat Content Btu per lb. Saturated Vapor	Latent Heat of Vaporization Btu per lb.
29	79	657.0	47	1094	1047
27	115	231.9	83	1110	1027
25	134	143.0	102	1118	1017
20	161	74.8	129	1130	1001
15	179	51.2	147	1137	990
10	192	39.1	160	1142	982
5	203	31.8	171	1147	976
1	210	27.7	178	1150	971

STEAM ABOVE ATMOSPHERIC PRESSURE

Pressure PSI (Gauge)	Saturated Temp ° F.	Specific Volume cu. ft. per lb.	Heat Content Btu per lb. Saturated Liquid	Heat Content Btu per lb. Saturated Vapor	Latent Heat of Vaporization Btu per lb.
0	212	26.8	180	1150	970
1	215	24.3	183	1151	967
2	218	23.0	186	1153	965
3	222	21.8	190	1154	963
4	224	20.7	193	1155	961
5	227	19.8	195	1156	959
6	230	18.9	198	1157	958
7	232	18.1	200	1158	956
8	235	17.4	203	1158	955
9	237	16.7	205	1159	953
10	239	16.1	208	1160	952
11	242	15.6	210	1161	950
12	244	15.0	212	1161	949
13	246	14.5	214	1162	947
14	248	14.0	216	1163	946
15	250	13.6	218	1164	945
16	252	13.2	220	1164	943
17	254	12.8	222	1165	942
18	255	12.5	224	1165	941
19	257	12.1	226	1166	940
20	259	11.1	227	1166	939
25	267	10.4	236	1169	933
30	274	9.4	243	1171	926
35	281	8.5	250	1173	923
40	287	7.74	256	1175	919
45	292	7.14	262	1177	914
50	298	6.62	267	1178	911
55	302	6.17	272	1179	907
60	307	5.79	277	1181	903
65	312	5.45	282	1182	900
70	316	5.14	286	1183	897
75	320	4.87	290	1184	893
80	324	4.64	294	1185	890
85	327	4.42	298	1186	888
90	331	4.24	301	1189	887
95	334	4.03	305	1190	884
100	338	3.88	308	1190	882
105	341	3.72	312	1189	877
110	343	3.62	314	1191	877
115	347	3.44	318	1191	872
120	350	3.34	321	1193	872
125	353	3.21	324	1193	867
130	355	3.12	327	1194	867
135	358	3.02	329	1194	864
140	361	2.92	332	1195	862
145	363	2.84	335	1196	860

STEAM ABOVE ATMOSPHERIC PRESSURE (Cont.)

Pressure PSI (Gauge)	Saturated Temp ° F.	Specific Volume cu. ft. per lb.	Heat Content Btu per lb. Saturated Liquid	Heat Content Btu per lb. Saturated Vapor	Latent Heat of Vaporization Btu per lb.
150	366	2.75	337	1196	858
155	368	2.67	340	1196	854
160	370	2.60	342	1196	854
165	373	2.53	345	1197	852
170	375	2.47	347	1197	850
175	378	2.40	350	1198	848
180	380	2.34	352	1198	846
185	382	2.29	355	1199	844
190	384	2.23	357	1199	842
195	386	2.18	359	1199	840
200	388	2.14	361	1199	838
210	392	2.05	365	1200	835
220	396	1.96	369	1200	831
230	399	1.88	373	1201	828
240	403	1.81	377	1201	824
250	406	1.75	380	1201	821
260	410	1.68	384	1201	817
270	413	1.63	387	1202	814
280	416	1.57	391	1202	811
290	419	1.52	394	1202	807
300	421	1.47	397	1202	805
325	429	1.37	405	1202	797
350	436	1.27	412	1202	790
375	442	1.19	419	1202	782
400	448	1.09	426	1202	774
425	454	1.06	432	1202	770
450	459	.972	438	1202	761
475	465	.948	444	1202	757
500	469	.873	449	1201	748
525	475	.850	455	1201	746
550	480	.820	461	1200	740
575	485	.784	466	1200	734
600	490	.733	472	1199	727
625	493	.721	476	1198	723
650	498	.692	481	1197	718
675	502	.645	485	1197	712
700	505	.642	490	1195	703
750	513	.598	498	1195	697
800	520	.555	514	1194	680
850	527	.521	523	1193	670
900	534	.489	532	1192	661
950	540	.462	540	1191	651
1000	548	.435	547	1189	642
1050	553	.413	550	1187	637
1100	558	.390	564	1185	621
1150	563	.372	572	1183	612
1200	567	.353	579	1182	603
1300	579	.322	593	1176	583
1400	588	.295	606	1172	565
1500	597	.271	619	1167	548
1570	604	.2548	624	1162	538
1670	613	.2354	636	1155	519
1770	621	.2179	648	1149	501
1870	628	.2021	660	1142	482
1970	636	.1878	672	1135	463
2170	649	.1625	695	1119	424
2370	662	.1407	718	1101	383
2570	674	.1213	743	1080	337
2770	685	.1035	770	1055	285
2970	695	.0858	801	1020	219
3170	705	.0580	872	934	62

Steam Flow in Pipes

TEMPERATURE CONVERSIONS—° F and ° C

Enter table at arrow. Numbers in bold type in center of table refer to either ° C or ° F, whichever is being converted into the other scale. If converting from ° C to ° F, equivalent temperature is found in upper section. If converting from ° F to ° C, answer is found in lower section.

°F	-112	-76	-40	-4	14	32	50	68	104	140	176	212	248	284	320	356	392	428	464	500	536	572	608	644	680	716	752
→	**-80**	**-60**	**-40**	**-20**	**-10**	**0**	**10**	**20**	**40**	**60**	**80**	**100**	**120**	**140**	**160**	**180**	**200**	**220**	**240**	**260**	**280**	**300**	**320**	**340**	**360**	**380**	**400**
°C	-62	-51	-40	-29	-23	-17.7	-12.2	-6.6	4.4	15.6	26.8	37.7	49	60	71	83	93	104	115	127	138	149	160	171	182	193	204

REASONABLE VELOCITIES FOR FLUID FLOW THROUGH PIPES

Fluid	Pressure PSI (Gauge)	Service	Velocities—FPM
SATURATED STEAM	0-15	Heating Mains	4000-6000
SATURATED STEAM	50-up	Miscellaneous	6000-8000
SUPERHEATED STEAM	200-up	Turbine and Boiler Leads	10000-15000
WATER	25-40	City Service	120-300
WATER	50-150	General Service	300-600
WATER	150	Boiler Feed	600

LBS./HR. SATURATED STEAM AT 6000 FT./MIN. velocity in iron or steel pipe

Pipe Size (Inches)	PRESSURE PSI (GAUGE)									
	5	10	15	30	50	75	100	125	200	250
½	30	40	45	60	90	120	150	180	270	330
¾	55	70	80	110	160	220	280	340	510	620
1	90	110	125	180	270	390	460	560	840	1020
1¼	160	200	225	325	480	650	820	990	1490	1830
1½	220	270	300	450	660	900	1100	1300	2060	2550
2	370	455	520	750	1100	1500	1900	2300	3450	4200
2½	525	650	750	1050	1600	2175	2750	3300	4950	6050
3	800	950	1350	1600	2500	3350	4250	5150	7700	9450
3½	1100	1350	1550	2200	3400	4550	5700	6900	10200	12700
4	1450	1800	2000	2900	4300	5850	7400	8900	13450	16400
5	2300	2800	3200	4600	6800	9300	11700	14100	21200	26000
6	3200	3900	4500	6400	9800	13200	16800	20300	30800	36900
8	5700	7000	8000	11400	17100	23300	29300	35400	53100	65200
10	9300	11400	13000	18900	28100	38000	48100	58100	87100	106500
12	13500	16600	18900	27000	40700	55300	69700	84200	126500	154700

ASHRAE Method for Sizing Return Lines

Condensate that collects ahead of a steam trap is approximately at saturation temperature and corresponds to the operating pressure. As the condensate (normally above 212°F.) drains into the return line, it must flash to reach saturation temperature at atmospheric pressure. The excess Btu's are released in the form of flash steam in the return lines. The return lines must be sized to handle the volume of steam and condensate at reasonable velocities to minimize any backpressure. The volume of steam is normally several times the volume of condensate and is generally maintained at less than 7,000 feet per minute.

The following tables are for horizontal return lines draining to a return system. Return lines should pitch 1½ in. per 10 ft. of horizontal run. Select the return line size based on the steam operating pressure and the allowable △p/L, psi/100 ft. Selections for 100 and 150 psig steam for either a vented return system or a 15 psig pressurized return system such as a flash tank, deaerator or closed return system.

Example: A condensate return system has a steam supply at 100 psig and the return line is at 0 psig and not vented. The return line is horizontal and must have a capacity of 2500 lbs./hr. What size pipe is required?

Solution: Since the system will be throttling non-subcooled condensate from 100 psig to 0 psig there will be flash steam and the system will be a dry-closed return with horizontal pipe. Select a pressure drop of ¼ psi/100 ft. and use a 2½ in. pipe for this system.

FLOW RATE (lbs./hr.) FOR DRY RETURN LINES

Flow Rate (lbs./hr.)	Supply Pressure= 5 psig Return Pressure=0 psig		
Pipe Size (in.)	△ p/L, psi/100 ft.		
	1/16	1/4	1
½	240	520	1100
¾	510	1120	2400
1	1000	2150	4540
1¼	2100	4500	9500
1½	3170	6780	14,200
2	6240	13,300	a
2½	10,000	21,300	a
3	18,000	38,000	a
4	37,200	78,000	a
6	110,500	a	a
8	228,600	a	a

Flow Rate (lbs./hr.)	Supply Pressure= 15 psig Return Pressure=0 psig		
Pipe Size (in.)	△p/L, psi/100 ft.		
	1/16	1/4	1
½	95	210	450
¾	210	450	950
1	400	860	1820
1¼	840	1800	3800
1½	1270	2720	5700
2	2500	5320	a
2½	4030	8520	a
3	7200	15,200	a
4	14,900	31,300	a
6	44,300	a	a
8	91,700	a	a

Flow Rate (lbs./hr.)	Supply Pressure= 30 psig Return Pressure=0 psig		
Pipe Size (in.)	△p/L, psi/100 ft.		
	1/16	1/4	1
½	60	130	274
¾	130	280	590
1	250	530	1120
1¼	520	1110	2340
1½	780	1670	3510
2	1540	3270	a
2½	2480	5250	a
3	4440	9360	a
4	9180	19,200	a
6	27,300	a	a
8	56,400	a	a

Flow Rate (lbs./hr.)	Supply Pressure= 50 psig Return Pressure=0 psig		
Pipe Size (in.)	△p/L, psi/100 ft.		
	1/16	1/4	1
½	42	92	200
¾	91	200	420
1	180	380	800
1¼	370	800	1680
1½	560	1200	2520
2	1110	2350	a
2½	1780	3780	a
3	3190	6730	a
4	6660	13,800	a
6	19,600	a	a
8	40,500	a	a

Flow Rate (lbs./hr.)	Supply Pressure= 100 psig Return Pressure=0 psig		
Pipe Size (in.)	△p/L, psi/100 ft.		
	1/16	1/4	1
½	28	62	133
¾	62	134	290
1	120	260	544
1¼	250	540	1130
1½	380	810	1700
2	750	1590	a
2½	1200	2550	a
3	2160	4550	a
4	4460	9340	a
6	13,200	a	a
8	27,400	a	a

Flow Rate (lbs./hr.)	Supply Pressure= 150 psig Return Pressure=0 psig		
Pipe Size (in.)	△p/L, psi/100 ft.		
	1/16	1/4	1
½	23	51	109
¾	50	110	230
1	100	210	450
1¼	200	440	930
1½	310	660	1400
2	610	1300	a
2½	980	2100	a
3	1760	3710	a
4	3640	7630	a
6	10,800	a	a
8	22,400	a	a

Flow Rate (lbs./hr.)	Supply Pressure= 100 psig Return Pressure=15 psig		
Pipe Size (in.)	△p/L, psi/100 ft.		
	1/16	1/4	1
½	56	120	1100
¾	120	260	2400
1	240	500	4540
1¼	500	1060	9500
1½	750	1600	14,200
2	1470	3100	a
2½	2370	5000	a
3	4230	8860	a
4	8730	18,200	a
6	25,900	53,600	a
8	53,400	110,300	a

Flow Rate (lbs./hr.)	Supply Pressure= 150 psig Return Pressure=15 psig		
Pipe Size (in.)	△p/L, psi/100 ft.		
	1/16	1/4	1
½	43	93	200
¾	93	200	420
1	180	390	800
1¼	380	800	1680
1½	570	1210	2500
2	1120	2350	4900
2½	1800	3780	7800
3	3200	6710	a
4	6620	13,800	a
6	19,600	40,600	a
8	40,500	83,600	a

a For these sizes and pressure losses, the velocity is above 7000 fpm. Select another combination of sizes and pressure loss.

System Problems that Cause Poor Temperature Control

Improper Regulator Sizing
Oversized regulators will increase temperature overshoots and cause the regulator to hunt. The result produces temperature variations from set point. The regulator should be sized to handle the maximum system load without adding safety factors.

Sensing Bulb Location
The regulator sensing bulb must be fully inserted in the fluid being controlled. On tanks, use a bushing to reduce the tank connection to match the bulb. Avoid nipples and couplings. For piping, install in straight run of tee with bushing. Flow should be through the side outlet of the tee. Locate as close to heat exchanger outlet as possible.

Trap Installation
The steam trap should be installed at least 15 inches below the equipment being drained and should drain by gravity into a vented condensate return unit. Lifting of condensate to overhead returns must be avoided at all cost. Any lifts will allow condensate to return to the steam space during light load or start up. Condensate backing up into the steam space will cause water hammer and damage heat exchangers, regulators and traps.

Trap Sizing
An undersized steam trap will cause condensate to back up into the heat exchanger. When this happens, the regulator must open wider and increase the pressure so that the trap can drain the condensate. If a sudden load change occurs, this can cause a temperature overshoot. **Steam traps used with modulating temperature regulators should be sized to handle the maximum condensate load at 1/2 psi differential pressure.** The trap must be 15 inches below the condensate outlet and drain by gravity to a vented condensate unit. Traps installed 7 inches below the condensate outlet should be sized at 1/4 psi differential.

Drip Traps
To drain any condensate in the steam line, install drip traps in the steam line upstream of the regulator. Condensate in the steam line can cause water hammer and damage to the regulator. On pilot operated valves, condensate can cause the regulator to respond slowly because condensate must drain through small orifices.

Pipe Sizing
The steam pipe and return line should be sized properly for the system load. See charts in this manual for pipe sizing.

Classification of Hot Water Heaters

Storage Heaters
Storage heaters have a large tank and a steam coil in the tank, or a separate shell and tube heat exchanger with a circulating pump. A temperature regulator senses the tank temperature. Cold water is added directly into the storage tank. The tank usually has 10 to 20 minutes' reserve capacity, and temperature change occurs gradually. Systems with storage tanks may have a recirculating pump to provide continuous recirculation of system water.

Semi-Instantaneous Heaters
Semi-instantaneous heaters have a small tank and either a steam coil in the tank, or a separate shell and tube heat exchanger and a circulating pump. The buffer tank should have a minimum of one gallon of storage for every GPM of system draw rate. Larger tanks may be used where system storage is desired. Temperature changes can occur quickly. If system load changes, pneumatic regulators are recommended.

Semi-instantaneous systems may have recirculating pumps to provide continuous recirculation of system water. A minimum recirculation of 20% of design flow rate is recommended.

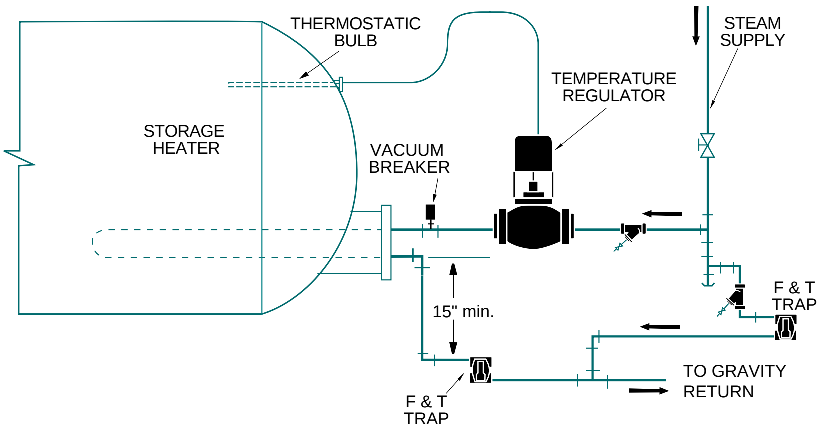
Instantaneous Heaters
Instantaneous heaters do not have a storage tank. Water is heated directly in a heat exchanger and sent to the system. As hot water is drawn off in the system, it is replaced directly in the heat exchanger with cold water. This causes sudden temperature changes. Pneumatic regulators should be used where possible, as they have faster response time. When instantaneous heaters are used for domestic hot water, separate anti-scald protection should be provided. Instantaneous heaters should have recirculating pumps. The recirculating return line should be at least 50 feet long, and the pump should recirculate at least 20% of the system draw rate.

Control Selection Guidelines

Typical Guidelines for Selection of Temperature Regulators
The degree of temperature variation depends on load change. The chart below is based on 0% through 100% load change.

TYPE OF HEATER	APPLICATION	TYPE OF REGULATOR
Instantaneous Heater	Domestic Hot Water	Series 2000 with pneumatic pilot for ± 4 deg. F. (must be used with anti-scald protection)
	Process fluids	Series 2000 with pneumatic pilot for ± 4 deg. F. Series 2000 with STPA pilot for ±10 deg. F. (System recirculation is recommended)
	Wash down stations	Same as process fluids (Pneumatic recommended if available)
	Steam to water converters	Series 1140 or Series 2000 with either direct or pneumatic operated pilots. ± 10 deg. F. accuracy.
Semi-instantaneous Heater	Domestic hot water	Series 2000 with pneumatic temperature pilot ± 4 deg. F. accuracy (must be used with anti-scald protection)
Storage Heater	Process fluids	Series 2000 with pneumatic temperature pilot ± 4 deg. F. accuracy Direct-operated pilots ± 10 deg. F. accuracy.
	Wash down stations	Same as process fluids

Application - Control of Temperature with Regulator



Control of hot water temperature in a storage tank with a steam coil in the tank.

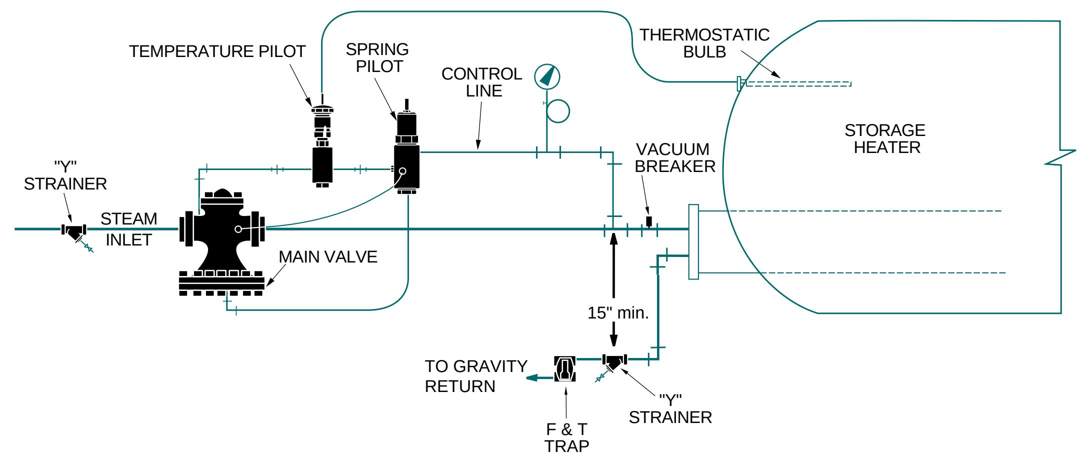
System Operation:
The sensing bulb on the temperature regulator senses the storage tank temperature. On a drop in temperature, the regulator opens. On an increase in temperature, the regulator closes.

For domestic hot water service double seated valves should be avoided. Double seated valves do not close tight and may cause overheating during periods of no demand.

Benefits:
A self-contained regulator is inexpensive, simple to use and easy to adjust. The storage tank provides hot water during peak loads and prevents a wide temperature fluctuation. Temperature changes occur gradually as hot water is drawn for the system and is a recommended practice for domestic hot water service.

The 1140 Temperature Regulator is normally open, thus it provides a minimal pressure drop making it ideal for steam pressures less than 5 psig. It has a 40 degree F. adjustable range.

Application - Control of Temperature with Main Valve and Spring and Temperature Pilots



Steam to domestic hot water storage tank system featuring a main valve with spring and temperature pilots and storage tank heater.

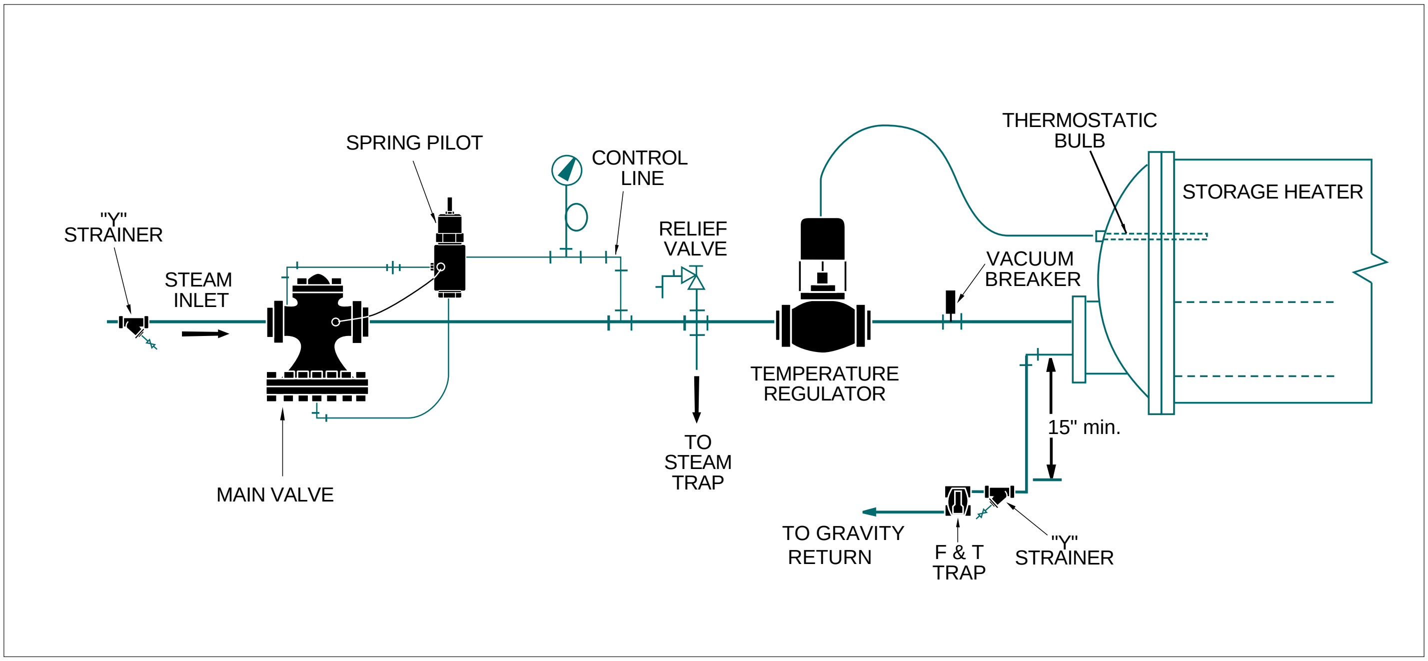
System Operation:
The spring pilot is set to maintain a maximum steam pressure leaving the regulator to match the specification of the coils.

Variations in temperature of stored water will be sensed by the thermostatic bulb, and the temperature pilot will modulate the main valve to maintain the set temperature.

Benefits:

- Pilot operation assures quick, accurate response to load changes.
- Thermostatic bulb in storage tank guards against over temperature.
- Pressure reduction and temperature control are accomplished by a single main valve and pilot combination.
- Controlling maximum pressure in the steam coil limits the condensate temperature from the steam trap to reduce flash steam loss.
- A solenoid pilot and aquastat may be added as a safety control. The aquastat is normally set 5°F. higher than the normal tank set temperature.

Application - Control of Temperature with Main Valve and Spring Pilot



Pressure regulating valve and low pressure temperature regulator with a main valve and spring pilot.

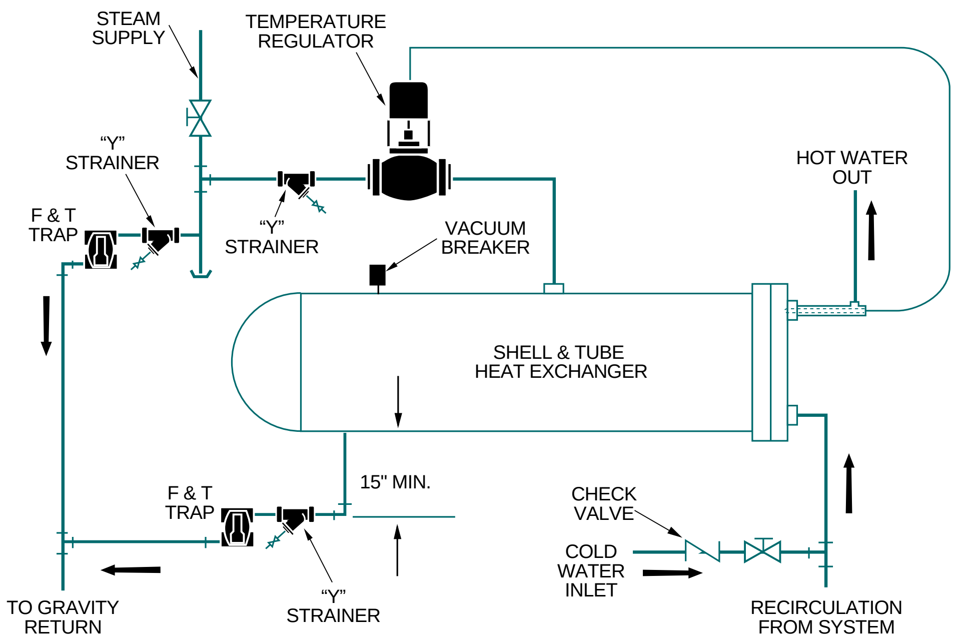
Spring pilot is set to maintain pressure setting for a low pressure temperature regulator.

System Operation:
Main valve maintains tight shut-off until temperature regulator calls for steam to raise storage tank temperature.

Benefits:

- Main valve provides dead end service.
- Main valve can be installed in header servicing other low pressure devices.
- Low pressure operation minimizes steam temperature and reduces possibility of temperature overshoots.
- Low pressure operation reduces condensate temperature and reduces flash steam losses.

Application - Shell and Tube Heat Exchanger, Instantaneous Type



Steam to hot water converter for hydronic heating system featuring a self-contained temperature regulator such as Hoffman Series 1140. Recommended for low pressure applications.

With a system recirculating pump the system acts as a buffer to reduce sudden temperature changes.

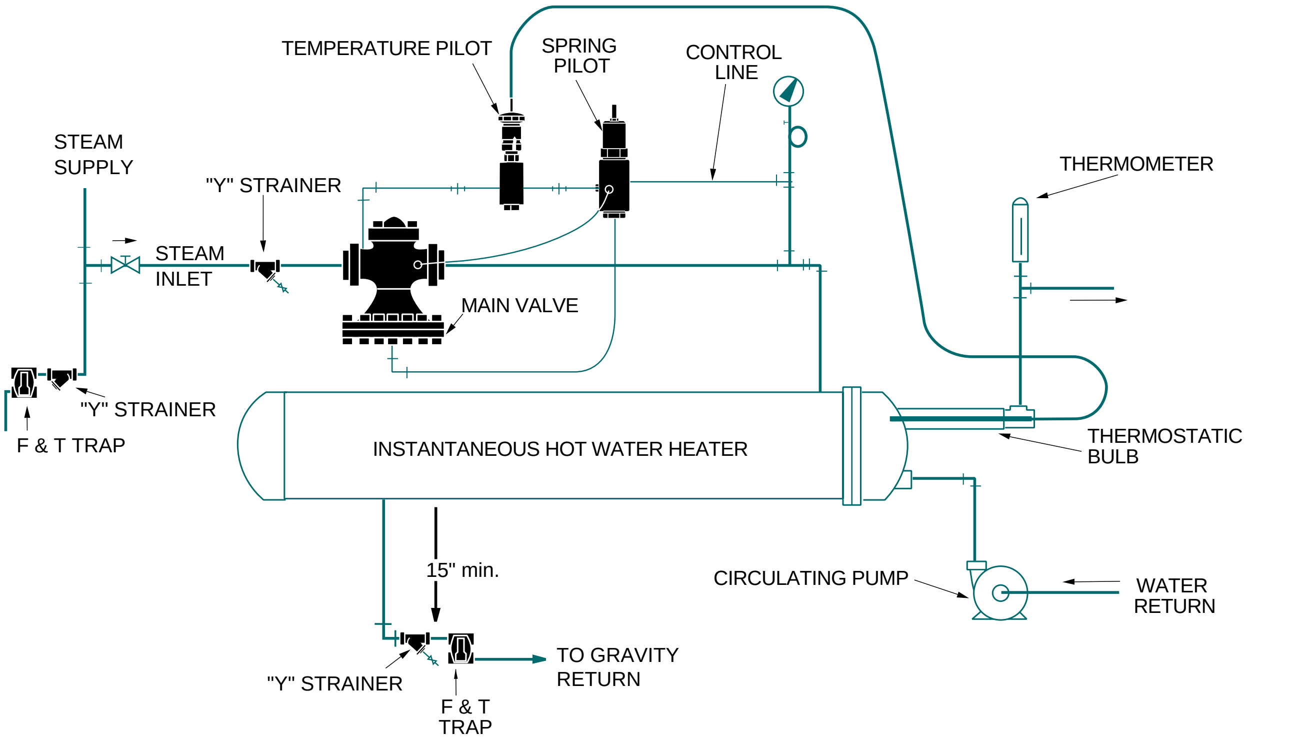
System Operation:
Fluid pumped through heat exchanger tube is heated by controlling steam in shell of heat exchanger.

Recirculating pump should be sized to recirculate a minimum of 20% of system design load. Heated return water blends with cold water make-up to reduce temperature fluctuations.

Benefit:
Hot water can be generated without storage tanks for non-critical temperature applications such as steam to hot water converters for hydronic heating systems.

Note:
Instantaneous heat exchange applications not having a storage tank should be avoided where close temperature ranges are required, this is particularly true where demand loads may charge quickly. Pneumatic temperature regulators provide the fastest response. Critical applications should use storage tanks equipped with single seated valves.

Application - Conversion of Steam to a Hydronic Heating System



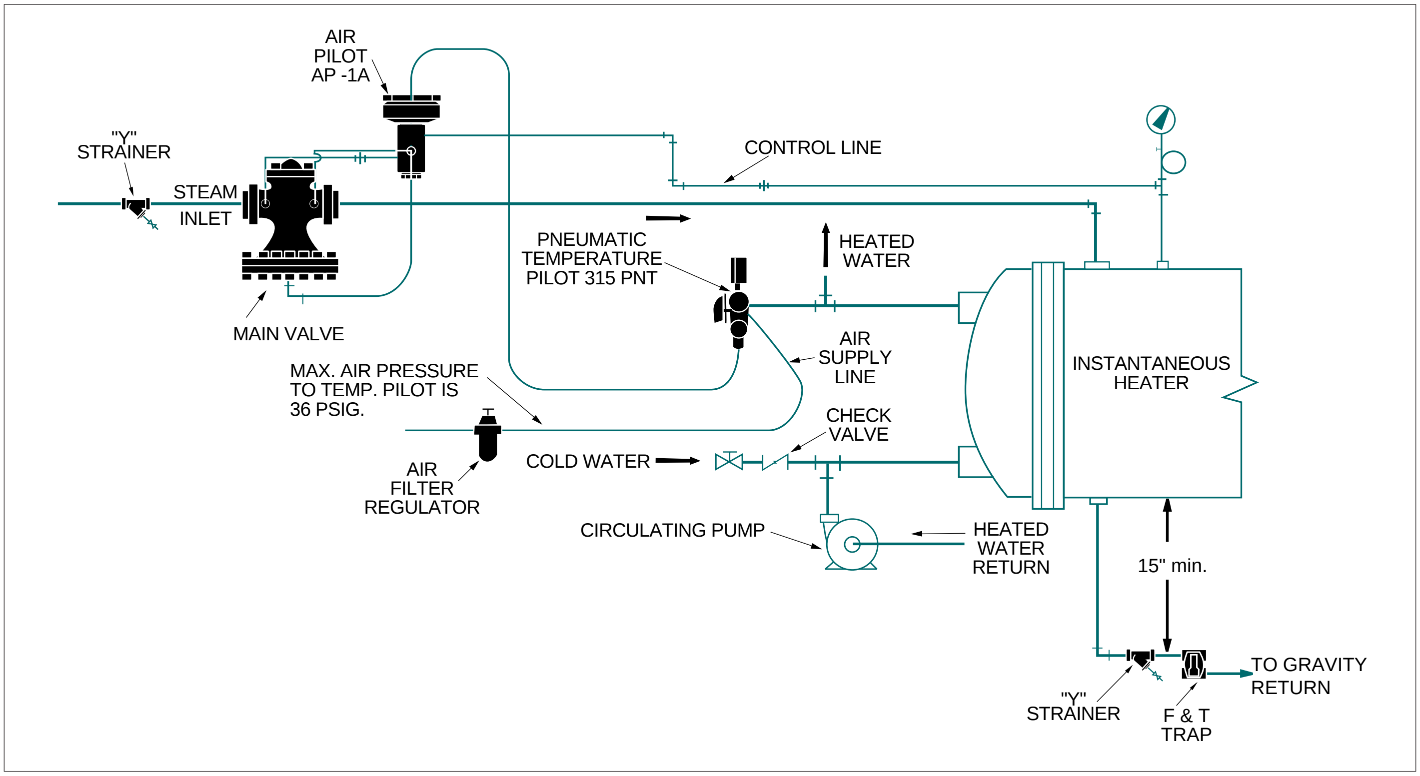
Steam to hot water converter for hydronic heating system with main valve and spring and temperature pilots. Recommended for high pressure steam applications.

System Operation:
Spring pilot controls steam pressure to converter on start-up. As thermostatic bulb senses a temperature rise, temperature pilot signals main valve to modulate and maintain a constant temperature at the converter outlet.

Benefits:

- Eliminates need for separate pressure reducing valves and temperature regulator.
- Self-contained system. No external power source required.
- For economical operation, main valve modulates to maintain set temperature at converter.
- Solenoid pilot can be added for shut off. Solenoid pilots may operate in response to aquastats, flow switches, timers, etc.
- Spring pilot may be set to limit maximum steam pressure in the shell. Limiting this pressure also limits the condensate temperature leaving the steam trap and increases system efficiency.
- Economical and reliable conversion method for better control of heating.

Application - Pneumatic Temperature Pilot for Instantaneous Heater Recirculation System



Instantaneous heater recirculation system with main valve and pneumatic temperature and air pilots.

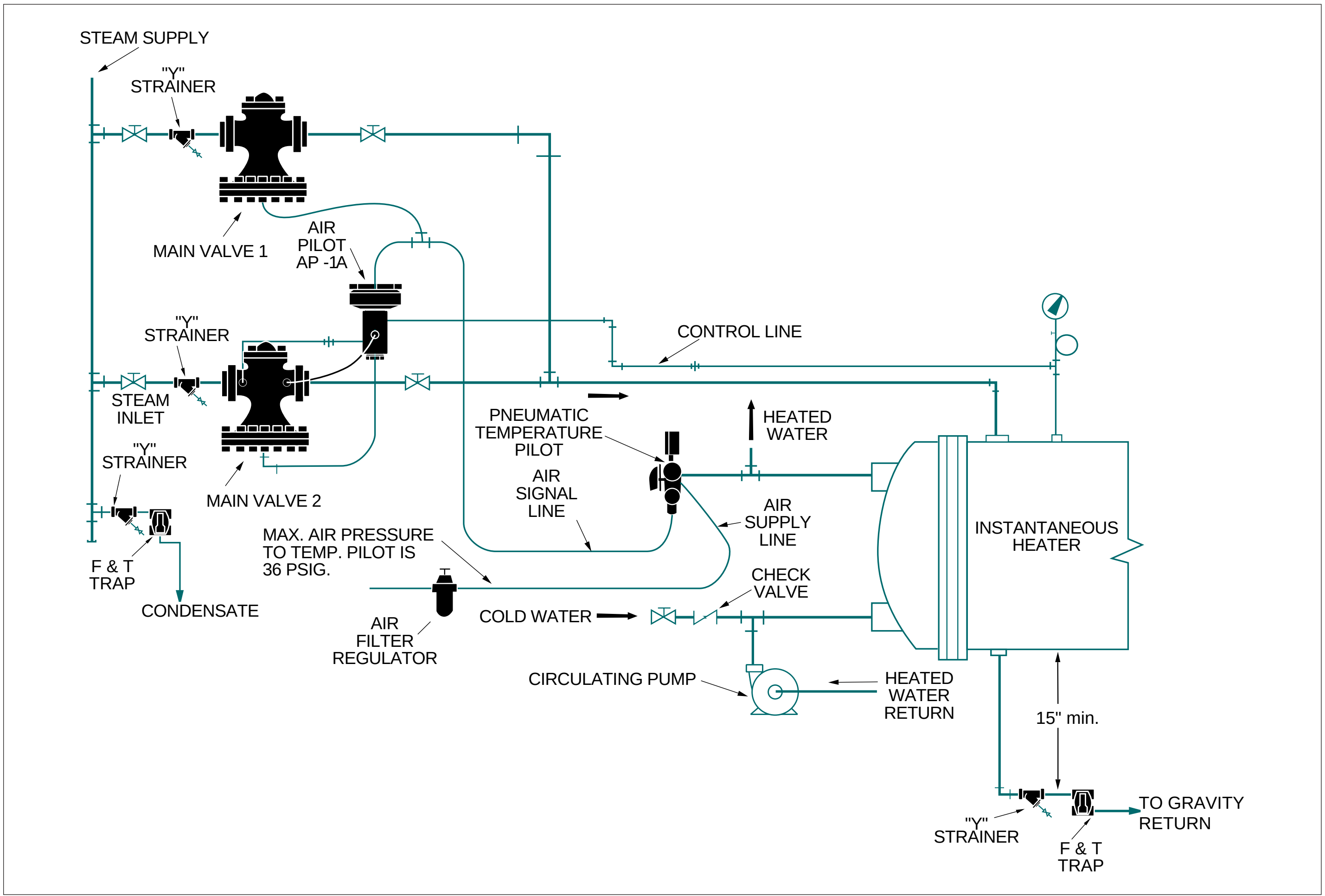
System Operation:
Pneumatic temperature pilot quickly senses changes in temperature in a recirculating system and signals the air pilot to modulate the main valve to maintain system temperature.

Benefits:

- Fast-acting temperature control for rapidly changing loads.
- Provides operator advantage of shutting system down simply by stopping inlet air signal to air pilot.
- Pneumatic temperature pilots can be remotely located, long distances from the main valve.
- Wide, adjustable temperature range.

Note:
Maximum outlet steam pressure will be 9 psi less than air supply from the pneumatic temperature pilot. With a maximum 30 psi air supply, the maximum steam pressure will be 21 psig using Hoffman AP-1A air pilot. Using a Hoffman AP-4A air pilot, outlet pressures may be as high as 84 psig. Using an air PRV to limit the air pressure from the pilot will also limit the maximum steam pressure in the heat exchanger shell. Limiting steam pressure also limits the condensate temperature from the trap and improves system efficiency by reducing flash steam loss.

Application - Pneumatic Temperature Pilot Maintains Temperature in Instantaneous Heater Recirculation System with Varying Load Conditions



Instantaneous heater recirculation system with two main valves and pneumatic temperature and air pilots. Controlled from single set point.

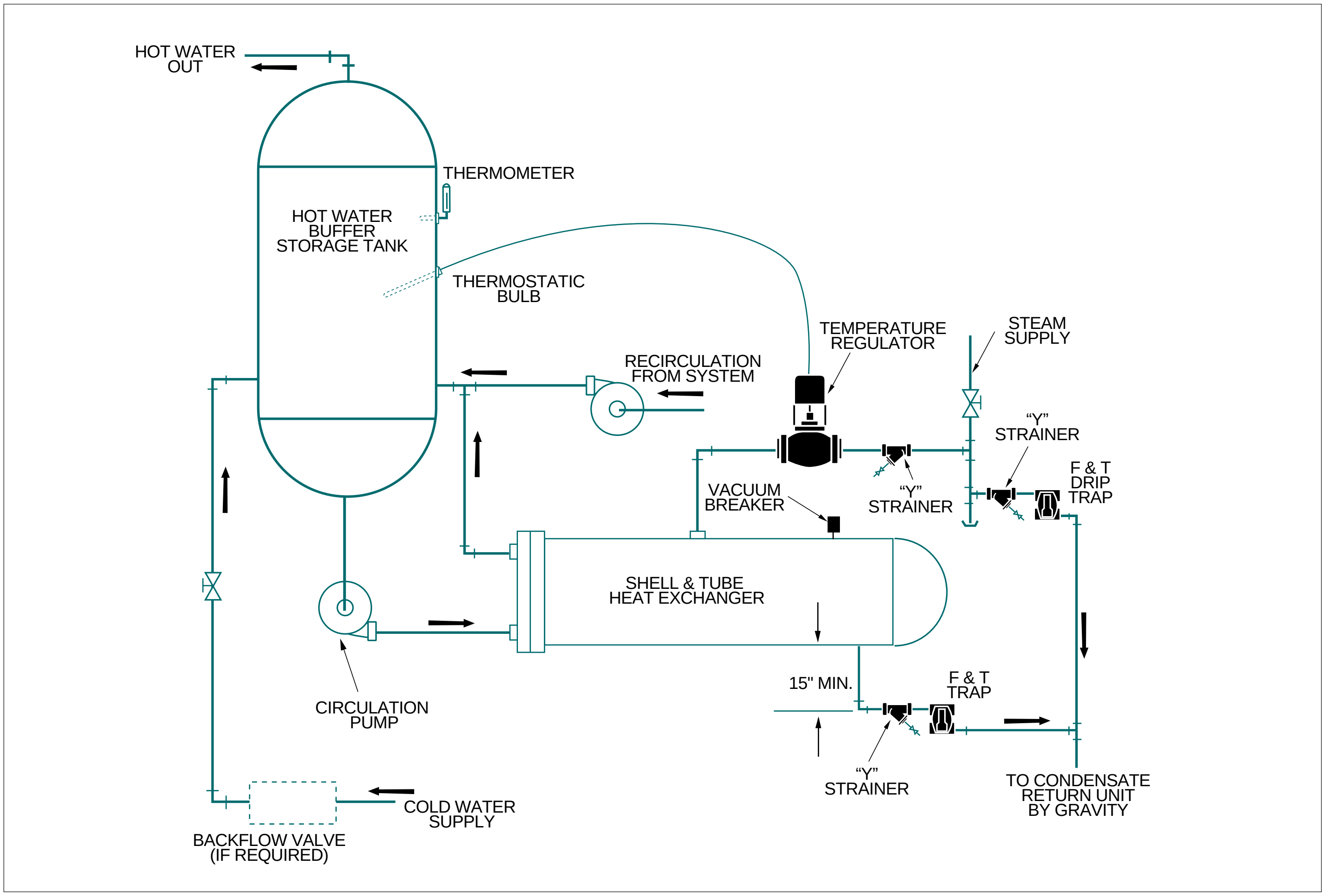
System Operation:
A pneumatic temperature pilot quickly senses a change in temperature and increases outlet signal pressure. From an approximately 5 psi signal, no. 1 main valve begins to open. As temperature continues to drop, the outlet pneumatic signal pressure continues to increase. At approximately 9 psig signal, air pilot begins to open which, in turn, begins to open main valve no. 2.

Benefits:
- Fast acting temperature response using pneumatic signal.
- During light loads only main valve no. 1 operates, during heavy loads both valves operate. This reduces possibility of wire draw on valve seats and reduces temperature swings as flow rates change.
- Wide adjustable temperature range.

Notes:
1. Maximum outlet steam pressure using this system will be 9 psi less than air supply pressure from, for example, Hoffman 315 PNT. With maximum 30 psi supply from 315 PNT, maximum outlet steam pressure will be 21 psig.

2. Consult factory for proper sizing of valves when direct loading air from pneumatic temperature pilots.

Application - Shell & Tube Heat Exchanger with Large Storage Tank Heater



Hot water storage tank using an external shell and tube heat exchanger to heat water in storage tank. A circulating pump circulates water from the tank through heat exchanger.

System Operation:
Buffer storage tank provides reserve hot water for peak loads and prevents wide temperature fluctuations.

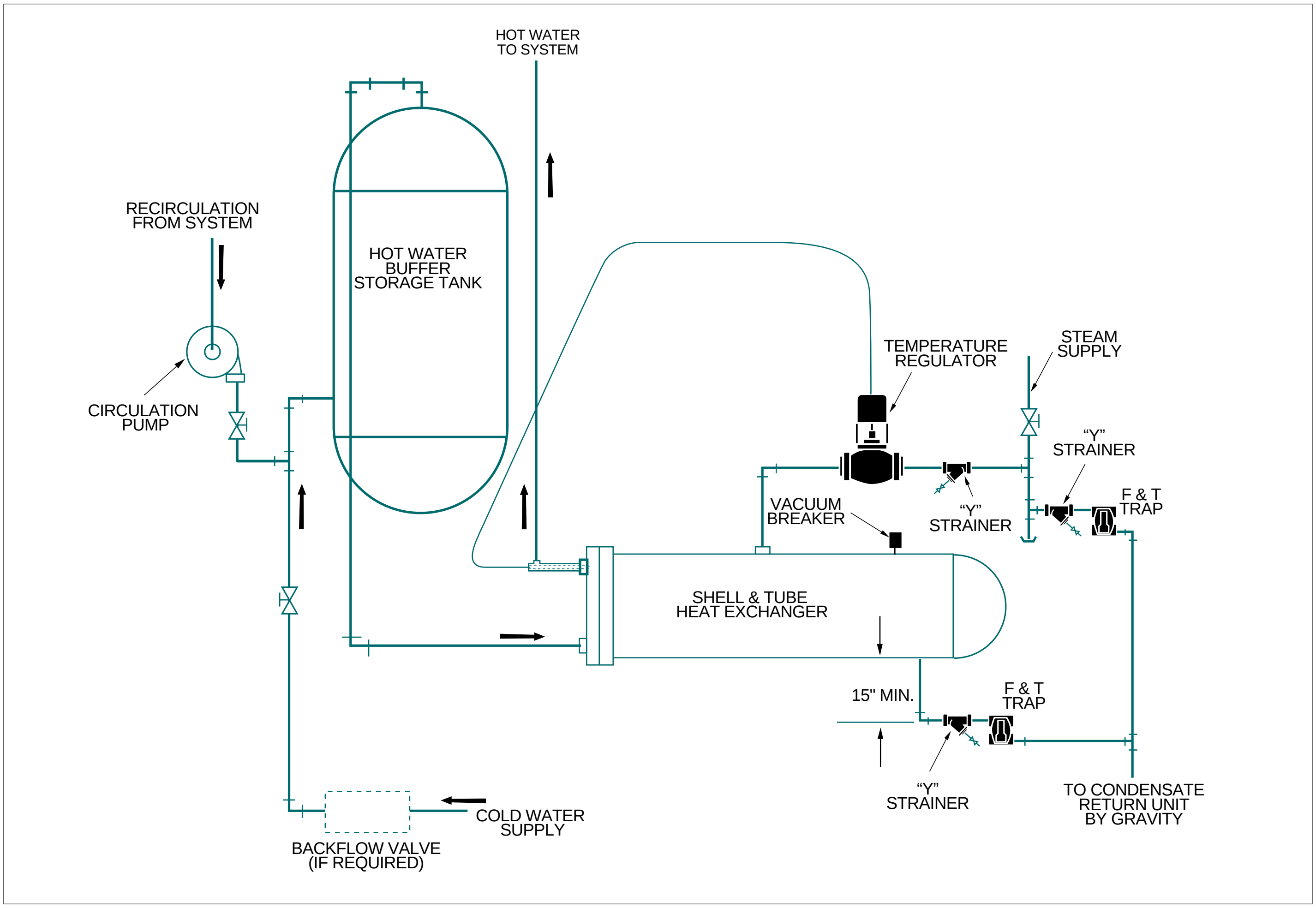
Standard shell and tube heat exchangers can be provided to replace obsolete tube bundles on old systems.

Temperature is controlled in storage tank. Due to large storage, temperature changes occur gradually, allowing regulator time to react and maintain tight temperature control.

System recirculating pump maintains hot water availability to remote points in the system.

Benefits:
Existing storage tanks with more than five minutes' storage capacity can be upgraded by replacing tube bundle with shell and tube heat exchanger. Hot water capacity of existing tanks can be increased through proper selection of new heat exchanger.

Application - Shell & Tube Heat Exchanger with Small Buffer Tank



Shell and tube instantaneous heat exchangers can be used to provide constant temperature in a system without large storage tanks.

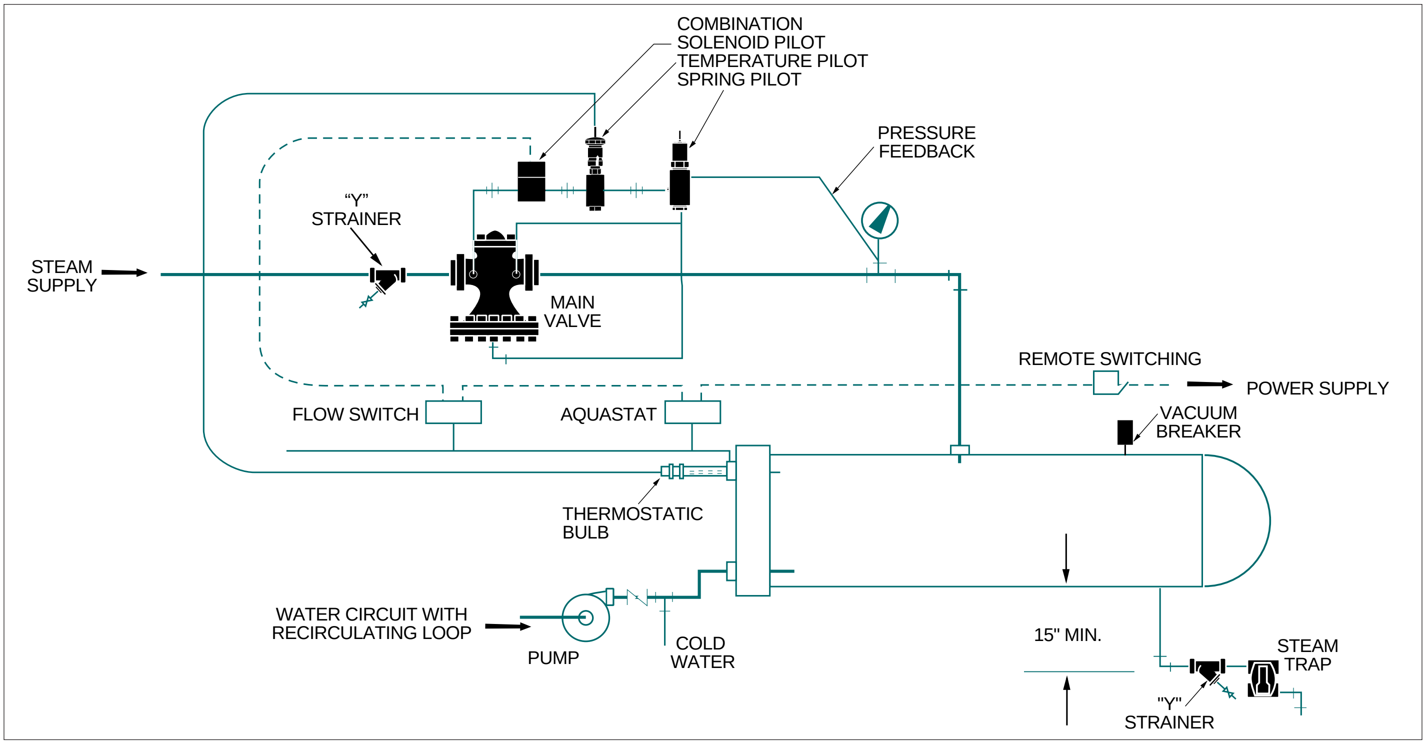
System Operation:
Small buffer storage tank blends hot and cold water to smooth load transitions and prevent wide temperature fluctuation.

Small buffer tank is used to blend make up water and system returns flowing into a shell and tube heat exchanger. Constant system recirculation is required to prevent temperature fluctuations. The recirculating pump should be sized for a minimum of 20% of system draw rate.

Benefit:
Standard heat exchangers save additional cost and space requirements of large storage tanks.

Small buffer tank systems with one to five minute reserves help smooth out load transitions caused by changes in flow rates. Instantaneous heat exchangers without buffer tanks usually cause momentary temperature fluctuations as flow rates or loads change.

Application - Temperature Control with Main Valve, Combination Solenoid/Temperature Pilot, Spring Pilot and Aquastat



System regulation with main valve, combination solenoid/temperature pilot, spring pilot and aquastat for safety override.

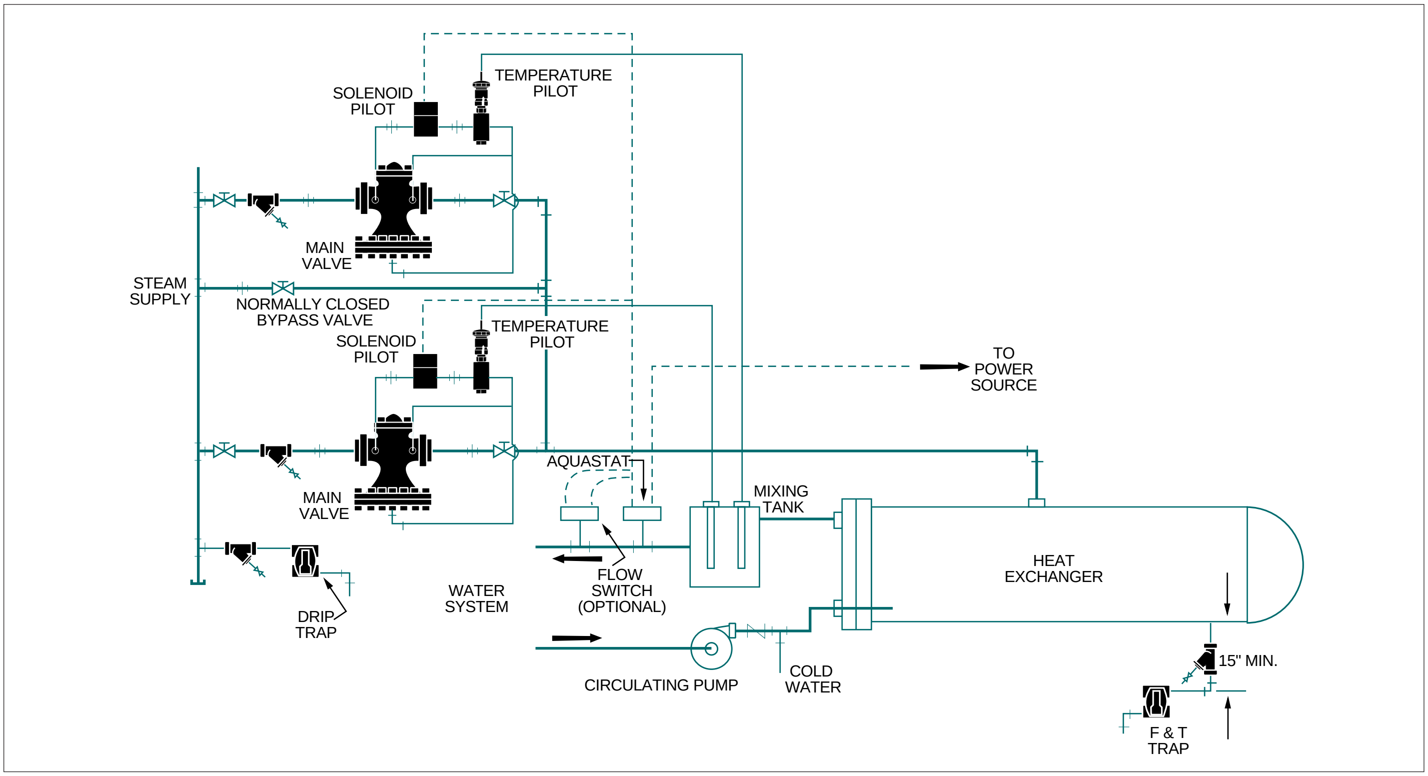
System Operation:
The main valve with a combination of spring, temperature and solenoid pilots controls the supply pressure to the heat exchanger and the temperature of liquid flowing through the heat exchanger. If the temperature rises a few degrees above the set point on the temperature pilot, the aquastat shuts down steam flow to the heat exchanger.

A main valve such as Hoffman Series 2000 is sized to handle maximum conditions of the system. This application uses a normally closed solenoid pilot wired to a flow switch, aquastat, and remote switch. The aquastat is set 5 - 10˚F. above the control temperature. When the remote switch is turned on and the temperature of the liquid is below the aquastat set point temperature and liquid is flowing across the flow switch, the solenoid pilot is energized.

If any of the three conditions mentioned are not met, the system will shut down. This fully automatic type system should be used where temperature limits on processes are critical. This application can also be used as a safety override for other systems such as domestic hot water.

Benefits:
- Temperature/pressure regulation is maintained with just one valve.
- Temperature safety override is built in.
- No flow safety override.
- May be wired into recirculating pump contactor to shut off steam flow in the event of power loss or if pump is shut off.

Application - Temperature Control with Two Main Valves and Temperature Pilots



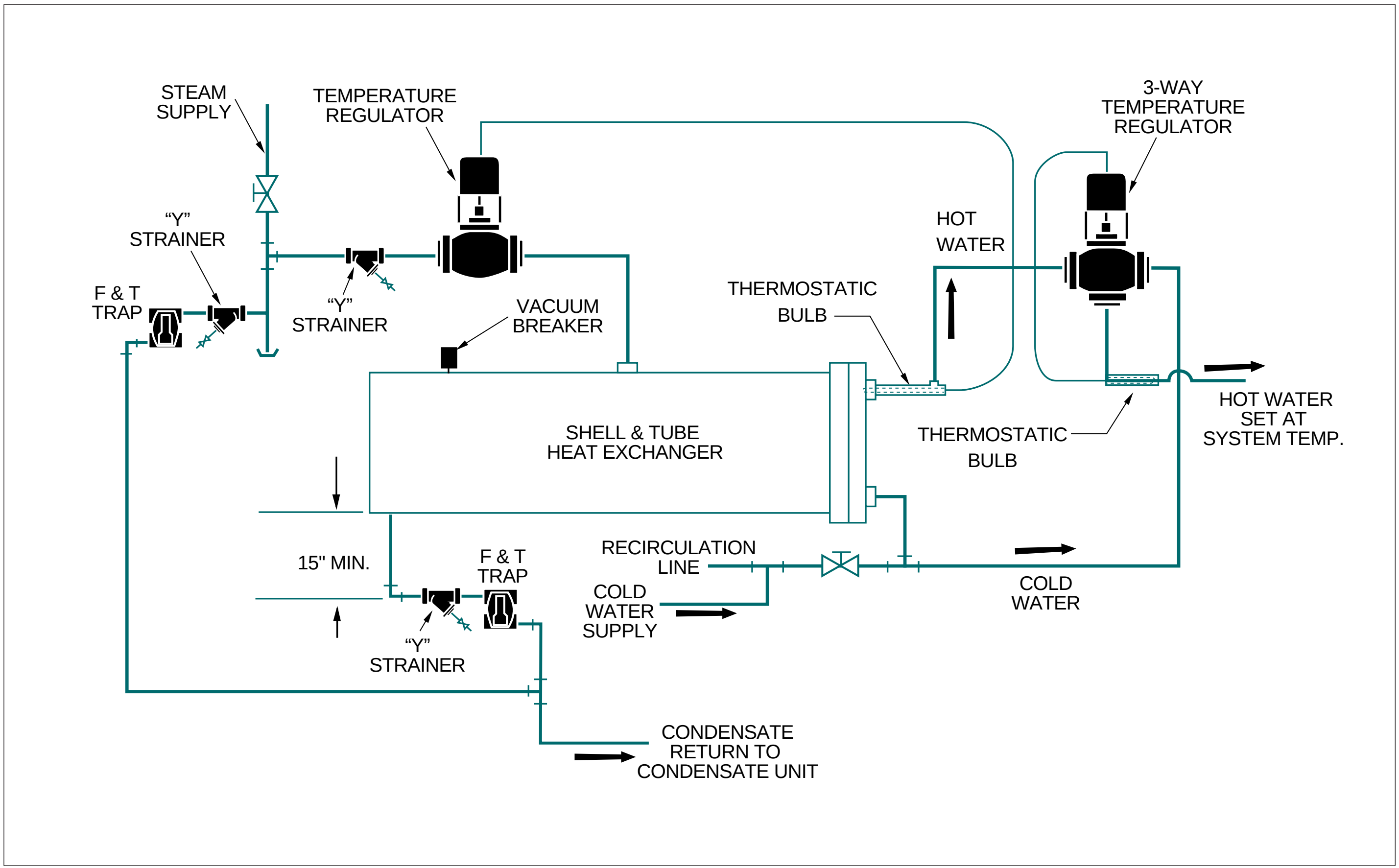
Domestic hot water system designed to handle peak loads and low demand periods. Uses two main valves in parallel with temperature and solenoid pilots.

This system configuration provides reduced steam capacity during low periods and also gives high temperature limit control.

System Operation:
Two regulators with temperature/solenoid pilot combinations are sized for maximum (heat exchanger) flow. One of the regulators is sized for "off peak" demand. Temperature setting for this regulator would be set 5° F. above the second valve in this system. During peak demand, both regulators supply steam to heat exchanger to heat water flowing through it. As demand for water drops, temperature rise satisfies pilot of larger regulator and shuts it off. Then, only smaller valve supplies steam to heat "off peak" demand, thus saving energy. Aquastat and solenoid valves are provided as a safety override should temperature rise beyond set point of temperature pilots. An optional flow switch may be used to shut steam off during no flow. Two Hoffman Series 2000 main valves are shown here.

Benefits:
- Automatic control of water temperatures.
- Stable temperature control for off peak demand.
- Safety override provided for temperature control.
- Fast-acting temperature control to handle rapidly changing loads.

Application - Instantaneous Heater using 3-way Mixing Valve for Stand-by Protection

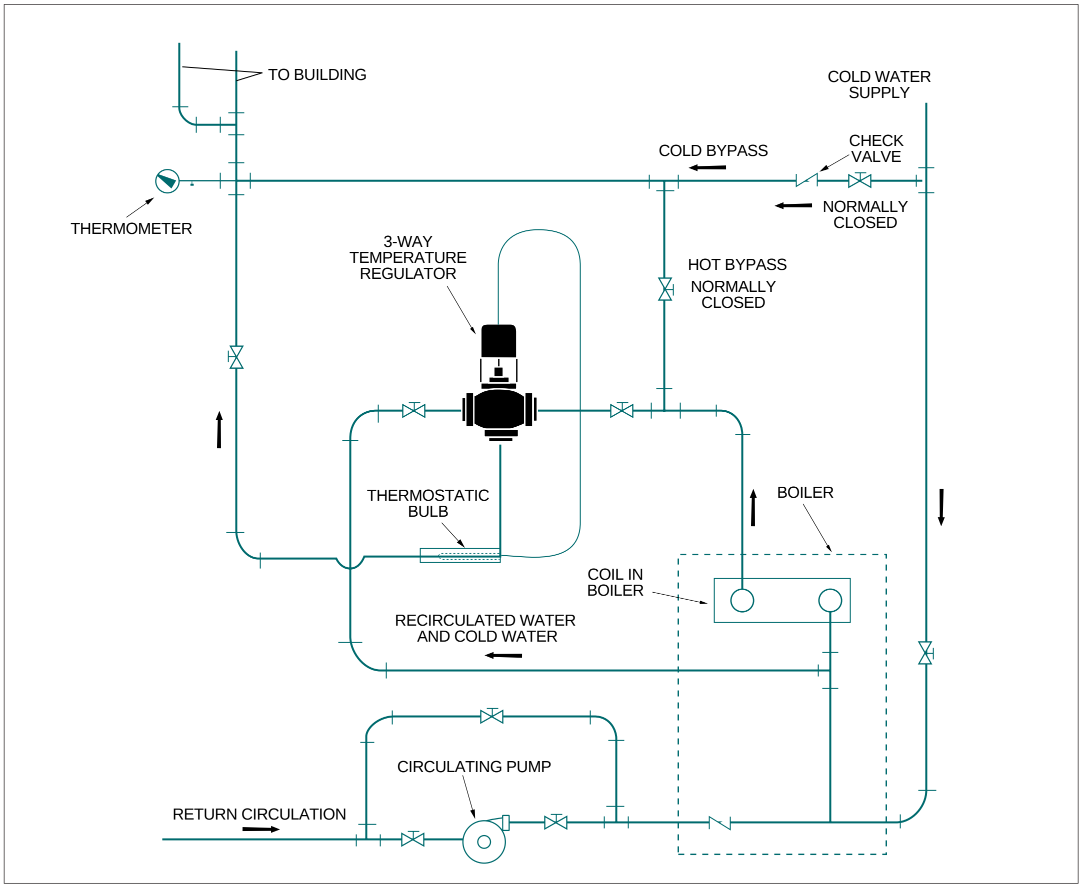


Shell and tube heat exchanger using a 2-way valve to control hot water temperature plus a 3-way valve to provide hot and cold mix for safety override.

System Operation:
Water is heated in heat exchanger to approximately 10 deg. F. above design temperature. A 3-way mixing valve then mixes hot and cold water to design temperature.

Benefit:
In the event of a temperature regulator failure, the outlet temperature is limited. This should be used in conjunction with alarms to indicate failure of either regulator.

Application - Control of Domestic Hot Water from Coil in Hot Water or Steam Boiler to Reduce Temperature



Heating coil in boiler provides hot water. Three-way valve mixes hot water with cold water to regulate temperature.

System Operation:
Temperature regulator is set to maintain required hot water temperature. Circulator pump running continuously provides flow across the sensing bulb to operate the regulator.

Benefit:
Heating boiler may be used to generate hot water.

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1) The tissue in plants that brings water upward from the roots;
2) a leading global water technology company.

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