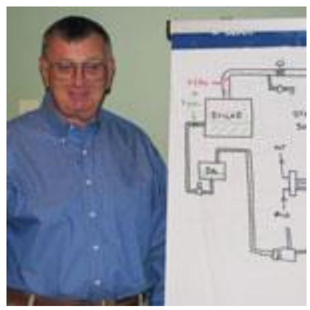
TABLE OF CONTENTS

Steam Distribution and Primary Equipment

Index

BIOGRAPHY OF EDWARD MOSCHETTI

Edward brings over 50 years of knowledge and experience to the manufacturing, medical, university, and commercial arenas. His education background includes a degree in physics from Muhlenberg College. The last 30 years have been devoted to providing solutions to industrial facilities geared around plant utilities and processes. He has spearheaded energy teams in major corporations resulting in the savings of energy dollars as well as building/designing small to medium size boiler facilities.



PREFACE

In our prior eBook, “**Boiler Plant Operations and Tips**”, we discussed steam boilers, how to achieve maximum efficiencies, and related boiler room equipment. In this eBook, we will discuss steam systems and the equipment that makes up an efficient, functioning system. As we discussed, a steam system consists of a steam-supply/boiler facility, a condensate return system, and lastly a steam-using facility with various steam applications. In this eBook on systems and related equipment, our discussion will be focused on the integration of various types of equipment that lies within a steam system. Our years of experience have allowed us to identify major issues with equipment and the selection and design of a system, which will hopefully allow you to develop some guidelines to avoid equipment pitfalls - thus unnecessary expense and downtime. Some of our suggestions will revolve around modifying existing systems and other considerations that may apply to the design of a new system.

Chapter 1- What is a Steam System

Chapter 1 Highlights – In our EBook entitled "Boiler Plant Operations and Tips" we covered the basics of steam, definitions, terms, boilers and steam production. A review of that EBook might be helpful to get you up to speed with the basics of steam and its production.

- **The Boiler Plant conditions feedwater which is fed to boilers to produce steam for use in a facility.**
- **The Steam Distribution System includes all of the piping and valves to route the steam in your facility for consumption**.
- **The Equipment Consumption Systems are used to convert the energy dollars spent to produce steam to production dollars.**
- **The Condensate Return System gathers the spent steam, which is hot conditioned water (condensate), and returns it to the boiler plant to make more steam.**
- **To better understand how widespread the use of steam is, take a moment right now and take a quick 360 degree scan around yourself. I would venture a safe guess that most everything you looked at that was manufactured had contact with steam at some point.**
- **The US Department of Energy has a great website covering many facets of a steam system and is a great source of information. Visit it at www.energy.gov/eere/amo/steam-systems**
- **I will try my best to stay above the sales fray and share with you what I've learned in designing, working with, trouble shooting, and in general improving steam systems.**
- **Let the fun begin!**

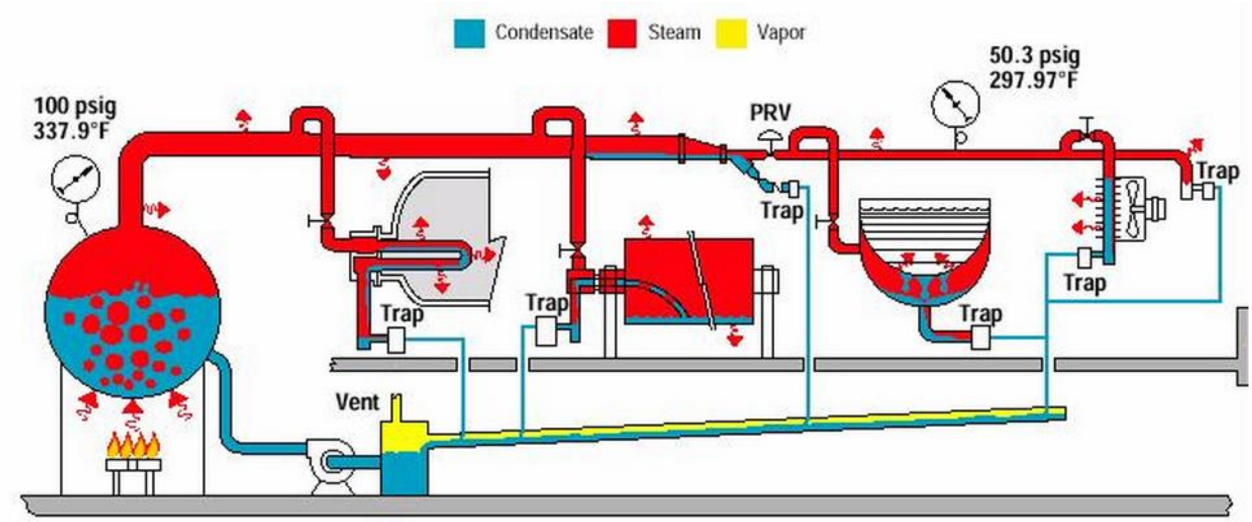
In our EBook entitled "Boiler Plant Operations and Tips" we covered the basics of steam, definitions, terms, boilers and steam production. A review of chapter 1 of that EBook might be helpful to get you up to speed with the basics of steam and its production. Highlights of that first chapter include –

- Thermal energy (heat) is hard to measure other than something is hot or cold. The measurement decided on was the British Thermal Unit (BTU), which was defined as the amount of energy to raise the temperature of one pound of water one degree Fahrenheit.

- With our steam heat transfer media let us examine the BTU, and the many sources of a BTU by burning a substance, from a great chart from the website Engineering Tool Box.
- The most common device used to produce steam is a boiler, which burns a fuel, which in turn boils water under pressure to produce steam. Stationary boilers powered industry and ships while movable boilers became steam locomotives. About 25% of all fuel consumed is used to make steam.
- Over a wide range of pressure, the Total Enthalpy remains for a pound of steam about 1200 Btu's per pound, but as the pressure increases, along with the temperature, the amount of energy to boil a pound of water decreases. Stated in a few words, as the temperature rises the amount of energy in a pound of steam goes down!
- Thermal energy (heat) flows from hot to cold. The amount of heat which will flow depends on the materials and other factors, but the temperature difference is a major issue. As a general rule of thumb this temperature difference should be about 50° F. As an example, if we wish to heat something to 290° F, we should have steam at a temperature of about 340° F (290° F + 50° F). Steam at 100 psig has a temperature of 338° F-close enough.

With that introduction let me define the sub systems which make up steam systems:

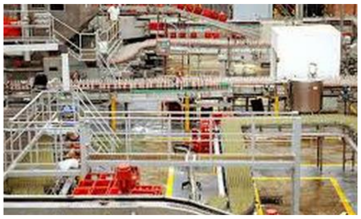
- The Boiler Plant conditions feedwater, which is fed to boilers to produce steam for use in a facility. For most steam systems, condensate is returned to the boiler plant to be re-used to produce more steam.
- The Steam Distribution System includes all of the piping and valves to route the steam in your facility for consumption. It typically also might contain flow meters, pressure reducing valves, and other equipment to monitor the status and condition of the distribution system. The boiler plant typically represents the largest capital investment. In many cases, in large steam systems, the distribution system also represents a significant capital investment. Steam is typically distributed at higher pressures to reduce pipe sizes and then reduced in pressure at the point of use.
- The Equipment Consumption Systems are used to convert the energy dollars spent to produce steam to production dollars. The variety and types of applications for using steam is widespread.
- The Condensate Return System gathers the spent steam, which is hot conditioned water (condensate), and returns it to the boiler plant to make more steam.



Without steam many of the items we take for granted would be difficult or impossible to produce. A short list of major steam uses include-

Refineries producing gasoline, diesel fuel, heating oil and other related products
Chemical plants producing a wide array of products
The medical industry
The food industry
The pulp and paper industry



I could continue this list for a significant number of pages. To better understand how widespread the use of steam is, take a moment right now and take a quick 360 degree scan around yourself. I would venture a safe guess that most everything you looked at that was manufactured had contact with steam at some point. Stated in another way, thermal energy (heat) is a key component to most every element of everyday living, and steam is the most common source of this thermal energy. As you ponder that point, in all probability the electricity powering the device you are reading this EBook on was produced by steam!

The US Department of Energy has a great website covering many facets of a steam system and is a great source of information. Visit it at
www.energy.gov/eere/amo/steam-systems

There has been much written about steam over the past few hundred years. This information is in widespread use, so my challenge is to distill all the information in a quick format you can use to solve problems in your steam system. This will help improve efficiency, improve production, and improve your knowledge of steam.

If you search “Steam Systems” you will bring up many pages of search results which, in most cases, are provided by manufacturers of steam products. As with any industry, each manufacturer offers what they feel are the best products with many unique features. Sorting all this out can be overwhelming, so I will try my best to stay above that fray and share with you what I’ve learned in designing, working with, trouble shooting, and, in general, improving steam systems.

A steam system has to be approached from both an engineering and practical point of view. An analogy (maybe a poor one) is a steam system is like cooking - follow the recipe but flavor it to suit yourself with the ingredients. In many portions of this book we will look at both engineering based solutions as well as using rules of thumb handed down over the past few hundred years.

Let the fun begin!

Chapter 2 – Steam Distribution Systems

The primary function of the steam distribution system is to deliver clean, dry steam for your facility requirements.

- Clean means steam which is free of gases such as carbon dioxide, oxygen and other gas which can combine to contaminate the steam. Primarily the deaerator, water softener, and chemicals added in the boiler room should remove gas contaminants.
- Clean also means free of physical contaminants such as rust, welding slag, mud, pipe dope, and teflon tape. Most of these contaminants tend to enter the piping system during construction and doing a major blow down before starting any new system or system addition can minimize a lot of later headaches. In over 50 years of being around steam systems, the most notable contaminant was a pair of coveralls left in a 10” steam line!
- Dry means no entrained moisture and is typically called steam quality, which is defined as the amount of moisture present in the steam. Steam with a quality of 100% is considered to be all water in vapor form with no entrained moisture. Most boilers will produce steam at about 98% quality which is considered dry steam.

Low steam quality (under 90%) can create major problems in both the steam distribution system as well as steam consuming equipment. Steam quality is measured with a calorimeter, which is a laboratory piece of equipment that is difficult to obtain and is expensive. A simple test taught to me long ago by an old timer was to take a piece of card board such as a box end and use it as a blow off target. Find a small blow valve and open it in a safe manner to blow to atmosphere. You should see a small of amount of condensate for a second or two followed by a pale blue vapor which should be clear for about ¼" to ½" right at the tip of the blow off point. Check with a flash light passing light through this point to make sure it is clear. Take your card board target and flick through the blow off and then quickly run it with your hand. It should be warm and dry. If it is wet to any degree, your steam quality is an issue which can cause you serious problems with potential water hammer, corrosion, and loss of production. Low steam quality is a real problem which should not be ignored.

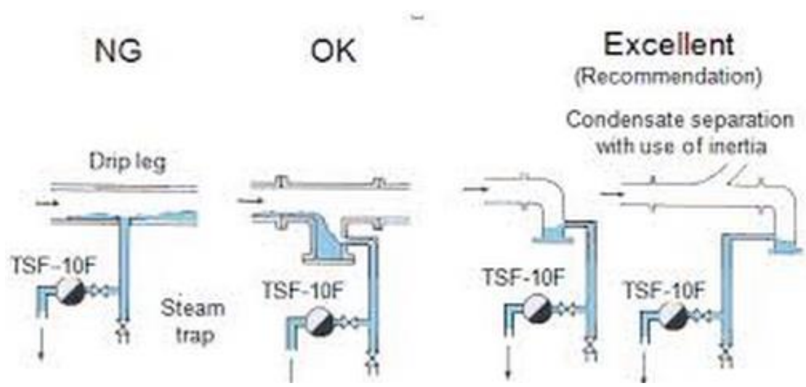
Causes of low steam quality can start in your boiler room. Run the same visual and card board test at each boiler, if possible, and on the main steam header supplying steam to the plant. If it is wet, then probable causes could be one or more of the following:

- Your boilers are not adjusted for proper combustion.
- The water level in the boiler is too high.
- Your feedwater conductivity is in excess of 4000 micro Siemens.
- You are using on/off feedwater level control on your boiler. Consider switching to modulating feedwater control for the boilers.
- Your steam demand exceeds the boiler capacity. If so, consider adding a back pressure control valve on the boiler discharge to restrict flows when the plant pressure drops. Orifice plates can also be used if sized to provide a 10-20 psig pressure drop at full boiler flow and act as a restricting device. Excess steam demand can be solved in other ways, such as adding a steam accumulator. If you suspect you have this problem, we suggest you contact us with details of your problem since the solution can be expensive and impact your plant operations.

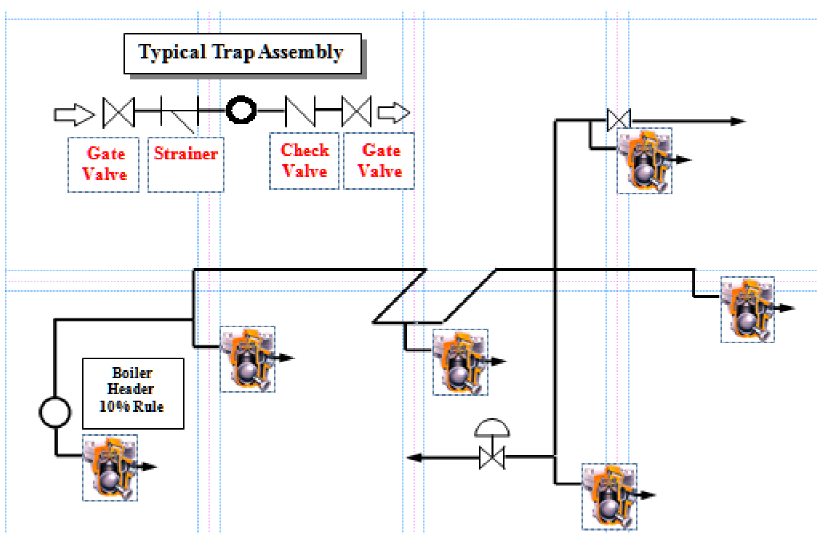
If your boiler plant steam is dry and of high quality, the steam distribution system may be lowering the quality. Do the card board test at a number of points starting with the main steam supply header in the boiler room. If it becomes wetter as you move away from the boiler plant, then your distribution system might be the cause of your problem. Some points to exam in your distribution system are:

- Since steam is typically distributed at higher pressures and used at lower pressures, radiation losses in the distribution system can be significant. If you consult a steam table, you will find that 0 psig steam is 212°F, 50 psig is 298°F, 100 psig is 338°F, 150 psig is 366°F, and 200 psig is 388°F. Why did I write these numbers down from memory? Because thermal energy (heat) flows from hot to cold and the rate increases with larger temperature differences. So high pressures mean high temperature differences and greater losses due to radiation. The great majority of steam distribution systems operate in the 100-200 psig range.

- A rule of thumb is one square foot of steel surface will radiate about 5000 BTU's per hour. You can get fancy, but for evaluating losses due to radiation for bare pipe, this is not a bad starting point for an average steam system. Most insulation is 80-90% efficient, but insulation which has deteriorated, or is missing, can increase radiation losses resulting in lower steam quality. Even worse is wet insulation. Air is considered an insulator, so imagine a large six inch line with insulation which has failed and is wet. It is literally a wet blanket with much higher losses. You are actually better removing wet insulation and going to bare pipe! Piping pitch is important to insure that condensate, as it forms in supply lines, can be directed to steam trap drip points. Set the piping support at appropriate intervals and avoid low points between supports. Set piping at a slope of no less than 1ft per 100 ft. As an example 12" of pitch for every 100' of horizontal run.
- Steam velocities range from 5000 feet/ minute (83 feet per second) to 10,000 feet per minute (166 feet per second). A speed of 88 feet per second is 60 miles per hour so typical steam line velocities are 57 to 114 miles per hour. Imagine steam going down an 8" main at say 70 miles per hour pulling a small stream of condensate at the same speed. If your drip point is a 1" pipe coming off the bottom of the 8" line the condensate will blow right past the opening rendering your drip point in-operative. All drip points or legs should be a full line size tee to provide a large enough gap for the condensate to drop out of the flow stream. Undersized steam supply lines result in much higher velocities, which can negate the effectiveness of a full size tee drip point. If going to a larger line is cost prohibitive, consider installing a separator to help knock the condensate out of the steam flow.



- Drip traps as a general rule of thumb should be installed about every 100' on horizontal runs, at the low point on the rise or fall of a horizontal run. Line size piping a minimum of 1.5 times the line size and a minimum of 18" should be used on all drip legs to a steam trap.
- Steam trap drip points must be installed at all manual valves which might be closed for maintenance or shut downs. These valves should be opened very slowly when the line is placed back in service by cracking the valve open (barely) for at least 5-10 minutes and then continue to slowly open the valve.
- Steam trap drip points must be installed ahead of all automated, pressure reducing or other types of valves which can close on some control signal. If automated valves are in series, a steam trap drip point must be installed ahead of the first automated valve and each subsequent valve to prevent condensate degrading steam quality or at worse generating water hammer. Water hammer is 5-10 gallons (40-80 lbs) of water moving down a steam line at 60-120 miles per hour hitting an obstruction. Forces on impact are very high and piping systems will quickly come apart!
- Steam trap drip points must be installed on expansion loops at the low point on the loop. They must also be installed ahead of expansion joints.



If wet steam continues to remain a problem, then adding a separator in the boiler plant or on selected primary and secondary lines is an option. Before adding a separator, trace all steam lines and make sure all steam drip traps are operating properly, then carefully review the piping to ensure that condensate is not being retained in pockets, sagging piping, or closed manual or automatic control valves.

From Swagelok Energy Advisors, Inc.:

“When Are Steam Separators Not Required?

Steam separators are rarely required when a steam system is properly designed, specified, installed, operated, and maintained. The “ideal” steam system that doesn’t require a steam separator will have the following:

1. Proper steam-line sizing

2. Steam line velocities below 10,000 fpm

3. Insulated steam lines and components, with the insulation being 95% efficient

4. Proper steam line drip legs with steam trap stations

5. Proper standard operating procedures in use throughout the plant, where properly sized steam lines may operate like a gravity separator. Here, proper steam velocities will allow the moisture to drop out of the steam vapor to the bottom of the pipe, where a functional drip leg steam trap station will remove it.

When Are Steam Separators Required?

There are cases where proper steam system design parameters and procedures are not followed and the steam has moisture entrainment. Here, a separation device needs to be installed because the presence of water in steam can, and will, cause problems, including:

1. Wiredrawing

2. Corrosion

3. Erratic operation of control valves and flow meters

4. Failure of system components

5. Reduced efficiency

6. Lower productivity because all steam separators produce a pressure drop across the device. The design of the separator determines the amount of pressure drop that occurs in the steam line. Therefore, a steam separator should only be used where necessary because a pressure drop in the steam system can affect efficiency and end user performance.”

For more information –

http://www.swagelokenergy.com/download/BP43%200060-43R0.pdf

Ensuring that your steam consuming equipment is operating at peak efficiency involves operating a boiler plant that delivers clean dry steam and a distribution system that maintains that same level of clean dry stream.

Chapter 3 - Steam Valves

In this chapter, we will examine steam equipment which is common to boiler plant, steam distribution system, steam consuming equipment and condensate return systems. This will then allow us to focus on application and system suggestions and not spend duplicate time on basic equipment. We will review this equipment from simple to more complex.

Isolation Valves

By numbers installed, isolation valves are the most common item used. Improper application of isolation valves can create maintenance headaches and in some cases lead to significant safety issues. Typically, materials of construction for steam valve bodies include brass, bronze, cast iron, cast and forged steel and various grades of stainless steel. All valves will carry two pressure and temperature design limits –

- WOG stands for the Water, Oil, and Gas pressure rating for a valve. It is the maximum operating pressure for a valve at 100°F. Call it the maximum cold operating pressure with cold being defined at 100°F.
- SWP stands for the Steam Working Pressure rating of a valve. It will state a maximum working pressure at a temperature. As an example, a cast iron valve might carry a typical rating of 250 psig steam pressure at a maximum temperature of 450° F. Call SWP the hot working pressure.

WOG and SWP define the characteristics of the valve from a materials point of view. The actual range of pressures and temperatures in installing the valve are also a function of the connection style. Typically valves in the ¼" to 2" range are either threaded or socket weld and will carry the same rating as marked on the valve. Flanged valves are typically used in steam systems 2 ½" and larger. Although as an example a cast iron valve would typically carry a SWP of 250 psig at 450°F. The rating of the valve flange will limit the maximum installed pressure for the valve. Cast iron valves are rated 125 and 250 psig.

From the Engineering Tool Box website here is a portion of a typical flange rating chart:

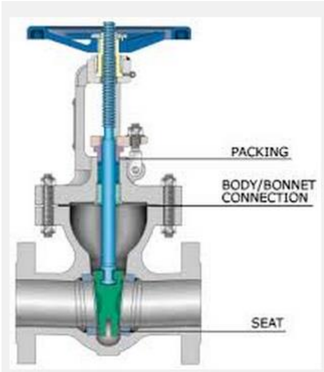
Nominal Pipe Size NPS *(inches)*	Class 150				
	Diameter of Flange *(inches)*	No. of Bolts	Diameter of Bolts *(inches)*	Diameter of Bolt Holes *(inches)*	Bolt Circle *(inches)*
1/4	3-3/8	4	1/2	0.62	2-1/4
1/2	3-1/2	4	1/2	0.62	2-3/8
3/4	3-7/8	4	1/2	0.62	2-3/4
1	4-1/4	4	1/2	0.62	3-1/8
1-1/4	4-5/8	4	1/2	0.62	3-1/2
1-1/2	5	4	1/2	0.62	3-7/8
2	6	4	5/8	0.75	4-3/4
2-1/2	7	4	5/8	0.75	5-1/2
3	7-1/2	4	5/8	0.75	6
3-1/2	8-1/2	8	5/8	0.75	7
4	9	8	5/8	0.75	7-1/2
5	10	8	3/4	0.88	8-1/2
6	11	8	3/4	0.88	9-1/2
8	13-1/2	8	3/4	0.88	11-3/4
10	16	12	7/8	1	14-1/4
12	19	12	7/8	1	17
14	21	12	1	1.12	18-3/4
16	23-1/2	16	1	1.12	21-1/4
18	25	16	1-1/8	1.25	22-3/4
20	27-1/2	20	1-1/8	1.25	25
24	32	20	1-1/4	1.38	29-1/2

For the complete set of charts see http://www.engineeringtoolbox.com/flanges-bolts-dimensions-d_464.html

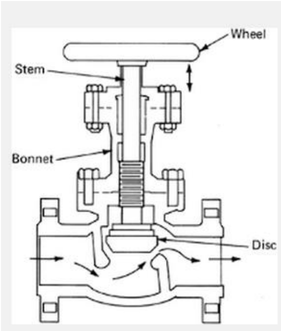
As a side note, typical steam operating pressures for many facilities are in the 100-200 psig range. A 125 psig cast iron flange will interchange with a 150 psig cast steel flange and a 250 psig cast iron flange will do the same with a 300 psig cast steel flange.

Steam valves come in two basic styles:

- On/Off valves include all gate valves and most ¼ turn valves such as ball valves and butterfly valves. On/off valves are not designed to throttle steam flows due to their quick open characteristics and will also be damaged if left in a throttling position for more than a short time.




- Modulating valves are globe valves in style with a plug or valve head which retracts from a seat. Offered in varying styles, globe valves should be used if you plan to manually throttle steam flows.



For some added information, see Pennsylvania Department of Environmental Protection website at:

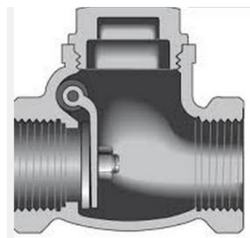
https://www.dep.state.pa.us/dep/deputate/waterops/redesign/TablesNFormulas/Pages/valvebasicsandselectiontips.htm

A wide variety of companies in many countries produce all types of isolation valves. For steam service, you would be wise to stay with proven manufacturers with a long term track record and avoid bargain valves at low prices which could fail when you most need a valve to close properly. If the prices are in the “too good to be true range” then beware.

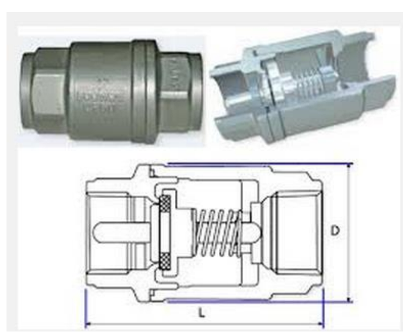
Check Valves

Check valves are widely used in steam systems and quite frankly misapplied in many cases. There is no universal check valve so the application details become important in selecting the proper type of check valve for your application. Failed check valves can cause all kinds of problems including water hammer, which can cause a major failure in your steam and condensate return systems. Check valves come in a number of different styles:

- A **swing check** valve, or tilting disc check valve, is a check valve in which the disc, the movable part to block the flow, swings on a hinge. Swing check valves in steam systems are not a wise choice since the hinge point is typically a failure point due to activity, stress and thermal shock which can occur in a steam system. Most stream traps require a check valve on the discharge side. Swing check valves are a very poor choice for this application which typically can go undetected if the hinge point fails and the flapper remains in line creating problems in both the steam side of the check valve as well as the condensate return side of the valve. Stated again, based on my past experience, I would avoid swing check valves in steam and condensate return systems.



- A **ball check valve** is a check valve in which the closing member, the movable part to block the flow, is a spherical ball. In some ball check valves, the ball is spring-loaded to help keep it shut. Ball checks are most typically used as vacuum breakers in steam systems and are well suited for this application. Due to lower capacities, they are not suggested for other steam and condensate return applications.



- **Piston check valves** use a spring loaded piston in a cylinder to provide both a positive shut off and also minimize slamming in the check valve when pressure pulses occur. They provide good service on the discharge side of steam traps and condensate pumps. Piston check valves should be installed in a horizontal orientation.

- **Spring loaded wafer check valves** provide an excellent solution for any application in a steam or condensate return system. Durabla is considered the control valve of check valves, the "Check Valve Doctor". Durabla Fluid Technology specializes in spring assisted in-line check valves that prevent water hammer and reverse flow and ensure long life if properly sized for the flow and not the line size. Due to the spring assist and short travel distance of the disc, by the time forward velocity has decreased to zero, the valve disc has reached the seat and the valve is closed.

Check valves in steam and condensate return systems should be installed in the following applications –

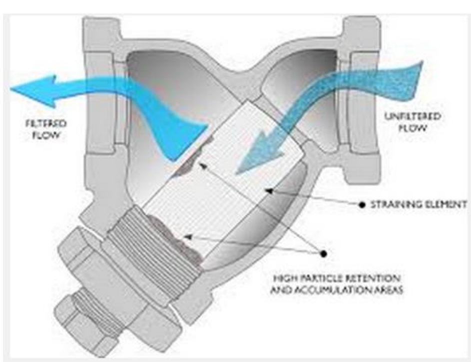
- On the discharge side of all steam traps except disc, thermodynamic and similar style traps which use a coin sized disc to provide operation of the trap. Disc traps are check valves by nature so installing a check valve on the downstream side will result in having two check valves in series; one being the disc trap and the second being the check valve you added. I can 99.99% guarantee you will have flooded and major equipment problems on the steam side of the system. For all other traps use a piston check or better yet a spring loaded wafer check such as a Durabla check valve. Some trap manufacturers offer a built in check valve option for portions of their product line.
- Check valves are not required on steam traps discharging through a single line to atmosphere.

- On the discharge side of all steam and motor driven condensate return pumps, spring loaded wafer checks are your best option for this application to eliminate slamming problems with the pumps.
- Use as vacuum breakers on systems where vacuum can occur when the steam supply is shut off, which would create flooding of the equipment due to negative pressures as the steam condenses. Spring loaded or wafer check valves work best for this application and some companies offer wafer or ball check valves designed and marketed for vacuum breaker service.
- Applications where steam is direct injected or sparged into vessels filled with water or other fluids to prevent reverse flow back into the steam line when supply or control valves shut down.
- Other specialized equipment or skids for specific applications using steam. Carefully review the suggestions of steam supply and condensate return piping.

Steam systems which work well are a very efficient way to provide large amounts of thermal energy to equipment. Improperly sized check valves can create many problems so selecting the proper check valve from a reliable vendor can save you a lot of grief and downtime.

<u>Strainers</u>

Steam systems, both new and old, tend to collect debris and other “junk”, which due to system velocities will migrate toward the end points of each main and branch pipe run. In most steam control equipment and steam traps, orifices are prone to being blocked when this debris encounters the small opening leading to failure, downtime and lost production.



You might find it odd that we will devote comments and suggestions on this simple device. Strainers come into two basic styles:

- Wye Strainer with an example shown above on the left. Installation of a drain valve is suggested with a pipe plug located on the discharge side for safety. Blowing down a wye strainer may not always remove dirt and chemicals which can block the strainer screen and might require wire brushing or even screen replacement if is really plugged up. Wye strainers installed in situations where they are subject to freezing should be installed upside down to avoid a condensate pocket, or installed with a drainer valve for use when the system is shut down.

- Basket strainers, as shown on the right, are sometimes used in steam systems and the same general comments regarding wye strainers apply to basket strainers. Use a bolted cover and not a clamp cover due to steam system pressure and the dangers of water hammer which will typically cause a clamped basket strainer to blow the cover.

Screen sizes for steam must be smaller than openings for a strainer used on water. Most manufacturers offer water and steam screens so make sure you use the steam screen which has smaller openings. Typical screen sizes for steam are 1/32” (~ 20 mesh) or 1/64” (~ 100 mesh).

Strainers are sold at many price points in our global economy so be an informed buyer on the source of your strainers and proceed with caution on unknown and questionable brands.

Chapter 4 – Pressure Gauge, Thermometers and More

A substantial portion of my career has been spent trouble shooting and offering solutions to steam systems plagued with problems. The two most basic instruments that are vital to know the conditions of your steam system are pressure gauges and thermometers.

Pressure gauges come in a wide range of sizes, accuracy, and price points with many options available.

I would suggest for most of your steam system applications you consider a gauge with the following specifications:

- Dial face 4” or for tight spots 2”.
- Accuracy of +/- 1 psig.
- Select a gauge range twice your expected pressure range. As an example, if your normal reading is 50 psig then select a range of 0-100 psig so your readings are about center scale on the gauge.
- Select a steam gauge with an internal armor front plate inside the gauge. Steam gauges are fragile and having a gauge blow its front out is a lifetime experience you should avoid.
- Always install a pigtail siphon on a gauge used in steam service.
- Install a shut off valve between the gauge and the siphon.

- If you expect or encounter pressure fluctuations, then install a pressure snubber before the siphon. You might also consider a glycerin filled gauge for indoor applications and a silicon filled gauge for outdoor applications. Silicon typically costs a bit more, but will not darken due to exposure to sunlight.
- If permitted in your facility, then mark the gauge face with a marker to indicate the normal range.
- Buy reputable brands of gauges since a bargain gauge giving false readings could cost you many times the cost of a cheap gauge.

Pressure gauges are your first tool to trouble shoot a steam system, so having proper gauges in key locations is really important.

Thermometers are a second critical tool for steam systems. Since the steam pressure will determine the steam temperature, installing thermometers in most applications is of no real value. Many steam applications involve heating a fluid, gas, or other materials from one temperature to a higher temperature. Thermometers become important when troubleshooting steam heated process systems. They can help identify issues that require further examination. Thermometers come in both liquid filled as well as bimetallic dial style. Some suggestions include:

- Bimetallic gauges are easier to read and less prone to damage and breakage.
- Common dial faces are 3" and 5" with the larger face being easier to read.
- Stems are offered in back and bottom connected versions. They are also offered in every angle styles where the dial face can be adjusted after installation for the best readability.
- Select a range which is about 50% of your expected reading for best accuracy. If your expected reading is 100°F, a common range for this application would be 30-240°F.
- Select a bulb or stem length which will be of the proper length to secure a good reading. For many applications, the temperature will vary quite a bit depending on the measuring location. If in doubt, installing an additional thermometer might be of help.
- Thermowells are suggested since they allow for easy replacement of the defective thermometer. Always put well paste in the stem to insure good contact between the stem and inside wall of the well.
- If permitted, mark normal readings on the dial face for quick confirmation that proper temperatures are being achieved.

Infrared guns are inexpensive and a great tool for checking so many issues in a steam system. On any trouble shooting visit I make, I always carry an infrared gun. A few points to help you get best results include:

- Infrared guns will give best results reading off a black surface. Readings from reflective surfaces such as stainless steel will not be accurate. A black magic marker can be used to temporarily darken the surface.
- Infrared guns are sort of a flashlight in the sense that the beam opens up with distance. Get as close as possible to the point you wish to read.
- An infrared gun with a laser is suggested so you know the point you are reading.
- Get an illuminated dial face since steam systems and dark places seem to go hand-in-hand.
- When reading from any metal surface, expect the reading you get to be about 5-10° F lower than inside the pipe or vessel.

Chapter 5 - Steam Control Valves

Steam is a great source for thermal energy for your plant and does an amazing number of tasks. As with any energy source, we need to be able to control the flow of energy by managing the flow of steam. In Chapter 3, we covered manual valves which can be used for isolation, and with globe valves, which can be used to manage steam flows. In the early days of steam usage, a person managed the steam flow to a process or device by looking at a pressure gauge, thermometer, sight glass or some other indicator to throttle up or down on steam flow.

A control valve is any valve which can modulate steam flow based on some input signal. The input signal can be:

- A pressure signal against a diaphragm or bellows to generate linear motion to stroke or operate a valve.
- A temperature signal from a thermal system made up of a sensing bulb, capillary, and point device which will generate linear motion to stroke a valve.
- Air pressure can be used to stroke a valve using either a diaphragm or cylinder operator to manage the valve opening positioning. Older systems would use the same mechanical elements to provide a control signal to a control panel, which would then typically generate a 3-15 psig air signal, to stroke the valve open or closed. Typically, electronic sensors read pressure, temperatures and other parameters and in conjunction provide a 4-20 mA signal, which when fed into an I/P transducer, will translate it to a 3-15 psig signal. As a side comment, in control systems, a zero signal is never represented by zero value since zero could be a real valve or a failed sensor. Zero is always some numerical value and the same with 100%. To illustrate one simple example this chart might be of help:

Signal Value	Air Pressure	Milliamp Signal
0%	3 psig	4 mA
25%	6 psig	8 mA

50%	9 psig	12 mA
75%	12 psig	16 mA
100%	15 psig	20 mA

- Electric operators can also be used to stroke a valve. These are typically operated by a servo motor or in some cases a small hydraulic pump. Typically, electric operators offer less stroking force for a given size, tend to be more expensive, less forgiving of harsh environments, and somewhat more prone to not be able to withstand high temperatures.

One of the most common applications for control valves in a steam system is to reduce pressure. They are commonly referred to as PRV's (pressure reducing valves). We will examine PRV's in detail, which will allow us to examine other types of control valves in a quick overview manner, since the basic styles of PRV's can be adapted to operate using other input signals such as temperature, flow, level and humidity.

Pressure is defined as the force per unit area or as an equation:

$$Pressure = Force \div Area$$

$$P = F \div A$$

For English system force is measured in pounds and area in square inches. As an example a force of 1000 pounds exerted over an area of 10 square inches would equal a pressure of 100 PSI (pounds per square inch):

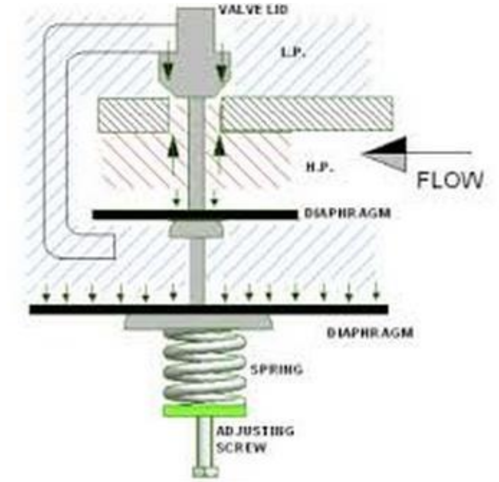
$$100\ PSI = 1000\ pounds \div 10\ Square\ inches$$

We can transpose the equation as follows:

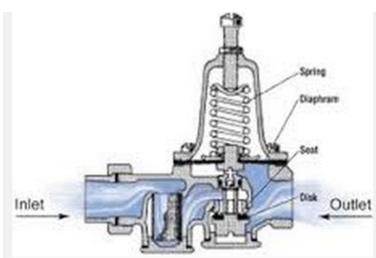
$$Force = Pressure \times Area$$

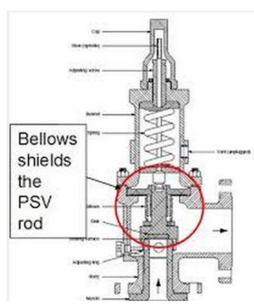
Using our same example, a pressure of 100 PSI acting on an area of 10 square inches would result in a force of 1000 pounds:

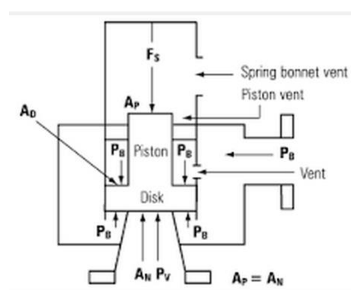
$$1000\ pounds = 100\ psig \times 10\ square\ inches$$



Referring to the above diagram, a diaphragm, bellows, or piston can be used to provide an area for pressure to act upon. This is counterbalanced by a spring using an adjusting screw to compress the spring. It then allows us to generate linear motion as a function of the pressure required to move a valve shaft as a function of the pressure in the valve. Turning the pressure adjustment screw down to compress will require a higher pressure on the diaghragm, bellows or piston to move in the opposite direction. We would call this a direct operated PRV with examples shown for each of the basic types.

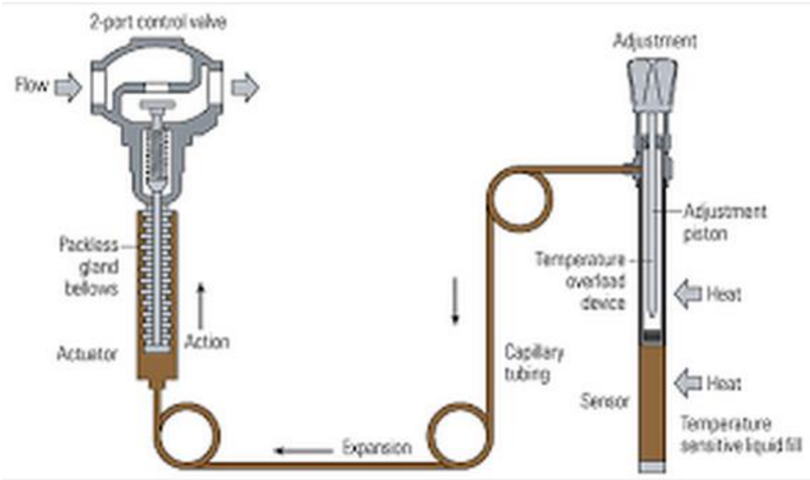






Direct operated PRV’s of all three types are typically offered in sizes ½” through 2” with limited capacities. The directed operated PRV can be coupled with a larger valve with the pilot (a direct operated PRV) being the “brains” and the main valve being the “brawn”.

In this photo, the four smaller PRV’s on the bottom are direct operated and by adapting them to a main valve, as shown by the larger valves on the top, can provide much higher capacities. Note that the same basic principle can be used to produce a direct operated temperature regulator using a bellows coupled to a thermal sensing system which allows a fluid to expand as it is heated, increasing internal forces on a valve shaft to open and close a valve based on temperature difference.



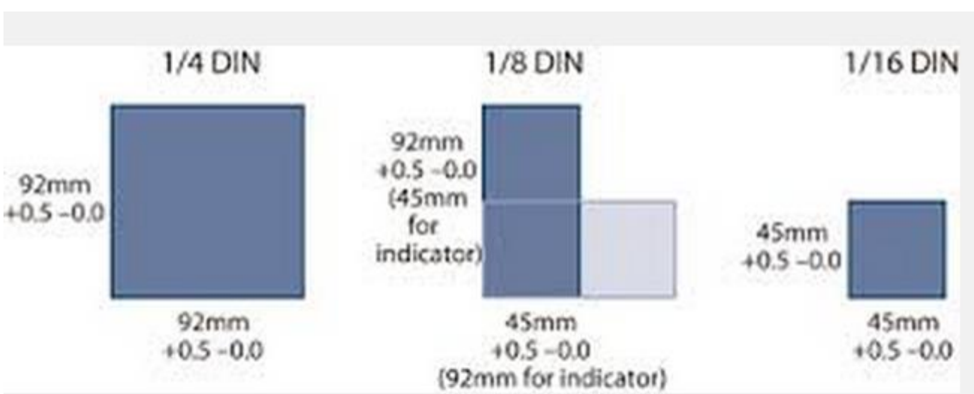
From Plant Engineering Magazine here is a great article to set-up and design for a steam-pressure-reducing valve station.

http://www.plantengineering.com/single-article/set-up-and-design-for-a-steam-pressure-reducing-valve-station/f2a97efd6dd70ea0222234b4a98135ec.html

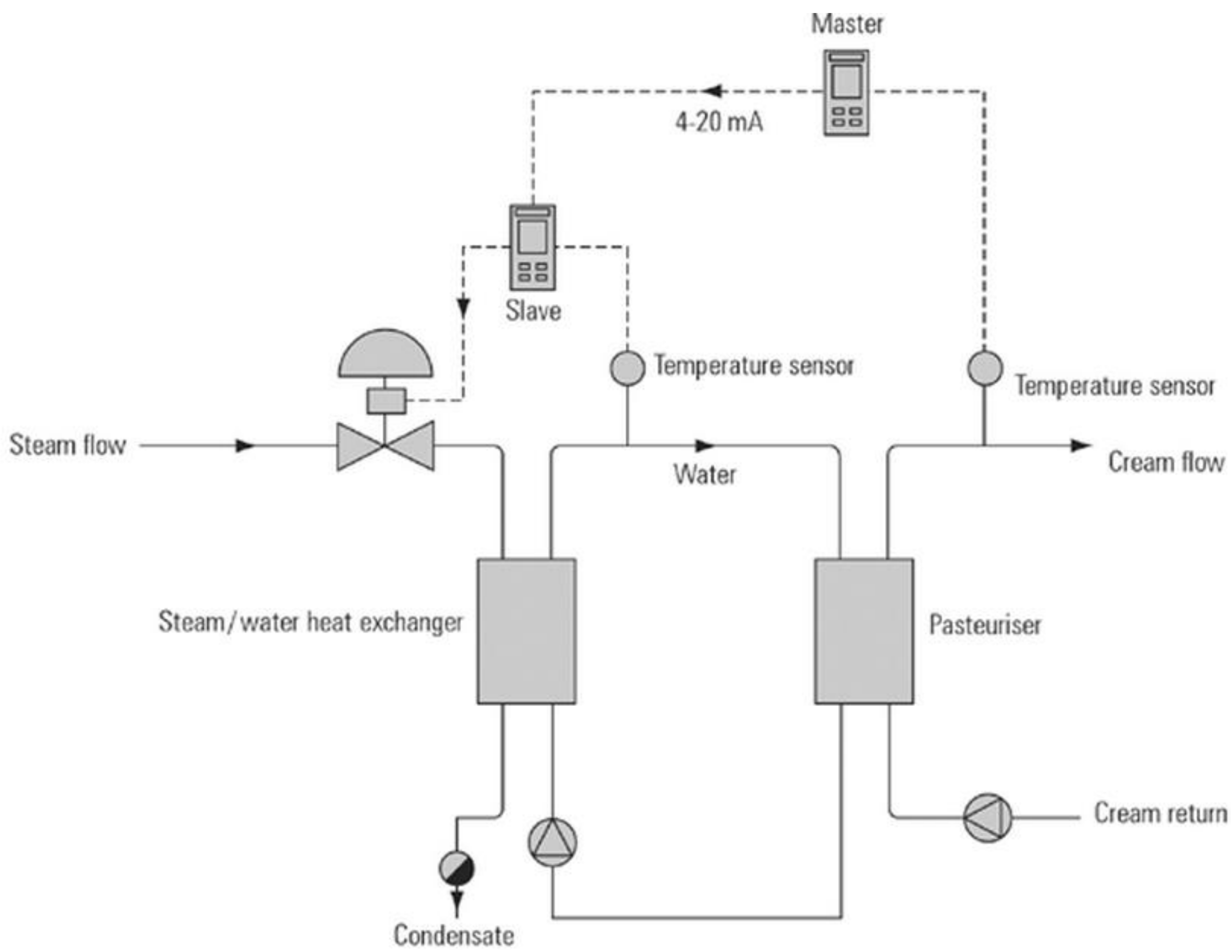
Direct and pilot operated steam control valves are offered by many companies such as Armstrong International, Fisher, Leslie, Spence, Spirax Sarco, Watson McDaniel and numerous other companies. Most offer pressure, temperature, electric on/off and air operated pilots for a wide variety of applications. Accuracy will vary by manufacturer so consult the literature for specifications. Expect on direct operated pressure reducing valves accuracy at the set point will be ~ +/- 3-4 psig and for pilot operated valves ~ +/- 1-2 psig. For temperature control valves expect ~ +/- 3-4°F.

If greater accuracy is required, or your control signal range is beyond pressure and temperature, then an air operated or electrically actuated valve should be considered. A wide variety of electrical and electronic sensors are offered to provide a signal for pressure, temperature, flow, level, humidity and many other variables. The control signal can be transmitted to a single loop controller or more sophisticated PLC or computer based control system. These will provide a signal for the air or electrically actuated control valve. A very common analog signal is a 4-20 mA signal from the electronic controller, PLC or computer based control device.

Single loop controllers are low in cost and provide a versatile way to provide control signals for air or electrically operated controllers. Common sizes range from 1/16 to 1/4 DIN, with the primary difference being the size of the display.



Controllers are offered in a wide range of inputs from RTD, thermocouple, dry contact to 4-20 mA as well as many options including single and multiple alarm functions. A wide range of output signals are offered with 4-20 mA being the most common for control valve applications. For air operated valves, adding an I/P transducer will convert the 4-20 mA signal to the most commonly used 3-15 psig air pressure. An example is shown for a more complex system for a pasteurizer using two controllers.



For more complex control systems, a PC or PLC based system offers greater flexibility with increasing cost and complexity.

Air actuated operators for valves come in two basic types:

- Linear motion for operating globe style control valves.
- Rotary motion for operating ball, butterfly and similar valves.

Electric actuators are primarily suited for rotary style valves. Which is best?

Eng-Tips website has a forum covering this topic and reading through this forum might give you an idea of the pro’s and con’s in selecting the right actuator for your control valve.

http://www.eng-tips.com/viewthread.cfm?qid=323523

For most process applications utilizing an air operated control valve and adding a positioner is a good choice to improve the accuracy and control characteristics of the valve. The positioner senses the stem position and provides whatever air pressure is necessary for the stem position to equal what the control signal position demands. A positioner doesn't know what pressure it provides (it has no pressure sensing), it knows only the position of the stem (feedback) and the stem position the control signal is asking for. The internal pneumatics is designed to make the feedback position equal to the control signal 'position'.

Control valves are a textbook topic and I’ve become a real fan of the website Engineering Toolbox.com which provides good information in a concise manner. For more information visit http://www.engineeringtoolbox.com/control-valves-t_45.html

Chapter 6 – Safety and Relief Valves

From the Engineering Design Encyclopedia website –

http://www.enggcyclopedia.com/2011/06/difference-safety-valve-relief-valve/

“'Pressure Safety Valve” and “Pressure Relief Valve” are commonly used terms to identify pressure relief devices on a vessel. Frequently, these terms are used interchangeably, and it depends on a particular project or company standard to identify all the pressure relief devices either as “safety valves” or as “relief valves” or sometimes even as “safety relief valves”.

Although freely used interchangeably, these terms differ in the following aspect:

Pressure Relief Valve - is the term used to describe a relief device on a liquid filled vessel. For such a valve, the opening is proportional to increase in the vessel pressure. Hence, the opening of valve is not sudden, but gradual if the pressure is increased gradually.

Pressure Safety Valve - is the term used to describe a relief device on a compressible fluid or gas filled vessel. For such a valve the opening is sudden. When the set pressure of the valve is reached, the valve opens almost fully.

Safety valves for steam can be set to meet one of three requirements.

V Stamp which applies to all ASME Section I valves installed on boilers operating at a pressure greater than 15 psig.

HV stamp which applies to all ASME Section IV valves installed on boilers operating at 15 psig or less.

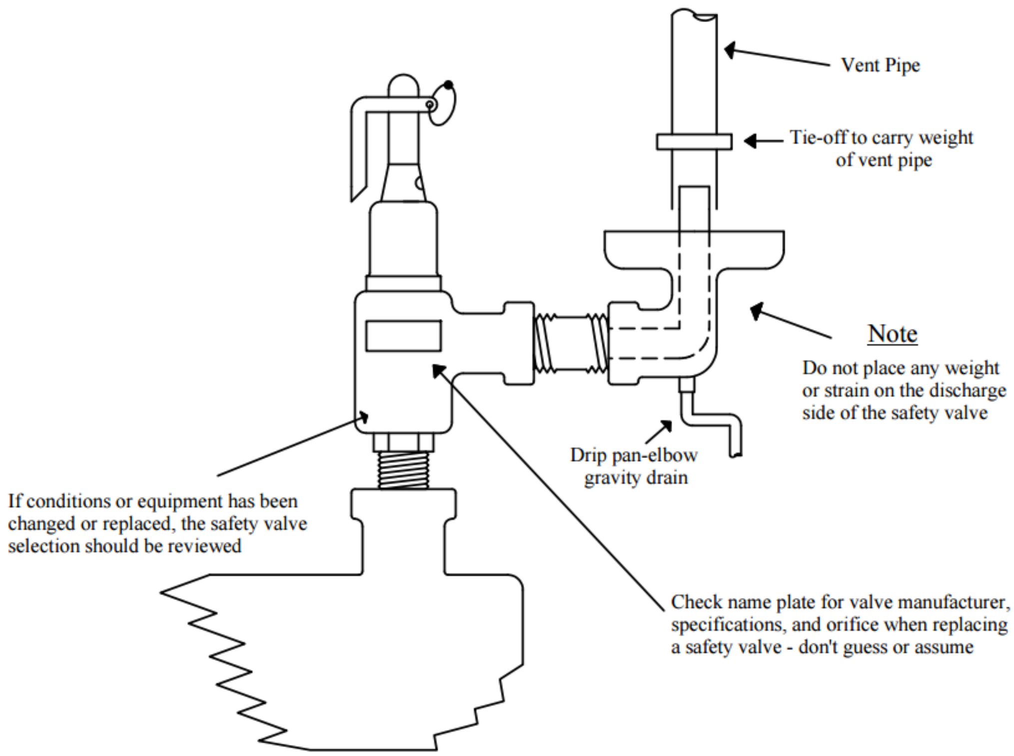
UV stamp which applies to all ASME Section VIII valves installed on unfired steam using equipment.

For boilers (Section I) above 15 psig, valves must be sized on capacity tables which reflect a 3% accumulation. Boilers operating at 15 psig or less (Section HV), safety valves must be set no higher than 5 psig above the boiler pressure.

Accumulation is the amount of pressure change in percent of set pressure required for the valve to go to full capacity.

As an example, a boiler with maximum operating pressure of 150 psig the 3% accumulation rule should first be checked. 3% of 150 psig is 4.5 psig so the minimum 15 psig requirement would mean the safety valve would be set at 135 psig. In operation the valve would begin to open at 135 psig and be 100% open at 150 psig. The valve capacity must equal or exceed the maximum output of the boiler.

I would suggest that all steam safety valves be vented outside even if this is not a local code requirement. Steam in a confined space is very dangerous and when combined with electrical panels even more dangerous.



The sketch shown illustrates a basic application and is not intended as a final working drawing

Control Specialties 2503 Monroe Drive Gainesville, GA 30507 770 532-7736 Toll Free 800 752-0556 Fax 770 535-0536	Designed By: Ed Moschetti Prepared By: Jared Moody Date: 10/16/2012

http://www.control-specialties.com/admin/uploads/safety_valve_final.pdf

Safety and relief valves are designed to protect equipment from over pressurization and failure. Some tips to ensure safe operation are as follows:

1. Before installing the valve, protect it from shock and prevent dirt from getting inside the valve.

2. Mount the valve in a vertical position so that the valve body is self-draining. Do not plug any bonnet vent openings.

3. Inlet piping should be as short as possible with no elbows and equal to or greater than the inlet size of the valves.

4. Discharge piping should be self-draining or use a drip pan elbow. Make sure the discharge piping contains no pressure.

5. Do not support discharge piping using the safety valve as the means of support.

6. For threaded valves, use small amounts of thread sealant to ensure that the sealant does not enter the valve and create leakage problems.

7. Maintain system pressure at least 5 psig or 10% below the set pressure of the valve, whichever is greater.

8. Safety valves should be checked every 12 months for proper operation.

See this link for more installation and operating tips –

http://www.control-specialties.com/admin/uploads/kunkle_installation_operating_instructions.pdf

There is a misconception that there is a LAW requiring safety valves be repaired or re-certified every year. Safety valve maintenance is typically mandated by company policy, your insurance inspector or by the state inspectors. Whatever the guidance, if a safety valve fails, the end result could cost you much more than any inspection program!

Any safety valve that leaks or dribbles should be considered as FAILED.

A number of companies, including Control Specialties, offer rebuilding of safety valves which can save you about 50% the cost of a new valve. If you this is of interest to you, then make sure that the repair business is an ASME certified facility.

Chapter 7 – Steam Traps

By page 15 on a Google search for steam traps I came away with eyes glazed and my brain a bit fried. Having starting a bit over 50 years ago with a steam trap company working in R&D, I would like to take a different approach to this small, but very important, device.

A steam trap, in a simple definition, is an automatic valve which will vent non-condensables and condensate from a piece of steam consuming equipment and stop the loss of live steam as it enters the steam trap. Steam traps started to appear in use about 1900 and replaced the prior device which was typically a pinched piece of tubing or a cracked valve adjusted by a pipefitter. As you can imagine, this approach was neither efficient, effective, nor cost effective. Steam trap development started with float or bucket operated valves and then evolved into many other types.

Service, and therefore service life, on a steam trap can become demanding since it is the interface device which separates the steam side from the condensate return side of a steam system. Pressure and temperatures can be high, which when combined with condensate, flashes as it enters and discharges to the return system. All steam traps fail so the question is not “if” but “when”. Typically traps operating in the 100-150 psig range, if properly sized and selected, will last 5-7 years - your results will vary quite a bit. Imagine a facility with 100 steam traps which has been in operation for many years. If the average service life of all traps is say 5 years, then we can expect failures to be about 20% per year or 20 bad traps per year. If the average life is 2 years, then 50% per year will fail and 10 years average life would forecast 10 failures per year.

Why then so much attention on a steam trap? A bit of math might help. Many traps operate 24/7 which works out to 720 hours in a 30 day month and 8,760 hours per year. If a failed trap blows $1.00 per hour of live steam, then it is costing you $720 per month and $8,760 per year.

As a rule of thumb, a trap which fails will blow about 10% of its condensate capacity in live steam. Actual results will vary on the trap type and operating conditions but this is a reasonable place to start. A typical ½” trap at 100 psig will have a capacity of about 1,000 lb/hr of condensate so open failure of the trap will result in the loss of about 100 lb/hr of live steam. If your steam cost per 1,000 lbs is $10.00, then your loss will be $720 per month. If you add the cost of a ½” trap with the labor to install it, you might spend $720.00, I suspect a bit less. Payback on finding and replacing failed steam traps is about one month. Not many items in a facility will payback in savings in a month or so. Knowing your steam trap population and keeping them in good order is not low fruit- it is fruit on the ground.

If we take all the steam traps made worldwide in every form and type, we can sort them into two broad categories:

- Blast traps are either open or closed. As they sense the presence of condensate, they go through a reaction sequence, open and discharge and then close again to begin the reaction sequence.
- Modulating traps, as the name suggests, discharge anytime condensate is present and adjusts typically by a float mechanism with a discharge rate to match the condensing rate. All float traps and thermostatic traps and few types of thermostatic traps are modulating traps. <u>All other steam traps by default are blast traps.</u>

One other “steam trap” type bears very important mention - orifice traps or other names used to describe a device with a fixed hole or orifice. I’ll open with a simple comment - they do not meet the definition of a steam trap starting with the word “automatic”. Orifice traps come and go in spans of 5-10 years. The sales pitch is simple - size an orifice to match the condensing rate of the piece of equipment or application to be drained.

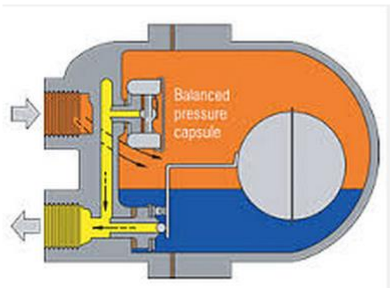
Simple - NO.

Assume that you manage to calculate with high degree of precision that the condensing rate for a piece of equipment is say 899 lb/hr. Assuming the condensing rate never changes along with the supply and return system also that never changes, you are good to go with a fixed orifice. The problem in the real world is that they will change. If the rate rises about 899 lb/hr, then you back up condensate in your equipment and if it drops below 899 lb/hr, then they will blow live steam.

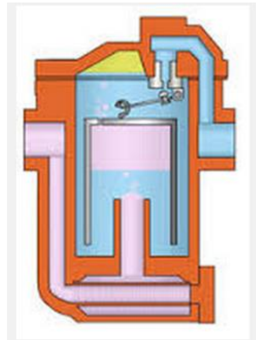
Orifice traps do have a valid application on closed loop systems which condenses all the flash and live steam to be fed back to the boiler. This situation occurs in some steam powered ships and in some cases large power generation plants. If this is not your application, I would suggest you steer clear of orifice traps to avoid a lot of issues and potential damage to your steam system.

Volumes have been written on steam trap operating types. We'll go with the very short version and you can further explore on the web if desired.

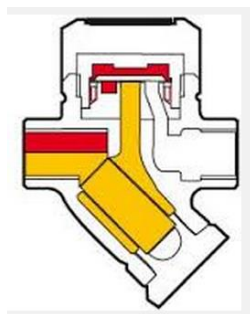
- Float and Thermostatic Traps use a ball float mechanism in the form of an internal level control which opens when condensate enters the trap. A thermostatic balance pressure air vent which follows about 15° F below the saturation curve, vents air and non-condensables.



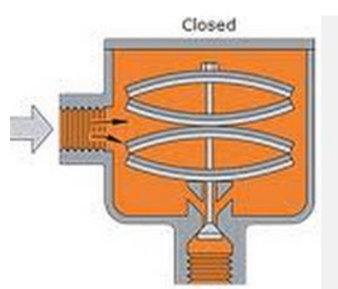
- Inverted Bucket traps substitute an upside down bucket combined with a mechanism to discharge condensate in a cyclic form - on/off operation. A small vent hole on top of the bucket will discharge limited amounts of air and non-condensables. An optional air vent can be added to most brands.



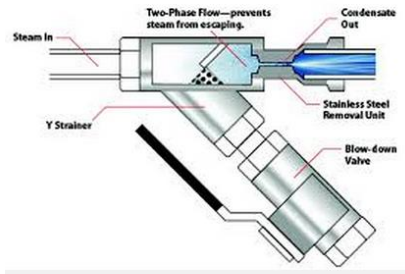
- Thermodynamic traps use Bernoulli's theorem which states that a gas or liquid will flow at a faster velocity when passing through a restricted area. This style of trap is on/off in operation and vents limited amounts of air. A small compact footprint lends itself to widespread use for steam tracing and similar applications.

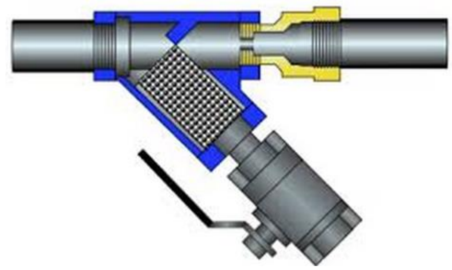


- Thermostatic traps utilize a bellows filled with a volatile fluid which has a higher pressure at any boiling point that expands the bellows and closes the trap. The internal fill fluid is selected to follow the saturation curve over a wide range of pressures. Bimetallic elements can also be stacked to provide them to follow the saturation curve. Thermostatic traps will vent large amounts of air and non-condensables on both start-up and during operation which can be important in some applications. The same element concept is the thermostatic part of the float and thermostatic trap which in reality is two traps in one body.



- I've included a cut away of an orifice trap to make the list but will again state I do not consider it to be a true steam trap since it fails the automatic part of sensing condensate and steam to provide proper operation. If you use this type of device, proceed with great caution, understanding that in most cases you will either back up condensate in your equipment or blow live steam. Neither mode of operation is a wise choice.





Two companies with a long track record in the R&D, manufacture and distribute steam traps are Armstrong International and Spirax Sarco. In my earlier years, I worked for both companies and can attest to sound R&D, manufacturing and reliable products. Both companies account for over 50% of worldwide trap sales. Many other companies, both regional and worldwide, also manufacture excellent products so be an informed buyer. Buyer beware that the lowest cost steam trap could become a very expensive waste of money if it does not perform well due to poor design, sub-standard materials, short cuts in the manufacturing process and poor product support. Being an informed buyer is my best advice.

From my personal experience I would rank overall performance of steam traps in the following list of best operational features:

1. Float and Thermostatic traps provide the best performance features with modulating discharge and high air venting capabilities. They are more expensive than other choices, subject to freezing if not properly protected; the float is vulnerable to water hammer and in some versions, a bit complicated if the piping is not inline design. For applications where a control valve modulates the steam flow, they remain the best choice.
2. Inverted bucket traps can be a close second in many applications and although they don’t modulate like an F&T, they will, if properly sized and applied, respond quickly to load changes. They are also offered in smaller physical dimensions and pipe sizes and in versions which will deal with freezing situations. Without an optional air vent they will be slow to vent gases.
3. Thermodynamic disc traps work well in small to mid-range capacity applications where on/off operation is not an issue and a small compact size is important. All models will operate over a wide range of pressures providing storeroom reductions in inventory if your facility uses a lot of traps on varying pressures. Properly installed they can be made to be freeze proof.

4. Thermostatic traps are popular in many parts of the world and could in reality enter this list in position 2 or 3 if properly selected and sized. Something had to be 4 in my list and thermostatic traps wound up in this position by default.
5. Orifice traps based on my 50+ years should not be on any list for the reason previously listed.

The most important issue with steam traps is to recognize that they all fail, and when that occurs it will cost you substantial losses in wasted energy to produce expensive steam. In most cases this will also impact your facility productivity. Steam traps should be checked at least twice per year. Many companies offer a variety of test equipment which can check for leaks or blow-through by sensing vibration combined with trap temperatures. Trap temperatures alone will not identify a bad trap and only give you an indication of the supply and return line pressure which can be inferred from a temperature measurement. Advances and cost reductions in electronics have made infra-red cameras a viable and reliable way to check steam traps if they are not insulated. If you insulate traps, consider using a removable jacket type if you use infrared cameras.

The best people to survey and check traps are your employees. They know your systems and have a vested interest to do a complete survey. Be very aware of “free” steam trap surveys offered by companies selling steam traps. Although some can be honestly done, most I’ve seen tend to be designed to sell you more steam traps of the types and brands they offer. If you sub-contract surveys, check carefully the credentials of the company and people performing the survey. This is a definite buyer beware area!

As previously mentioned, all steam traps will fail; not if, but when. Failures typically occur for the following reasons:

- Steam traps fail prematurely due to improper sizing and selection with oversizing being high on the list of trouble-makers.
- Dirt and debris getting into the small internal passages are also a significant cause of failure with a strainer or built-in strainer offering an effective solution.
- Water hammer and pressure surges can cause failure of all types of traps with F&T traps being most vulnerable. I once saw the caps blown off of Spirax Sarco TD-52 traps which were not due to the trap, but extreme water hammer which can generate extremely high pressure spikes.
- Traps installed in installations where freezing occurs need to be protected with proper insulation jackets and drain valves for when the steam system is shut down.
- Poor water treatment and insufficient removal of carbon dioxide can result in formation of carbonic acid. CO_2 + H_2O (hot condensate) combine to form H_2CO_3 which is carbonic acid. Carbon acid attack is common around traps and

formations of red brown magnetic debris (rust is the indicator that carbonic acid is present). If in doubt, check the condensate pH and if less than 6.8-7.0 then you have a problem with CO_2 removal in your deaerator.
- Trap age is also a cause of failure with large amounts of trap cycles eventually wearing out the moving parts causing a failure.

For more information look at a study by the State of Michigan:

http://www.michigan.gov/documents/CIS_EO_DTE_Steam_Traps_138473_7.pdf

UE Systems produces steam trap test equipment and provides surveys. They have a lot of good information on their web page:

http://www.uesystems.com/resources/articles-and-announcements/why-do-steam-traps-fail

Few items in a facility offer a payback period of 1-3 months based on energy dollars saved. Steam traps, along with steam leaks, offer this opportunity. Taking the time to manage your steam system for leaks and steam trap failures is worth the effort with excellent opportunities to lower energy costs and emissions.

Sizing a steam trap is based on the condensate load to the trap, pressure differential across the trap, and safety factor.

Three quick formulas can be used to calculate the steam load for many applications.

Heating water with steam

Q = GPM/2 x (temp rise)

Heating air with steam

Q = CFM/800 x (temp rise)

Heating oils with steam

Q = GPM/4 x (temp rise)

Where

Q= lb/hr of steam

GPM= gallons/ minute

CFM=cubic feet/minute

The pressure differential across the trap is inlet pressure minus outlet pressure. Trap inlet pressure is line pressure to the trap less any pressure drop through control valves and equipment. Trap outlet pressure is the combination of static pressure plus any pressure due to elevation changes. For most applications, use a safety factor of twice the actual load.

Piping errors result in premature trap failure. All steam traps should be installed with a discharge check valve, inlet and outlet isolation valves, and an inlet strainer. Always allow condensate to flow to the trap and lift from the trap. Make all return lines at least equal in size to the trap connections.

Attempting to lift condensate on equipment applications where the steam supply is controlled will lead to flooding and trap problems. By definition, a control valve will adjust to whatever position is required to maintain your set point. In many cases the valve will either be throttled close to a closed position or closed. If the back pressure is equal to or greater than the inlet pressure to the trap, no flow can occur resulting in flooded equipment. On applications of this type, use a condensate pump.

Steam traps are another text book topic. For articles and tips see –

http://www.control-specialties.com/tech-info/index.php?c=15

Chapter 8 – Steam Flow Meters

Steam is an expensive utility to produce. With energy costs ever changing, a quick way to get a handle on steam costs is to take your energy cost per one million BTU's and divide by .7. The .7 assumes a boiler efficiency of about 80% and then adds in the cost of water and feedwater chemicals. This is a rule of thumb number so you should do the actual calculations for your facility by factoring in costs of energy, water cost per 1000 gallons and chemical costs per 1000 gallons.

$$Steam\ Cost = (Energy\ per\ million\ BTU) \div .7$$

As an example, if energy costs are $10.00 per million BTU's, then estimated steam costs for 1,000 lbs of steam (one million BTU's is the energy content of 1000 lbs of steam) plus feedwater and chemicals would be $14.29 per 1,000.

The real cost driver in any energy delivering system is time, or hours of use, per year. A 365 day year contains 8,760 hours. If you used 1,000 lbs/hr of steam at $14.29 per 1,000, then your energy cost would be $125,180 per year. If you use 10 times as much steam (10,000 lb/hr); then your cost would be $1,251,800 per year.

Sir Isaac Watt has been stated to say "if you cannot measure it, then you don't know much about it". "It" in our case is the cost of steam and steam costs in your facility.

There are many types of flow meters available, those suitable for steam applications include:

- Orifice plate flowmeters
- Turbine flowmeters (including shunt or bypass types)
- Variable area flowmeters
- Spring loaded variable area flowmeters
- Direct in-line variable area (DIVA) flowmeter
- Pitot tubes
- Vortex shedding flowmeters

Each of these flowmeter types has its own advantages and limitations. To ensure accurate and consistent performance from a steam flowmeter, it is essential to match the flowmeter to the application.

For much more information on flow meter types and operation see –

http://www.epa.gov/chp/documents/wbnr011013_ierna.pdf

This technical paper covers all of the issues to evaluate, size, select and install a flow meter or meters for your facility.

From personal experience some added comments-

- Meter turn down is a very important issue and states what range a meter can accurately measure the flow. The oldest steam flow meter is an orifice plate which has a known precise area and a differential pressure gauge to measure the pressure drop across the orifice plate. Tables can be calculated to show steam flows for a given pressure drop. Orifice plates will typically have a turn down ratio of 4:1. If your maximum meter flow is 10,000 lb/hr, the meter will not read under 2,500 lb/hr or 25% of the maximum flow rate (1÷4). In many cases, you will wind up with no readings if you drop below the turn-down ratio point.
- A meter with a high turn down ratio will cost more but provide more accurate data. As an example, a meter with a 30:1 turn-down ratio size to read 10,000 lb/hr maximum flow will read down to 333 lb/hr (1÷30).
- Most meters rely on pipe velocity as the measure variable to arrive at a flow rate. Meters should be sized for maximum design flow rate and not the pipe size.
- If your pressure and temperature are constant for the steam being measured, then no additional data is required for the meter. In most cases, pressure and temperature will vary so added data in the form of pressures and temperatures

from sensors should be provided for the mass flow computer which provides the actual flow rate.

- Always meter the rate and total. As with a car, you need a speedometer and odometer to understand travel. The same applies to steam flow measurements. Rate flows are best charted to see how demand varies in a 24 hour period and is valuable in understanding boiler operations to improve steam efficiency. Totalized information should be used to arrive at all energy consumption data and cost analysis.
- Steam flows are typically seasonal in many facilities, so establish base consumption data for a system in good working order. I would suggest that a period of one month is a good starting point for studying steam consumption.
- With baselines established, look for unexplained increases in consumption which are usually due to steam leaks, failed steam traps, and condensate losses.
- Changes of 5% or more are significant since they will reflect a potential savings in energy use, reduction in water consumption, and increases in chemical treatment costs.

Water in many areas is becoming a resource issue. Steam systems consume large amounts of water. The conversion is:

$$500\frac{lb}{hr}\,of\ steam = 1\ gallon\ per\ minute\ of\ water$$

Assume you are producing 10,000 lb/hr of steam with no return. To produce 10,000 lb/hr of steam you need to feed your boiler 20 GPM of water or 1,200 gallons per hour. For 8,760 hours in one year, that works out to 10,512,000 gallons of water. If your consumption of steam rises 10% for no sound reason other than losses, then you have wasted right at one million gallons of water. If you add in energy costs and water treatment costs, this should lead to the conclusion that steam meters are in fact a great investment.

Sir Isaac Watt has been stated to say “if you cannot measure it, then you don’t know much about it” sure applies to a steam system.

Chapter 9 – Final Thoughts

In our first EBook we covered Boiler Plant Operations and Tips. My intent was to write Book 2 to cover Steam Systems. With over 50 years of working with every facet of steam systems something odd happened as I began to write the second book. It was the realization that trying to cover all the squares in a second book was a formidable task and may burden you with information over load. Hence, the title of Book 2 “Dealing With Steam Distribution and Primary Equipment”.

My intent is to distill as much as possible on a very broad topic with practical information that I have learned over these many years of dealing with steam systems.

As I finish this book, the next EBook will cover steam usage in equipment and applications. If form follows true, I suspect it will be longer in content than I now imagine it might be at this point.