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Review of Orifice Plate Steam Traps

C. B. Oland

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REVIEW OF ORIFICE PLATE STEAM TRAPS

C. B. Oland

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C. B. Oland

ABSTRACT

This guide was prepared to serve as a foundation for making informed decisions about when orifice plate steam traps should be considered for use in new or existing steam systems. It presents background information about different types of steam traps and defines their unique functional and operational characteristics. The advantages and disadvantages associated with using orifice plate steam traps are provided to highlight their capabilities and limitations. Finally, recommendations for using orifice plate steam traps are presented, and possible applications are identified.

1. INTRODUCTION

Steam traps are important parts of any steam system. Their basic function is to prevent the passage of steam while allowing condensate to flow.[1] Figure 1 shows the steam supply and condensate drainage piping for a typical space heater application. Large steam systems often include hundreds or even thousands of traps used in similar installations.

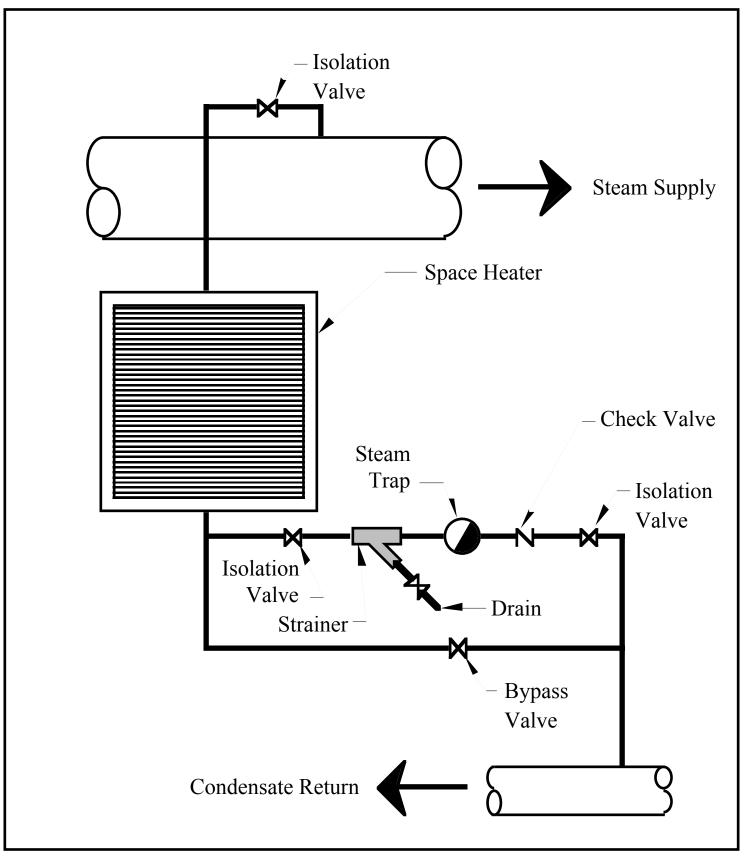

Fig. 1. Steam supply and condensate drainage piping for a common space heater.

For a steam system to operate efficiently, each trap must remove condensate as it forms without releasing valuable steam. Malfunctioning traps represent a significant source of wasted energy. In one large government-owned facility, a comprehensive steam trap survey was conducted to identify each trap in the system, characterize its in-service performance, and determine the total cost of the wasted steam energy. Of the 910 traps surveyed, 207 traps were found to be wasting a total of 4,783 lb of steam per hour at an annual cost of more than $60,000.[2]

Steam traps are produced by a number of manufacturers. There are a wide range of designs and sizes with different operational characteristics. Some traps release condensate continuously, while others discharge condensate intermittently after it accumulates. Although there is no universal trap design that is suitable for all applications, trap selection is critical for efficient steam system performance.

An orifice plate steam trap is a relatively simple condensate removal device. Its design includes a thin metal plate with a small-diameter hole through the center. Figure 2 shows a typical orifice plate steam trap installation. The plate keeps live steam from flowing, and the hole or orifice allows either condensate or a small amount of live steam to escape. When orifice plate steam traps are properly sized for the flow conditions, they can function properly, but they are not suitable for all applications. Steam will escape when no condensate is present, and condensate backups can occur at start up and during periods of high demand. Orifice plate steam traps are best suited for situations where the pressure difference across the plate and the condensate load remain constant.

Conventional traps are more complex than orifice plate steam traps. They have at least one moving part that provides automatic control of condensate releases. Depending on its size and design, a conventional trap can handle a relatively wide variation in condensate loads, ranging from start-up to steady-state operating conditions. Conventional traps are used extensively in most applications, but they can malfunction while in service. Traps that fail in the closed position result in condensate backups, while traps that fail in the open position allow steam to escape.

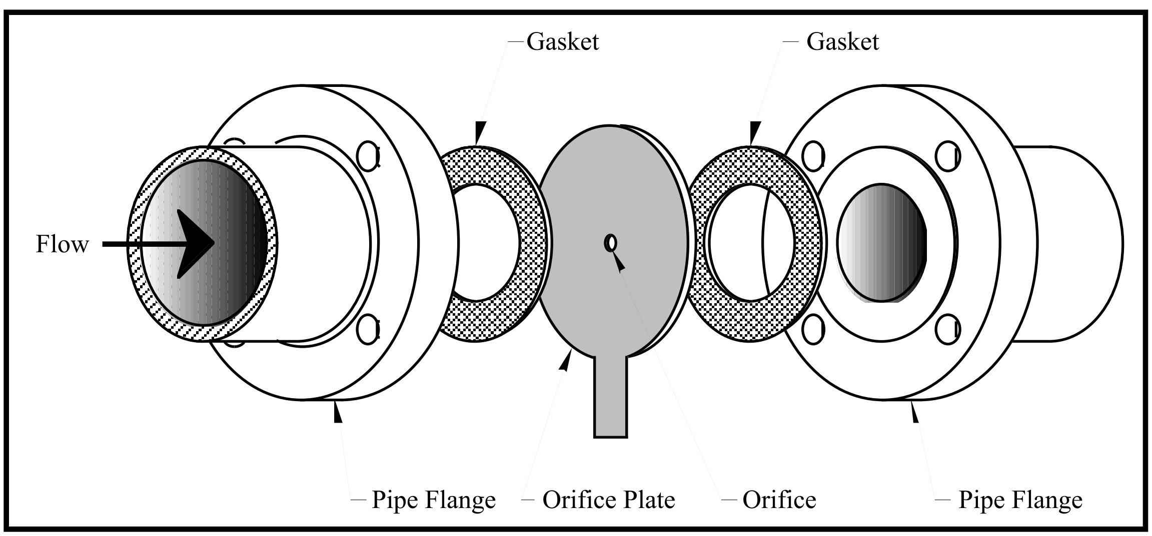

Fig. 2. Typical orifice plate steam trap installation.

2. SCOPE AND OBJECTIVE

This guide is intended to serve as a foundation for making informed decisions about when orifice plate steam traps should be considered for use in new or existing steam systems. The optimum steam trap choice for any process equipment involves selection of a device that has sufficient capacity to remove condensate when needed with no loss of steam at any time. As in most design efforts, equipment selection is a compromise among many competing factors. Selection of a suitable steam trap for a particular application requires an awareness of the various designs that are available, an understanding of their capabilities and limitations, and knowledge about their in-service performance.

The guide first presents background information about steam traps and defines the three basic functions they perform. The focus is then on identifying the different categories and types of traps that are available and describing their unique operational characteristics. The advantages and disadvantages associated with using orifice plate steam traps are provided to highlight their capabilities and limitations. Finally, recommendations for using orifice plate steam traps are presented, and possible applications are identified.

Note that orifice trap designs and configurations other than the one shown in Fig. 2 have been developed as an attempt to solve various operating problems associated with orifice plate steam traps. Some of these designs and configurations include the following:

- Venturi orifice traps have been used to alter flow characteristics through the nozzle-type opening and thereby accommodate a wider variation in condensate flow. Traps of this type are relatively new on the market, so there is virtually no documentation describing their operational characteristics, in-service performance, or reliability.
- Variable orifice traps have the ability to change the flow rate by varying the size of the orifice. They are constructed with a cylindrical-shaped element that is filled with temperature-sensitive hydrocarbon wax. A hole or opening along the central axis of the element serves as a variable orifice. At start up, when the wax is cool, the opening is large. This allows air and cool condensate to flow freely. As the temperature of the condensate increases, the wax expands. This action reduces the size of the opening, thereby restricting flow. If live steam is present, the opening will completely close. Variable orifice traps are also relatively new on the market, so there is virtually no documentation describing their operational characteristics and in-service performance.
- A number of orifice traps can be installed in either a parallel or series flow configuration. Arrangements such as this can possibly handle wider variations in condensate flow.

This guide focuses only on orifice plate steam traps. At the present time, insufficient information is available to include discussions about other configurations of orifice traps, such as venturi and variable orifice traps. As the needed information becomes available, similar guides for these devices will be developed.

3. FUNCTIONAL REQUIREMENTS

Steam traps represent a common type of process equipment used in virtually all steam systems. Depending on their design, they may perform one or more of the following functions.[3]

- Keep steam from escaping. Steam that escapes through a trap reduces the overall efficiency of the steam system and wastes valuable resources. Wasted steam is expensive.
- Remove condensate. Condensate that forms when the latent heat of evaporation is reclaimed from steam must be removed as it accumulates or the steam system will not function properly. A backup of condensate, known as waterlogging or flooding, can adversely affect heat transfer, promote corrosion of carbon steel components, and cause a potentially dangerous condition known as water hammer.
- Remove air. Air and other noncondensable gases must be removed from any steam system because they can combine with condensate to form a corrosive mixture. This mixture can be very detrimental to the long-term performance of certain metallic components, particularly those made of carbon steel. The noncondensables can also act as an insulator and impede the transfer of heat from the steam. Removal of air and any other gases that may be present is usually most critical during system start up.

Steam trap manufacturers are very aware of these functional requirements, but they also recognize that there is no universal design that is suitable for all applications. Consequently, they produce a wide range of steam traps with different operational characteristics. Proper trap selection depends primarily on the service conditions.

When steam is first introduced into the steam system, the temperature difference between the steam and the various metal surfaces is the greatest. At this time, the rate of heat transfer and condensate formation is high. As the steam warms the metal surfaces, the gradual decrease in temperature difference produces a corresponding drop in the rate of condensation. Eventually, a stable condition is reached, and the amount of condensate that forms is relatively constant. These two extremes of variable condensate formation are generally known as the start-up load and the running load.[4] The amount of condensate that is produced at any given time is a function of the steam system design, its process equipment and operating conditions, and the heating load.

4. TRAP CLASSIFICATION

According to the Fluid Controls Institute,[5] a steam trap is a self-contained valve that automatically drains the condensate from a steam-containing enclosure while remaining tight to live steam or, if necessary, allowing steam to flow at a controlled or adjusted rate. This definition applies to all types of condensate removal devices that are generally grouped into two broad categories—orifice traps and conventional traps.

Orifice plate steam traps are relatively simple devices that have a fixed diameter opening and no moving parts. They remove condensate continuously but have no way to shutoff or limit flow. The only variable in their design that affects performance is the diameter of the orifice, which can be as small as 0.020 in.

Conventional traps are more complex. They have at least one moving part that permits automatic control of condensate releases. Conventional traps are subdivided into the following categories:

- Thermostatic
- Mechanical
- Thermodynamic

These three types of steam traps automatically release condensate based on a difference in properties between live steam and liquid condensate.

5. OPERATIONAL CHARACTERISTICS

Operational characteristics for orifice plate steam traps and various conventional traps are briefly described below. Detailed parts diagrams and discussions about specific trap designs are available elsewhere.[6–11]

5.1 ORIFICE PLATE STEAM TRAPS

Removal of condensate from any piece of equipment in a steam system can be accomplished by providing an adequately sized hole or opening at the bottom of each condensate collection point. This opening or orifice allows the condensate to drain freely from the system. One of the first steam traps ever used involved a piece of copper tubing that was crimped with pliers to achieve the desired opening. With no means for controlling flow, either condensate or steam escaped continuously. The next generation of steam traps involved use of mechanical components to automatically open and close a valve.

A simple orifice plate steam trap consists of a thin metal plate with a small-diameter hole drilled through the plate. When installed at the appropriate location between two adjoining flanges[12] in a steam system as shown in Fig. 2, condensate that accumulates is continuously removed as the steam pressure forces the condensate to flow through the hole. During conditions when no condensate is present, a limited amount of steam flows through the hole. Other types of orifice plate steam trap designs include the Drain Flange Assembly (DFA) and the Drain Union Assembly (DUA), which are described in Ref. 6. These assemblies are typically installed in a piping system with threaded rather than flanged connections.

Orifice plate steam traps have no moving parts that can malfunction. Although their design is simple, there is always flow of either condensate or live steam through the orifice because there is no way to automatically change the size of the opening or limit the mass flow rate through the orifice. Over time, the orifice diameter may gradually increase because of erosion, especially in steam systems that contain corrosion products or debris. The following discussions describe the performance of an orifice plate steam trap under various operating conditions.

- When an orifice plate steam trap is functioning properly, all of the condensate that is produced by a piece of equipment flows through the orifice. The mass flow rate through the orifice is sufficient to keep condensate from backing up and live steam from escaping. Under ideal conditions, it may be possible to achieve this operating state, but in practice it is usually difficult to sustain this constant balance for long periods of time. Temperature changes and pressure variations, as well as system demand, directly influence condensate formation and flow. Optimum orifice plate steam trap performance is only possible when the orifice is properly sized for the application, and the pressure difference across the plate and the condensate load remain constant.

- When too little condensate is present, live steam escapes through the orifice, thereby wasting energy and reducing the overall efficiency of the system. This operating condition produces the same result as a conventional thermostatic, mechanical, or thermodynamic trap that fails in the open position. The only difference is the rate of steam loss.

  For the same application, a conventional trap has a valve opening (orifice) that is much larger than the corresponding opening in an orifice plate steam trap. This larger opening is required to accommodate a wider variation in condensate loads. When the conventional trap functions properly, steam flow through the opening is automatically limited, but when the trap fails in the open position, steam escapes freely through the large valve opening. Under the same pressure and operating conditions, more steam escapes through a large opening than through a small opening. Consequently, conventional traps that fail in the open position can waste more steam than corresponding orifice plate steam traps that would have smaller openings. Although live steam may be lost during normal operation through any size orifice, the mass flow rate of steam is much less than that of condensate.[7]

- When the rate of condensate accumulation is greater than the flow capacity of the orifice plate steam trap, waterlogging or flooding of the steam system can occur. This condition can also occur when the small-diameter hole of an orifice plate steam trap becomes blocked or clogged with dirt or debris. This operating condition produces the same result as when a conventional thermostatic, mechanical, or thermodynamic trap fails in the closed position. Consequences of waterlogging or flooding include reduced heat transfer and potentially damaging effects of water hammer. Installation of a fine-mesh inline screen or strainer located upstream of an orifice plate steam trap is generally required to reduce the chances of blockage or clogging (screens and strainers are also typically installed upstream of conventional steam traps to reduce chances of potential damage). Although these devices will remove dirt and debris and thereby keep the orifice plate steam trap from malfunctioning, periodic back flushing or cleaning is usually necessary. As with any system that includes an inline screen or strainer located upstream of a steam trap, this maintenance activity can be time-consuming and is often neglected or not performed in a timely manner. Removal of dirt and debris by inline screens and strainers is also an important long-term performance consideration. Flow of these materials through an orifice plate steam trap can result in a gradual increase in the orifice diameter due to erosion.

The designer's objective for any orifice plate steam trap is to select a small enough orifice to keep too much live steam from escaping and a large enough orifice to keep condensate from backing up. Selecting the proper orifice size for a particular application can be an iterative engineering effort that involves mathematical equations based on scientific principles and use of a Mollier or similar chart.[13] Although the flow dynamics through orifices can be complex, data obtained in accordance with requirements in the performance test code for "Condensate Removal Devices for Steam Systems"[14] can be useful in selecting an orifice of the proper size.

Another important consideration for the designer involves an evaluation of the condensate return system. The piping must be capable of handling pressure-induced mechanical loads associated with flow of live steam through the orifice. Also note that orifice plate steam traps may not have sufficient capacity to effectively remove air during start up. Consequently, provisions for an alternate method of air removal, such as a manually operated or thermostatically controlled valve, may need to be considered by the designer. A summary of the advantages and disadvantages of using orifice plate steam traps is presented in Table 1.

The primary reasons for considering an orifice plate steam trap include its simple design with no moving parts and its relatively long service life with little or no required maintenance. Major reasons why orifice plate steam traps should not be considered include (1) inability to handle air on start up, (2) inability to handle variations in condensate loads especially during start up, (3) inability to keep live steam from flowing when little or no condensate is present, and (4) potential for clogging by dirt and debris contained within the steam system.

5.2 CONVENTIONAL TRAPS

5.2.1 Thermostatic Traps

Thermodynamic traps use temperature difference to distinguish between condensate and live steam. This difference is used to open or close a valve. Under normal operating conditions, the

Table 1. Advantages and disadvantages of orifice plate steam traps

Advantages	Disadvantages
Can be used for high-pressure steam applications Performance can be computed if the condensate load and inlet and outlet pressures are known Continuous discharge No moving parts Easy to maintain Cannot fail open, but erosion can gradually cause an increase in the orifice diameter Relatively low initial cost Resistant to damage by water hammer and thermal shock Pressure drop across the orifice reduces potential for overpressure of the downstream condensate system Resistant to freeze damage Can be mounted in several positions	Usual failure mode is closed due to plugging or blockage by dirt or debris Screen or strainer may be required to reduce possibility of plugging or blockage Live steam losses are usually small when the orifice is properly sized, but wear and erosion can enlarge the orifice and cause excessive loss of live steam Orifice opening cannot be adjusted to accommodate varying condensate loads Automatic or manual drain valve may be required to accommodate large condensate loads that occur during start up or periods of high demand Air can only be discharged very slowly during start up Engineering is required to select the appropriate size orifice for a particular application (ineffective if oversized or undersized) Consequences of live steam in the return system must be evaluated Difficult to field check because of continuous discharge Does not function effectively when back pressure is excessively high If the load is likely to vary by a factor of 2 or 3, the orifice plate steam trap may not be cost-effective because waterlogging or flooding is possible or excessive steam may escape

Source: Refs. 1, 4, and 7.

condensate must cool below the steam temperature before the valve will open. Common types of thermostatic traps include bellows, bimetallic, and thermal expansion traps. Brief descriptions of their operational characteristics are provided below.

1. Bellows traps include a valve element that expands and contracts in response to temperature changes. An alcohol mixture with a boiling point lower than that of water is contained inside the element and provides the necessary force to change the position of the valve. At start up, the bellows trap is open. This operating condition allows air to escape and provides maximum condensate removal when the load is the highest. Bellows traps can fail either open or closed. The configuration of a bellows steam trap is shown in Fig. 3.

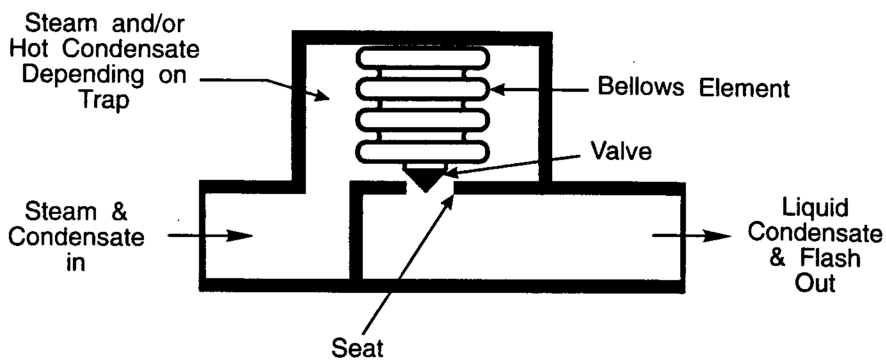

Fig. 3. Configuration of a bellows steam trap. *Source*: Ref. 1.

2. Bimetallic traps rely on the bending of a composite strip of two dissimilar metals to open and close a valve. Air and condensate pass freely through the valve until the temperature of the bimetallic strip approaches the steam temperature. After steam heats the bimetallic strip and causes it to close the valve, the trap remains shut until the temperature of the condensate cools sufficiently to allow the bimetallic strip to return to its original shape and thereby open the valve. Bimetallic traps can fail in either the open or closed position. The configuration of a bimetallic steam trap is shown in Fig. 4.

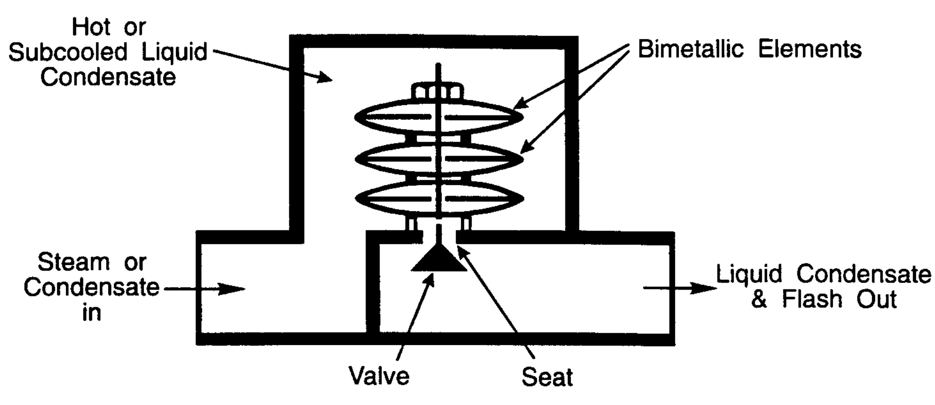

Fig. 4. Configuration of a bimetallic steam trap. *Source*: Ref. 1.

3. Thermal expansion traps contain a thermostatic element that is filled with oil. As the oil heats up and expands, it causes a piston to move and thereby close a valve. During start up, air and condensate are expelled from the open valve. When the oil is sufficiently heated by the steam, the valve closes to keep the steam from escaping.

5.2.2 Mechanical Traps

Mechanical traps use the difference in density between condensate and live steam to produce a change in the position of a float or bucket. This movement causes a valve to open or close. Several mechanical trap designs are based on this principle. They include ball float, float and lever, inverted bucket, open bucket, and float and thermostatic traps. Brief descriptions of their operational characteristics are provided below.

1. Ball float traps rely on the movement of a spherical ball to open and close the outlet opening in the trap body. When no condensate is present, the ball covers the outlet opening, thereby keeping air and steam from escaping. As condensate accumulates inside the trap, the ball floats and uncovers the outlet opening. This movement allows the condensate to flow continuously from the trap. Ball float traps cannot vent air on start up.

2. Float and lever traps are similar in operation to ball float traps except the ball is connected to a lever. When the ball floats upward due to accumulation of condensate inside the trap body, the attached lever moves and causes a valve to open. This action allows condensate to continuously flow from the trap. If the condensate load decreases and steam reaches the trap, downward ball movement causes the valve to close, thereby keeping steam from escaping. Float and lever traps cannot vent air on start up.

3. Inverted bucket traps are somewhat more complicated than float and lever traps. At start up, the inverted bucket inside the trap is resting on the bottom of the trap body, and the valve to which the bucket is linked is wide open. As steam enters the trap and is captured inside the bucket, it causes the bucket to move upward. This upward movement closes the valve and keeps steam from escaping. When the condensate collects and cools the steam, the bucket moves downward. This movement causes the valve to open thereby allowing the condensate to escape. Unlike float traps, inverted bucket traps have intermittent discharge. The configuration of an inverted bucket steam trap is shown in Fig. 5.

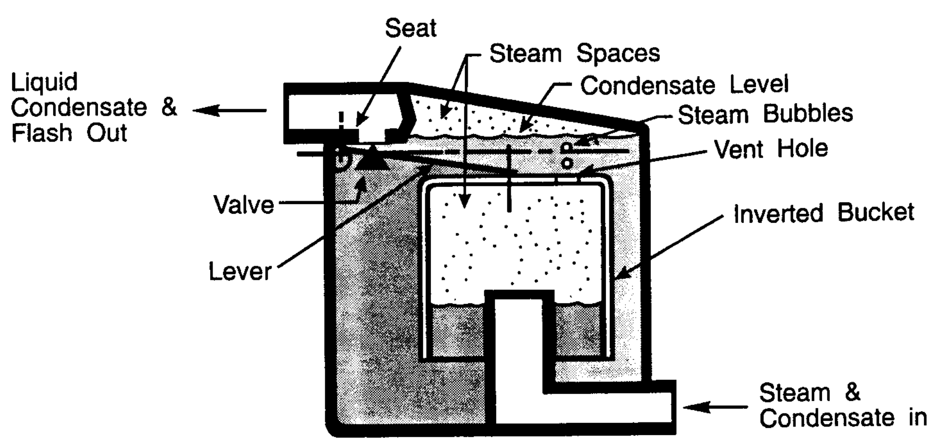

Fig. 5. Configuration of an inverted bucket steam trap. *Source*: Ref. 1.

4. Open bucket traps consist of an upright bucket that is attached to a valve. At start up, the bucket rests on the bottom of the trap body. In this position, the valve is wide open. As condensate accumulates in the trap body on the outside of the bucket, the bucket floats upward, which causes the valve to close. When sufficient condensate accumulates outside the bucket, it spills over the top and fills the inside of the bucket. At this time, the bucket sinks, which causes the valve to open. Similar to inverted bucket traps, open bucket traps have intermittent discharge. The configuration of an open bucket steam trap is shown in Fig. 6.

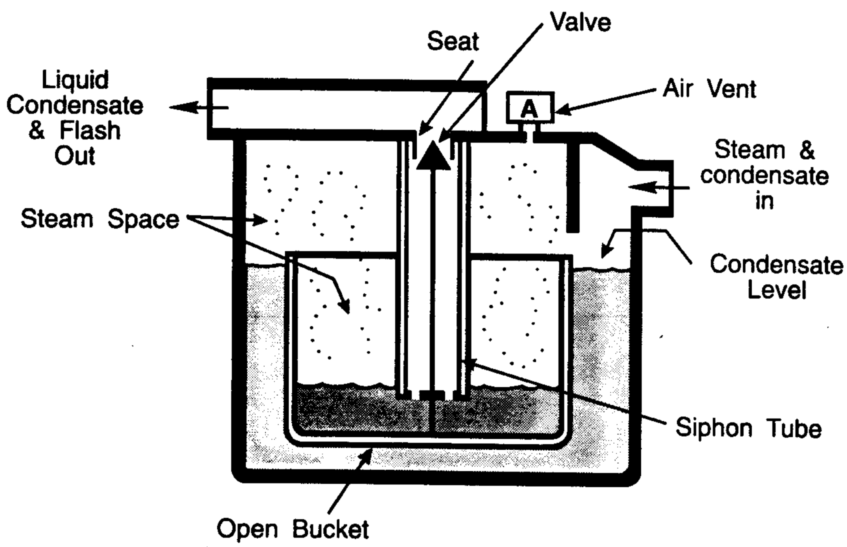

Fig. 6. Configuration of an open bucket steam trap. *Source*: Ref. 1.

5. Float and thermostatic traps (F&T) traps are similar to float and lever traps except they include a thermostatic element that allows air to be discharged at start up. Thermostatic elements used in these traps are the same as those used in thermostatic traps. The configuration of an F&T steam trap is shown in Fig. 7.

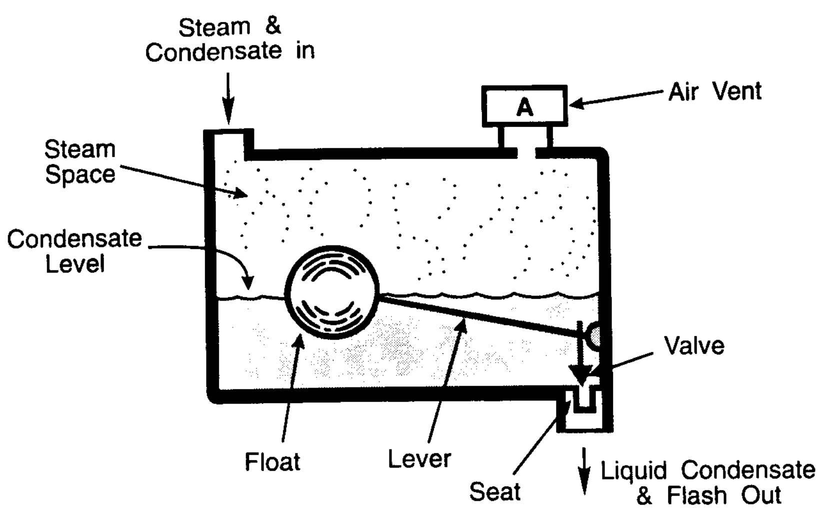

Fig. 7. Configuration of an F&T steam trap. *Source*: Ref. 1.

5.2.3 Thermodynamic Traps

Thermodynamic traps use the difference in either kinetic energy or velocity between condensate and live steam to operate a valve. The disk trap is the most common thermodynamic trap, but piston or impulse traps are sometimes used. Brief descriptions of their operational characteristics are provided below.

1. Disk traps use the position of a flat disk to control steam and condensate flow. When condensate or air flows through the trap, the disk is raised, thereby causing the trap to open. As steam heats the trap and the condensate above the disk flashes to steam, the disk moves downward. The force that causes the disk to move downward is generated by the difference in pressure between the low-velocity steam above the disk and the high-velocity steam that flows beneath the disk. Disk traps normally fail open and have an intermittent discharge. The configuration of a disk steam trap is shown in Fig. 8.

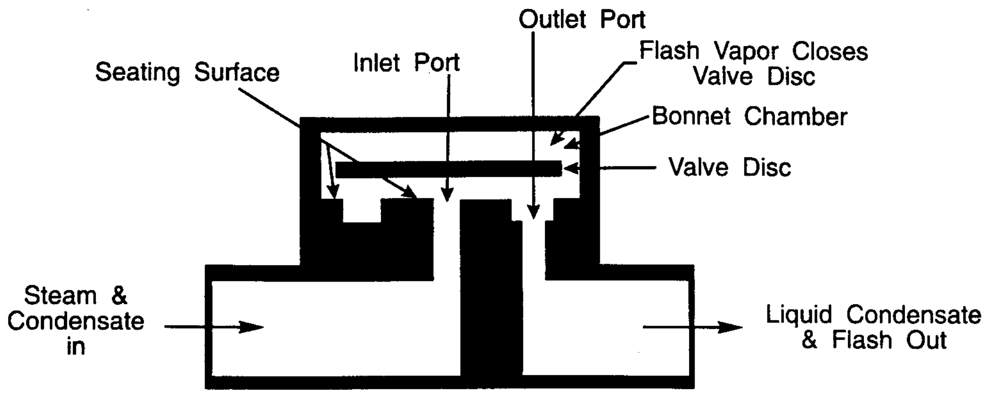

Fig. 8. Configuration of a disk steam trap. *Source*: Ref. 1.

2. Piston traps or impulse traps rely on flashing steam and the associated change in pressure to force a valve closed. These traps have an intermittent discharge and can fail either open or closed.

Although conventional traps are designed to accommodate rather large variations in condensate load, their moving parts and mechanical links are prone to damage and wear. Keeping a conventional trap operating properly usually involves regular inspection, periodic maintenance, and occasional replacement. Maintenance and repair costs can be significant, but energy wasted by malfunctioning traps that are not repaired or replaced in a timely manner can exceed the cost of maintenance and repair.

6. USER EXPERIENCE

When this guide was being prepared, users of orifice plate steam traps were contacted to learn about their experiences. Contacts were made with individuals from the U.S. Air Force, a university, and a private company. Information about the use of orifice plate steam traps by the U.S. Navy was obtained from published sources.

To help the Air Force make an informed decision about replacing approximately 5000 steam traps at Hill Air Force Base in Utah, a steam trap testing program was conducted by a steam trap manufacturer. The objective of the testing program was to compare the performance of fixed orifice steam traps with conventional steam traps under the same operating conditions. In the side-by-side tests that were performed at the manufacturer's facility, various test conditions were evaluated. At least five of the test conditions were selected by Hill Air Force Base personnel to reflect pressures and temperatures typically encountered in different parts of their steam system. When the testing was completed and the data were analyzed, the Air Force concluded that fixed orifice steam traps only performed satisfactorily under one set of operating conditions. Based on this conclusion, the decision was made to continue using conventional steam traps at Hill Air Force Base rather that replace them with fixed orifice steam traps.[15] Performance testing such as this can be effective in providing unbiased data for making objective comparisons.

Orifice plate steam traps were installed in at least 100 locations in the University of North Dakota steam system. After some time, they were all removed for a variety of reasons. Based on experience with this steam system, it was difficult or impossible to determine if the orifice plate steam traps were clogged or if steam or condensate was flowing. Problems with waterlogging were also experienced.[16] Unfortunately, a comprehensive report on these experiences and problems was not prepared.

Orifice plate steam traps were installed at the Allied Signal research and development (R&D) facility in Buffalo, New York, for many applications. Based on poor in-service performance such as flooding, most of these traps were replaced with standard F&T traps. It was reported that orifice plate steam traps could not keep up with condensate formation especially in winter during periods of peak demand. Some success with orifice plate steam traps was achieved, however, on certain process applications where the load was light and constant. Although orifice plate steam traps are promoted as maintenance free, experience at this facility suggests that some level of maintenance is always required to keep them functioning properly.[17]

In 1964, the Navy conducted a study to examine the use of orifice plate steam traps on fossil-fuel-powered ships. The tests were so successful that the Navy decided to convert the entire fossil-fuel-powered fleet to traps of this type.[4] After considering all factors, the Navy concluded that orifice plate steam traps function well where the steam is relatively clean and the load does not vary much. Based on this conclusion, orifice plate steam traps are still being used onboard Navy ships.

Although orifice plate steam traps are being used by the Navy for certain offshore applications, they are not used as extensively in onshore steam systems. The Naval Construction Battalion[18] has concluded that orifice plate steam traps are not recommended

- for systems having back pressure greater than 50% of the inlet pressure,
- where efficiency is a factor, or
- where subcooling temperature is 30°F (17°C) below the saturated steam pressure. (Note: Although this final recommendation was reported in Ref. 18 exactly as it appears, the statement is not meaningful unless the word pressure is replaced with temperature.)

7. NEEDED INFORMATION

This guide reflects results of a search that was conducted to identify references dealing with orifice plate steam trap issues. Although the search was successful, only a limited number of open-literature documents were actually acquired and reviewed. Before additional objective guidance can be provided on when orifice plate steam traps should be considered, additional information and engineering data about the in-service performance of orifice plate steam traps are needed, especially documented case studies of actual orifice plate steam trap installations. The specific necessary information includes

- details of the orifice plate steam traps used, as well as engineering data and vendor information for each design;
- descriptions about successful orifice plate steam trap installations, including cost savings;
- problems, if any, with orifice plate steam traps such as water hammer, clogging, or flooding, including costs for periodic maintenance and repairs or replacements;
- reasons why conventional steam traps were removed and replaced with orifice plate steam traps; and
- reasons why orifice plate steam traps were removed and replaced with conventional steam traps, if applicable.

8. CONCLUSIONS

The efficiency of any steam system is influenced by the in-service performance of its steam traps. Oversized orifice plate steam traps and conventional traps that fail open can waste steam. For the same application, conventional traps that fail open can waste more steam than corresponding orifice plate steam traps that typically have smaller valve (orifice) openings. Undersized or blocked orifice plate steam traps or conventional traps that fail closed can cause waterlogging or flooding. Avoiding these undesirable operating conditions usually involves a program of periodic inspections and preventative maintenance to keep the traps operating at peak performance. Although performing these activities can be time-consuming, the cost associated with inappropriately sized or blocked orifice plate steam traps or malfunctioning conventional traps can be excessive.

Trap selection usually involves a compromise among many competing factors because no universal trap design is suitable for all applications. From an operational viewpoint, conventional thermostatic, mechanical, and thermodynamic steam traps are generally selected over orifice plate steam traps in most industrial applications. They are typically much better at automatically handling variable condensate loads, especially for equipment with a wide range in demand. This advantage often outweighs the fact that orifice plate steam traps require less maintenance and have no moving parts that can malfunction.

Guidance for deciding when orifice plate steam traps should be considered is not well established, and there are no rules in consensus codes or standards for addressing this issue.[5,14,18,19] Their use tends to be based on economic factors rather than effective removal of condensate.

To achieve peak performance from orifice plate steam traps, their use should be considered only when all of the following conditions are satisfied:

- Provisions are taken to keep the system clean of dirt and debris.
- A method (manual or automatic) for removing air during start up is provided.
- The inlet and outlet pressures are known, and the pressure difference across the orifice remains essentially constant.
- The condensate loads that the trap must handle are essentially constant.
- Operations are continuous with limited start-up and shutdown cycles.
- The return system is capable of handling all of the live steam that flows through the orifice, and the consequences of live steam in the return system piping are acceptable.

Orifice plate steam traps should not be considered for applications where occasional steam loss is objectionable or when occasional condensate backup cannot be tolerated. Use of orifice plate steam traps for heat exchangers, air handling equipment, sterilizers, laundry equipment, and other heat-transfer devices with condensate loads that vary widely with demand are also not recommended for the following reasons:

- The opening in an orifice plate steam trap is seldom the correct size. Consequently, it cannot accommodate wide variations in condensate loads. It will either pass too much live steam because it is oversized, or it will cause waterlogging or flooding because it is undersized.
- Occasional live steam flow into the return system piping can cause water hammer that produces objectionable noises, leaks, or excessive vibrations that can damage steam system components.

- Operator intervention may be required during start up to remove air or excessive condensate that the orifice plate steam trap cannot handle (also applies to some conventional steam traps).
- Dirt or debris in the system can cause clogging or blockage of flow through the orifice, and frequent cleaning of screens and strainers may be required (also applies to some conventional steam traps).

Although use of orifice plate steam traps in steam systems may be attractive for a variety of economic reasons, they only make sense in applications where condensate loads are essentially constant or where less than optimum performance can be tolerated. Use of orifice plate steam traps may only be feasible in situations where occasional steam losses during periods of low demand are acceptable. Specific reasons for selecting orifice plate steam traps over conventional traps must be made on a case-by-case basis because they can only be cost-effective when their in-service performance is satisfactory.

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