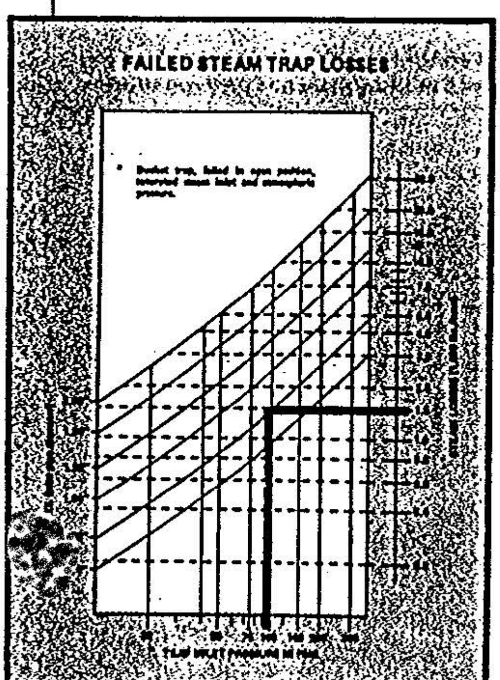
How to organize a steam trap maintenance program

Steam traps are designed and applied to rapidly remove condensate with minimal steam loss. However, without a regular program of performance monitoring and maintenance, a steam trap can become the site of a significant energy loss.

SURVEYS OF MAJOR plants without a regular steam trap maintenance program have shown an average of ten percent of all steam traps to be ineffective.

For example, a simple one-half inch thermodynamic disk trap can be as wasteful as a one-sixteenth inch hole on a 100 psig steam line and will amount to a steam loss of approximately 13,300 pounds of steam per month. Similarly, as the theoretical case demonstrates in Figure I, a three-quarter inch bucket trap which fails in the open position on that same 100 psig steam supply line is equivalent to a steam loss of approximately 1500 pounds per hour or 1,000,000 pounds of steam lost per month.



Effective program

A steam trap maintenance program requires an initial in-depth survey and subsequent regularly scheduled resurveys to be effective in controlling condensate energy losses. The initial steam trap survey is a planned examination of all steam traps in a boiler system in order to record their location, type, size and operating condition.

The survey is done to locate traps hidden by fittings, equipment, insulation or other piping systems. Each trap should be tagged in order to identify the exact location and to facilitate records and subsequent maintenance reports.

With extensive steam distribution systems, it is best to segment the survey and maintenance program by:

A) Section or area of the facility (north area vs. south area)
B) By use of the steam (processed coils vs. heat trace) or,
C) By steam system (high pressure vs. low pressure heating system).

Judging performance

The initial trap survey will always reveal various types of obvious steam losses such as bad valves, open traces, returnable condensate discharged to waste and traps failed in the open position. Subsequent scheduled maintenance surveys will reveal significantly less obvious steam losses.

If steam traps are repaired or replaced on a timed schedule such as a yearly maintenance shut-down, the possibility exists that traps could have failed long before the scheduled maintenance or that repair or replacement was not even necessary. While traps are in operation, there are three simple methods of gauging their performance:

1) Visual observation
2) Sound
3) Temperature measurements

☐ Visual observation of discharging condensate is the easiest and least costly method of checking trap performance. No special equipment is required. However, the method is time-consuming and operators have to be trained in order to be able to distinguish flash steam from live steam. If the trap discharges into a closed condensate return system, a test port should be installed on the discharge side of the trap.

If the trap is opening and closing (cycling) and discharging condensate and flash steam, the trap can be judged as operating properly. If the condensate is relatively cool with little flash steam produced, the trap should be suspected of holding back condensate. However, if live steam is discharged at a high velocity with little entrained liquid, the trap may be gauged as failed or at least failing in the open position.

☐ By listening carefully to steam traps as they cycle, a judgment can be made on whether they are operating properly or not. This method is as easy as the visual inspection

Maintenance program

and is definitely faster. However, the suspected trap performance should be cross-checked visually or by temperature since a trap that does not cycle may be failed open or it may be under a very heavy load of condensate.

The ability to gauge a trap as operating correctly by sound requires some training and some equipment. Equipment may range from very sophisticated ultrasonic sound detectors to very simple industrial stethoscopes.

☐ There is a significant temperature differential across a properly functioning steam trap. Therefore, knowledge of the line pressures and temperatures before and after the trap indicates overall trap performance. Pipe surface temperatures should be read at sites two or three feet before and after the trap.

For example, the temperatures before and after one trap on a 150 psig line discharging to a 15 psig condensate system are found to be 360°F and 240°F respectively. At the same time, the temperatures for a similar trap are found to be 360°F before and 320°F after. It can be safely stated that the first trap is operating properly while the second trap is definitely failing in the open position. Figure II indicates the temperature that should be found on the steam side of the trap.

Equipment used for measuring trap performance differential can range from sophisticated portable infrared meters, to contact thermocouples and thermistors, to simple, magnetic contact thermometers. Heat sensitive markers attached to the surface of the discharge piping can be used to quickly and easily check for traps which are failing in the open position. These tags or markers change color if the temperature of the pipe increases 10 to 15°F above the proper discharge temperature. However, heat sensitive markers do not indicate whether the trap is "cold" and backing up condensate.

Whether simple techniques or sophisticated equipment is used to monitor steam trap operation, the key to a successful maintenance program is regular inspection. With such a program in place, significant energy gains can be achieved in the operation of the steam generator system.

Survey records

The first survey is the most time consuming since all the steam traps must be located, identified by type and model, their sites permanently tagged, rated on operating efficiency, and all data recorded on a survey form. Subsequent trap surveys involve checking the already located traps for operating efficiency and using a maintenance priority to repair or replace faulty traps.

Without a permanent record, the results of trap surveys cannot be compared to determine if there are specific, recurring problem sites. Completed data forms of the regular trap surveys also serve as both general maintenance and energy management records. See worksheet on following page.

Technical assistance on this report provided by T.L. Molnar, The Mogul Corp., Chagrin Falls, OH 44022.

The following OPERATING CONDITION RATINGS and MAINTENANCE PRIORITY CODES can be used with the Steam Maintenance Log on the following page.

OPERATING EFFICIENCY RATING

Bad ..... Failed open, blowing live steam
Leaking .. Trap leaking condensate or steam through fittings
Waste .... Trap wasting steam but not excessively
Cold ..... Equipment not operating or trap failing in closed position
Good

MAINTENANCE PRIORITY CODE

#1 – Repair or replace immediately
#2 – Repair or replace as soon as possible
#2 – Repair or replace as soon as possible
#3 – Check with production department and repair or replace as soon as possible
#4 – No maintenance required

EXPECTED STEAMLINE TEMPERATURES

Operating Pressure (psig)	Approximate Line Temperatures (°F)	Operating Pressure (psig)	Approximate Line Temperatures (°F)	Operating Pressure (psig)	Approximate Line Temperatures (°F)
0	212	25	267	150	366
5	227	50	298	200	388
10	239	75	320	250	406
15	249	100	338	300	422

STEAM TRAP CHARACTERISTICS

	THERMOSTATIC BELLOWS	FLOAT AND THERMOSTATIC	INVERTED BUCKET	THERMODYNAMIC DISK
Method of operation	Intermittent	Continuous	Intermittent	Intermittent
Prevention of steam loss	Good	Excellent	Excellent	Fair
Ability to handle start-up air load	Excellent	Excellent	Excellent	Poor
Vent air and CO_2 at steam temperature	No	No	Yes	No
Corrosion resistance	Excellent	Good	Good	Excellent
Resistance to mechanical wear	Good	Good	Good	Fair
Resistance to freeze-up	Excellent	Poor	Poor	Excellent

How to select and size a steam trap

In order to receive the greatest return from the cost of generating and using steam as a heating and process medium, a good working knowledge of steam traps is necessary. The following report provides information for effectively selecting steam traps.

WITH THE steam trap application in mind, refer to the "Steam Trap Selection Guide" on page 12 for the best type of trap to choose. When no unusual conditions are involved the "Trap Selection Guide" will provide the best choice for many often encountered applications.

Sizing steam traps

To accurately size a steam trap, information is required to determine its condensate load, inlet pressure, and any back pressure in the return line. The following steps should be followed to determine the correct size.

Step 1—Collect Information Required

A. Calculate or estimate the maximum condensate load in pounds/hour. Refer to Table I for calculating condensate load.

B. Pressure at inlet of trap. This may be significantly less than the pressure in the steam supply main. For example, in a heat exchanger application, the pressure at the trap will be the steam line pressure less the pressure drop through the control valve at maximum load. In some cases the pressure drop in the heat exchanger will also further reduce the pressure at the trap. Select a trap with pressure rating equal to or greater than the steam line pressure, but with a capacity based on the estimated pressure at the trap inlet. In the heat exchanger example, if all the steam is condensed in the coil, the trap will only be pres-

TABLE II

EFFECT OF BACK PRESSURE ON STEAM TRAP CAPACITY

% Reduction In Capacity

% Back Pressure	Inlet Pressure PSIG 5	25	100	200
25	6	3	0	0
50	20	12	10	5
75	38	30	28	23

TABLE III

RECOMMENDED SAFETY FACTOR FOR STEAM TRAPS

Type of Trap	Safety Factor
Balanced-Pressure Thermostatic Traps	2 to 4
Thermo-Matic Thermostatic Traps	1.5 to 2.5
Liquid Expansion Traps	2 to 4
Bimetallic Traps	2 to 3
Float-and-Thermostatic Traps	1.5 to 2.5
Inverted Bucket Traps	2 to 3
Thermo-Dynamic Traps	1.2 to 2

Note: The actual safety factor to use for any particular application will depend upon accuracy of:
1. Estimated load
2. Estimated pressure at trap
3. Estimated back pressure

Any unusual or abnormal conditions must be taken into consideration.

TABLE I. CALCULATING CONDENSATE LOADS

When the normal condensate load is not known the load can be approximately determined by calculations using the following formulae.

Lbs. Condensate/Hr. of 100 ft. of Insulated Steam Main at 70°F (At 0°F. Increase by 50%)

Steam Pressure PSIG	MAIN SIZE 2"	3"	4"	6"	8"	10"
10	6	9	11	16	20	24
60	10	14	18	27	33	41
125	13	20	24	36	45	56
300	20	30	37	54	68	85
600	30	44	55	82	103	128

STEAM TRACING LINES:
Approximate load is 50 Lb./Hr. for each 100 ft. of tracer.

GENERAL USAGE FORMULAE

Heating water with steam

$$\text{lbs Condensate/hr} = \frac{GPM}{2} \times \text{Temperature Rise °F}$$

Heating fuel oil with steam

$$\text{lbs Condensate/hr} = \frac{GPM}{4} \times \text{Temperature Rise °F}$$

Heating air with steam coils

$$\text{lbs Condensate/hr} = \frac{CFM}{900} \times \text{Temperature Rise °F}$$

Steam Radiation

$$\text{lbs Condensate/hr} = \frac{\text{Sq. Ft. E.D.R.}}{4}$$

SPECIALIZED APPLICATIONS

Sterilizers, Autoclaves, Retorts Heating Solid Material

$$\text{lbs Condensate/hr} = \frac{W \times Cp \times \Delta T}{L \times t}$$

W = Weight of material lbs.
Cp = Specific heat of the material
ΔT = Temperature rise of the material °F
L = Latent heat of steam BTU/lb
t = Time in hours

Heating Liquids in Steam Jacketed Kettles

$$\text{lbs Condensate/hr} = \frac{G \times s.g. \times Cp \times \Delta T \times 8.3}{L \times t}$$

G = Gallons of liquid to be heated
s.g. = Specific gravity of the liquid
Cp = Specific heat of the liquid
ΔT = Temperature rise of the liquid °F
L = Latent heat of the steam BTU/lb
t = Time in hours

Steam Jacketed Dryers

$$\text{lbs Condensate/hr} = \frac{1000\,(Wi - Wf) + (Wi \times \Delta T)}{L}$$

Wi = Initial weight of the material—pounds per hour
Wf = Final weight of the material—pounds per hour
ΔT = Temperature rise of the material °F
L = Latent heat of the steam BTU/lb

Heating Air with Steam; Pipe Coils and Radiation

$$\text{lbs Condensate/hr} = \frac{A \times U \times \Delta T}{L}$$

A = Area of the heating surface in square feet
U = Heat transfer coefficient (2 for free convection)
ΔT = Steam temperature minus the air temperature °F
L = Latent heat of steam BTU/lb

Note: The condensate load to heat the equipment must be added to the condensate load for heating the material. Use same formula.

surized by the hydraulic leg of water ahead of it. This is ½ psi for each 12 in. drop from the coil outlet to the trap inlet.

C. Back pressure against which the trap must operate. In many installations the piping from the outlet of the trap is connected into a common return system which may contain some pressure. The trap will have to operate against this pressure plus any static head created if the trap is required to lift the condensate to an overhead return. The total back pressure will reduce the capacity by the amount given in Table II.

Step 2—Apply Safety Factor

The ratio between the maximum discharge capacity of a steam trap and the condensate load it is expected to handle is the safety factor. The safety factor is influenced by:

A. Operational characteristics of the trap.
B. Accuracy of the estimated or calculated condensate load.
C. Pressure conditions at the inlet and outlet of the trap.

If the condensate load and pressure conditions can be accurately determined, the safety factor can be held to a minimum, thus avoiding oversizing of the trap. Oversized traps, especially inverted bucket and balanced-pressure thermostatic types, not only cost more initially but also operate less efficiently creating abnormal back pressures and reduced operating lifetimes.

By multiplying boiler horsepower by 34.5 to determine its total lb. per hr. output, a smaller plant can compare this to their total trap capacities to help prevent oversizing. Table III shows the recommended safety factors for the various types of steam traps.

Step 3—Size Trap from Manufacturers Capacity Table

Make sure the capacity tables are based on hot condensate under actual operating conditions rather than cold water ratings which are considerably higher. Spirax Sarco companies published capacity ratings are actual test ratings based on various inlet pressures discharging to atmosphere. On applications where back pressure conditions exist, the published capacity ratings must be corrected as shown in Table II.

Technical assistance on this report provided by Spirax Sarco Inc., Allentown, PA 18105.

Refer to following page (p. 8) for the Steam Trap Selection Guide.

STEAM TRAP SELECTION GUIDE

APPLICATION	FIRST CHOICE	SECOND CHOICE
Air Heating Coils		
Low and Medium Pressure	Float-and-Thermostatic	....
High Pressure	Float-and-Thermostatic	....
Hot Water Heaters (Instantaneous)	Float-and-Thermostatic	....
Hot Water Heaters (Storage)	Float-and-Thermostatic	....
Shell-and-Tube Exchangers		
Small—High Pressure	Thermo-Matic Thermostatic	Float-and-Thermostatic
	Balanced-Pressure Thermostatic	....
Large—Low and Medium Pressure	Float-and-Thermostatic	....
Reboilers	Float-and-Thermostatic	....
	Thermo-Matic Thermostatic	....
Steam Humidifiers	Float-and-Thermostatic	Inverted Bucket
Steam-Jacketed Vessels		
High Pressure	Thermo-Matic Thermostatic	Float-and-Thermostatic
	Thermo-Dynamic	....
Low Pressure	Float-and-Thermostatic	Thermo-Dynamic
Steam Line Drip Traps		
0- 15 PSIG	Float-and-Thermostatic	....
16-125 PSIG	Thermo-Dynamic	Float-and-Thermostatic
126-600 PSIG	Thermo-Dynamic	....
High Pressure—Superheat	Thermo-Dynamic	....
Steam Pipe Coils (Air Heating)	Balanced Pressure Thermostatic	Thermo-Dynamic
	Thermo-Matic Thermostatic	....
Steam Radiators	Balanced-Pressure Thermostatic	Thermo-Dynamic
Steam Separators		
0- 15 PSIG	Float-and-Thermostatic	....
16-125 PSIG	Thermo-Dynamic	Float-and-Thermostatic
126-600 PSIG	Thermo-Dynamic	Inverted Bucket
Steam Tracer Lines	Thermo-Dynamic	Liquid Expansion
	Bimetallic	....
Storage Tank Coils	Liquid Expansion	Thermo-Dynamic
	Bimetallic	Thermo-Matic Thermostatic
Submerged Heating Coils		
High Pressure	Thermo-Matic Thermostatic	Inverted Bucket
	Thermo-Dynamic	Balanced-Pressure Thermostatic
Low and Medium Pressure	Float-and-Thermostatic	Balanced-Pressure Thermostatic
Unit Heaters	Float-and-Thermostatic	Balanced-Pressure Thermostatic
Sterilizers	Thermo-Dynamic	Balanced-Pressure Thermostatic
Autoclaves	Thermo-Dynamic	Inverted Bucket
Dryers	Thermo-Dynamic	Float-and-Thermostatic
Platen Presses	Thermo-Dynamic	Balanced-Pressure Thermostatic

NOTE: Unusual operating conditions or [illegible] may influence the choice of a steam trap for a particular application.

TROUBLE SHOOTING

The following summary will prove useful in locating and correcting virtually all steam trap troubles. Many of these troubles are actually system troubles rather than trap troubles.

More detailed trouble shooting literature is available for specific products and applications — consult factory.

Whenever a trap fails to operate and the reason is not readily apparent, the discharge from the trap should be observed. If the trap is installed with a test outlet, this will be a simple matter —otherwise, it will be necessary to break the discharge connection.

Cold Trap—No Discharge.
If trap fails to discharge condensate, then:

A.

1. Wrong pressure originally specified.
2. Pressure raised without installing smaller orifice.
3. P.R.V. out of order.
4. Pressure gauge in boiler reads low.
5. Orifice enlarged by normal wear.
6. High vacuum in return line increases pressure differential beyond which trap may operate.

B. No condensate or steam coming to trap.
   1. Stopped by plugged strainer ahead of trap.
   2. Broken valve in line to trap.
   3. Pipe line or elbows plugged.

C. Worn or defective mechanism. Repair or replace as required.

D. Trap body filled with dirt. Install strainer or remove dirt at source.

E. For I.B., bucket vent filled with dirt. Prevent by:
   1. Installing strainer.
   2. Enlarging vent slightly.
   3. Using bucket vent scrubbing wire.

F. For F & T Traps, if air vent is not functioning properly, trap will likely air bind.

G. For Thermostatic Traps, the bellows element may rupture from hydraulic shock causing the trap to fail closed.

H. For Disc Traps, trap may be installed backward.

Hot Trap—No Discharge.

A. No condensate coming to trap.
   1. Trap installed above leaky by-pass valve.
   2. Broken or damaged syphon pipe in syphon drained cylinder.
   3. Vacuum in water heater coils may prevent drainage. Install a vacuum breaker between the heat exchanger and the trap.

Steam Loss. If the trap blows live steam, trouble may be due to any of the following causes:

A. Valve may fail to seat.
   1. Piece of scale lodged in orifice.
   2. Worn parts.

B. I.B. Trap may lose its prime.
   1. If the trap is blowing live steam, close the inlet valve for a few minutes. Then gradually open. If the trap catches its prime, the chances are that the trap is all right.
   2. Prime loss is usually due to sudden or frequent drops in steam pressure. On such jobs, the installation of a check valve is called for

C. For F & T and thermostatic traps, thermostatic elements fail to close.

Continuous Flow. If an I.B. or disc trap discharges continuously, or an F & T or thermostatic trap discharge at full capacity, check the following:

A. Trap too small.
   1. A larger trap, or additional traps should be installed in parallel.
   2. High pressure traps may have been used for a low pressure job. Install right size of internal mechanism.

B. Abnormal water conditions. Boiler may foam or prime, throwing large quantities of water into steam lines. A separator should be installed or else the feed water conditions remedied.

Sluggish Heating. When trap operates satisfactorily, but unit fails to heat properly:

A. One or more units may be short-circuiting and the remedy is to install a trap on each unit. See page 26

B. Traps may be too small for job even though they may appear to be handling the condensate efficiently. Try next-sized larger trap.

C. Trap may have insufficient air-handling capacity, or the air may not be reaching trap. In either case, use auxiliary air vents.

Mysterious Trouble. If trap operates satisfactorily when discharging to atmosphere, but trouble is encountered when connected with return line, check the following:

A. Back pressure may reduce capacity of trap.
   1. Return line too small — trap hot.
   2. Other traps may be blowing steam — trap hot.
   3. Atmospheric vent in condensate receiver may be plugged — trap hot or cold.
   4. Obstruction in return line — trap hot.
   5. Excess vacuum in return line — trap cold.

Imaginary Troubles. If it appears that steam escapes every time trap discharges, remember: Hot condensate forms flash steam when released to lower pressure, but it usually condenses quickly in the return line.