simple techniques for surveying steam traps

Costs of energy and steam have fluctuated significantly in recent years. When these costs were low, economic analysis did not justify repair of steam leaks from gaskets, holes, valves or steam traps. Later, when steam costs escalated dramatically, economics favored the quick repair of these same leak sources. While steam costs vary from time to time, the need to survey for leaks and perform repairs never lessens.

While the value of steam can be a basis for decision making regarding the repair of leaks, it is not the only reason. Other values need to be considered: cost and availability of water, cost of handling, pumping and treating water, and production itself.

Production is why the plant is in business, and this alone should justify steam trap surveys. Not only are leaks a consideration, but so are traps that are backing up condensate and causing lost production. This cost is another major consideration.

When condensate is not being drained, bypass or drain valves are opened to solve the problem. Bypasses discharging into closed returns are not readily seen, but both approaches to solving the back up problem can be result in lost energy.

Fig. 1—Ruptured tracing is a typical and costly steam loss.

When discharging into the closed return line, these pressures can become unexpectedly high. The high return pressure can inhibit drainage from other equipment, as well as producing additional steam trapping problems.

Table I—Cost of Steam Leak
(Open Bypass, Defective Valve or Trap)

Leak Diameter (in.)	Steam Wasted Per Month (lb.)	Cost Per Year
1/16	13,300	$ 798
1/8	52,200	3,132
1/4	209,000	12,540
1/2	833,000	49,980

(Steam 100 psi; at $5.00 per 1000 lb. discharging to atmosphere)

The survey, locating both failed open and failed closed traps, is usually justified on the basis of energy savings alone.

Considering only steam cost, Table I shows the value of leakage for various sizes of leaks. The assumed conditions are steam at 100 psi, discharging to atmosphere with an assumed value of $5.00 per 1,000 pounds of steam.

The losses for 100 psi shown in Table I are 2.75 times greater for steam generated at 300 psi; 5.35 times greater with 600 psi steam. There has not been any attempt to figure cost of the additional make-up water, water treatment chemicals into these costs.

This awareness of the seriousness of steam leaks leads first to the question of where those leaks can be expected in a typical plant. Usually they exist in open bypasses; defective valves (or those left in a "cracked open" position merely for visual indication of system operation); ruptured and open steam tracing; and in defective steam traps. In one refinery that had never inspected their traps, a steam trap survey revealed that 34% of the traps examined had failed—most in the open position.

Fig. 2—Defective gasket of this trap permits loss of live steam from the system.

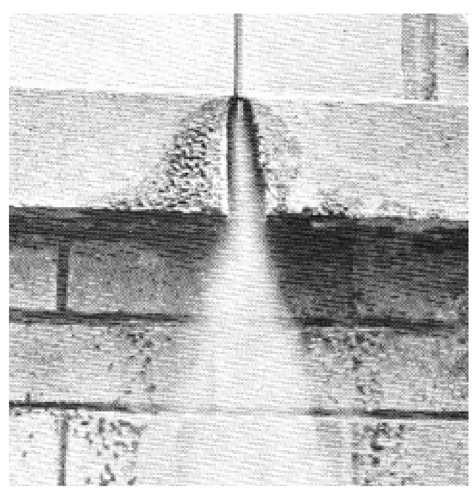

Fig. 3—Open end of tracing not only loses steam but can also create other maintenance problems such as the corrosion of concrete sill shown here.

The Steam Trap Survey

The steam trap survey is a planned examination of a number of traps with the methodical cataloging of the essential data pertaining to each—type and size, steam pressure at trap inlet, temperature at inlet and outlet, and operating condition.

If the plant or steam system is extensive, the survey need not include all the traps on the first pass. In fact, it is preferable to survey a big plant by section, system or process unit. By taking this approach, the work can be done more thoroughly. For example, traps hidden by fittings, other equipment, or covered by insulation can be located. And of equal importance, each trap can be tagged.

Traps are tagged in order to identify their location and facilitate record keeping and reporting. The tags can be made of aluminum, stainless steel or plastic by a hand operated printing tool as the surveyors move down the system. Tagging can go according to a fairly standard coding. For instance, "T-1" would be the tag for the first trap on a tracing line; "D-3" would be the third drip trap in a piping system. Other designations would be "P-" for process, "H-" for heating, "MB-" for meter box. Or a different coding system could be developed to suit the requirements of a certain plant.

The trap survey will reveal various types of steam losses—like open tracing and bad valves. But it's main purpose is the checking of trap performance. There are various methods for trap checking: (1) visual observation, (2) by sound, and (3) by temperature measurements.

None of the checking methods provide a "cure-all" for all trap troubleshooting situations. The best results can be achieved by using a combination of checking methods or by using one method to cross-check indications provided by another. Always use more than one method.

Visual Method

Visual observation of condensate discharging from the trap is the easiest, and perhaps the best way to check its performance. No special equipment is needed, but you should know the difference between *flash condensate* and *live steam*. Figure 4 illustrates the difference between condensate and steam.

Flash condensate is the vapor that forms when hot condensate is discharged to the atmosphere. The presence of flash is natural and does not imply waste steam or trap failure.

If the trap does not discharge to the atmosphere but into a closed condensate return system, a test valve should be installed downstream of the trap. When it is desired to check trap performance by observation, the isolation valve is closed to shut off the condensate return line, and the test valve is opened to the atmosphere. If flash and condensate discharge to the atmosphere as the trap cycles a few times, the trap is operating properly.

But suppose the steam that accompanies the condensate is not flash but is live steam discharging hot, at high velocity (and, in the case of a disc trap, with a rapid chattering in excess of 60 times per minute). Then you can assume the trap has failed.

Sound Method

By carefully listening to them operate, traps can be checked without visual observation of the condensate discharged. This method is more convenient when working with closed condensate return system. The necessary equipment consists of an industrial stethoscope, or a homemade listening device such as a two-foot length of 3/16" steel rod in a file handle, a piece of wood dowel, or a screwdriver.

With practice, the operation of the trap can be heard with any of these homemade devices by placing one end of the tool against the trap bonnet and the other end to your ear.

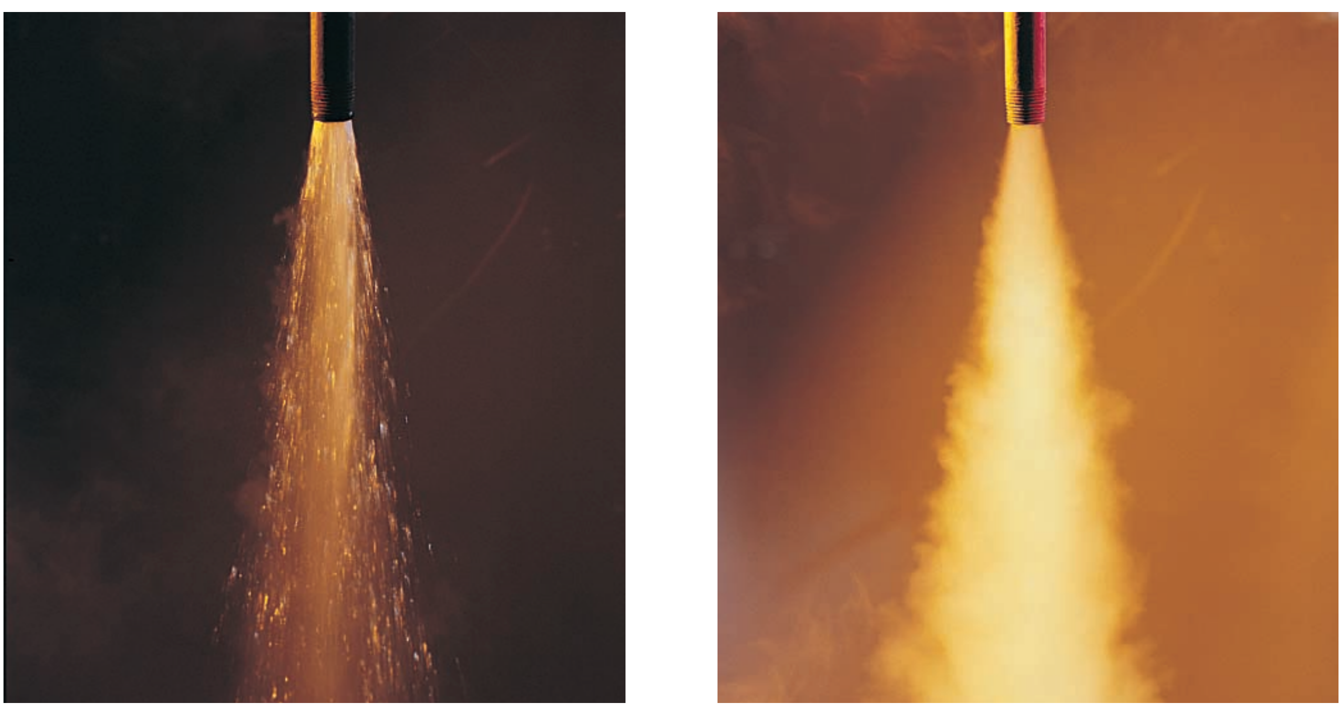

Fig. 4—To determine trap performance by visual observation of condensate discharge, you should know the difference between flash steam (lazy vapor discharging with condensate—left) and live steam (high temperature, high velocity discharge—right).

Temperature Measurements

A steam trap is essentially an automatic condensate valve, the only function of which is to pass condensate and hold back steam. This definition implies the presence of liquid condensate-water. Trap operation, therefore, can be checked by making temperature measurements on the pipeline about 12 inches upstream and downstream of the trap.

Two requirements for this method are a simple contact pyrometer for making the measurements on the surface of the pipe, and a knowledge of line pressure upstream and downstream of the trap. For each steam pressure there is a corresponding steam temperature. Table II shows typical pipe surface temperature readings corresponding with several operating pressures.

Let's assume the upstream pressure in the piping system is 150 psig and the pressure downstream of the trap is 15 psig. An upstream temperature measurement with the pyrometer is 335F and a downstream reading is 225F. File or wire brush the pipes at points of measurement to provide good contacts for the tip of the pyrometer.

Table II—Pipe Surface Temperature vs. Steam Pressures

Steam Pressure (psig)	Steam Temperature (F)	Pipe Surface Temperature Range (F)
15	250	238-225
50	298	283-268
100	338	321-304
150	366	348-329
200	388	369-349
450	460	437-414

Table II shows that for an upstream pressure of 150 psig, a pyrometer reading between 348F and 329F should be obtained. And for a downstream pressure of 15 psig, a pyrometer reading of between 238F and 225F is desirable. We can conclude, therefore, that the trap is operating properly.

Now let's assume the same pressures, but a pyrometer reading of 335F upstream and 300F downstream of the trap. The elevated downstream temperature is greater than expected for a 15 psi return line. The high temperature suggests high pressure and this may be due to a blowing trap. Use another checking method to verify before repairing.

Fig. 5—Determining trap performance by the sound method is difficult where many traps discharge in close proximity. Temperature measurement method is preferable.

In still another example, suppose the pyrometer readings are 210F on *both* sides of the trap. That's okay downstream where we know pressure is 15 psig. But it's too low for a reading upstream where we know we have 150 psig in the line. There is probably a restriction in the line that is reducing the pressure to the trap. A clogged strainer may be the culprit, so blow it down before looking any further for the problem.

Although the foregoing examples deal with a closed return system, the temperature measurement method can also be used to check traps discharging to the atmosphere. In this situation, of course, the downstream pressure is always atmospheric.

Review Application Basics

Occasionally, a trap will be found to be fully operable after a performance check by one of the above methods has led to it's being pulled out of the line. In such a situation, misapplication should be considered as the cause of nonperformance rather than trap failure. Here is what to look for if misapplication is suspected:

1. *Oversizing*—probably the most common type of misapplication. The trap simply has too much capacity for the situation. Try a smaller capacity trap.
2. *Freeze-Proof Installation*—thermostatic and thermodynamic (disc) traps can be installed to provide self-drainage, thus making the installation freeze-proof in cold weather. The freeze-proof method for installing a Yarway disc trap, for instance, is in vertical piping discharging down. If the trap must be installed horizontally, it's bonnet should be on the side. Read the printed instructions packed with the trap. Use a vacuum breaker to assure gravity flow.

Table III—Typical Operating Sounds of Various Types of Traps

Trap	Operating Properly	Failure
Disc (impulse or thermodynamic)	Opening and snap closing of disc	Normally fails open. Cycles in excess of 60 per minute.
Mechanical (bucket)	Cycling sound of bucket as it opens and closes	Fails open—sound of steam blowing through. Fails closed—no sound.
Thermostatic (bellows)	Sound of periodic discharge if on medium to high load; possibly no sound if light load, throttled discharge.	Fails open—sound of steam blowing through. Fails closed—no sound.

Fig. 6—This operator is using a contact pyrometer to make upstream and downstream temperature measurements to determine trap performance in a closed condensate return system.

3. *Proper Direction Flow*—although it may sound obvious, the fact is that a trap is occasionally installed backward, with its upstream or inlet side connected into the downstream piping. Look for the arrow or "inlet"/"outlet" markings on the trap and install it in the line properly.

4. *Trap Location*—condensate discharge piping should be connected to equipment at its low point to prevent accumulation or pockets of condensate and blanketing the heating surfaces. Pitch the piping toward the trap to minimize water hammer.

5. *Gravity Flow to Trap*—a good pitch of the inlet piping to the trap helps condensate flow toward the trap, displacing steam which otherwise could cause steam binding of the trap.

6. *Short Drainage Legs*—these also minimize the tendency for freezeup in cold weather.

7. *Trap Each Unit Individually*—if you try to drain more than one piece of equipment with one trap, short circuiting is very likely to occur due to differences in pressure drops. The unit with the least pressure drop will blanket or short circuit the others and cause uneven and inefficient heating.

8. *Size Each Trap Separately*—condensate loads vary from one piece of equipment to another. So you can't expect one trap to perform equally well in all cases. Higher capacity traps are required for heavier condensate loads.

What Kind of Savings from Trap Survey?

If your steam system is extensive enough to include more than 500 traps, a steam trap survey will probably uncover some significant steam losses. Take the remedial actions indicated by the survey, and savings in steam should be apparent. For instance, in the refinery mentioned at the beginning of this article, a 3/4-inch trap failed open was found to be wasting about $160 per month in generated steam. Multiplied by the number of defective traps (34% of those surveyed) approximately $70,000 *per month* in steam was being lost.

In a midwestern chemical plant, a trap survey resulted in a steam saving of 20,000 lb/hr (cost of steam at plant unavailable). In a midwestern refinery that included its cost of steam factor, $3,000 per month savings were reported.

A steam trap survey will uncover significant problems with regard to the steam and condensate systems. This is especially true if your systems have not had any attention for a period of time. The benefits of a system survey and repair include improved production, improved condensate collection and energy savings.

If we assume some typical or average conditions, we can estimate the potential energy savings based on the leaks (gaskets, pinched tubes, etc.), leaking valves (isolation and bypass) and steam traps for an installed trap population of 150.

Leak Source	# of Leaks	lb/hr	$/day (4)
Leak (1)	5	---	12.50
Valves (2)	2	260	62.40
Traps (3)	20	34	81.60
TOTAL			156.50
= $40,690/year (5 days/week, 52 weeks)			

(1) Surveys show that leaks are 3% of the installed trap population. Length of leak is assumed to be 4 ft. at 100 psi and $2.50/day.

(2) Surveys show that valve leaks are 1% of the trap population. Assumed average operating pressure is 300 psi.

(3) Surveys show that in systems without a maintenance program, 20% of the installed traps can be leaking. There is no accounting for the cold and plugged strainer and orifice drainers.

(4) Steam cost assumed at $5.00/ 1000 lb.

This potential reduction in operating costs, combined with the improvement in operation, makes the survey an attractive proposition.

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