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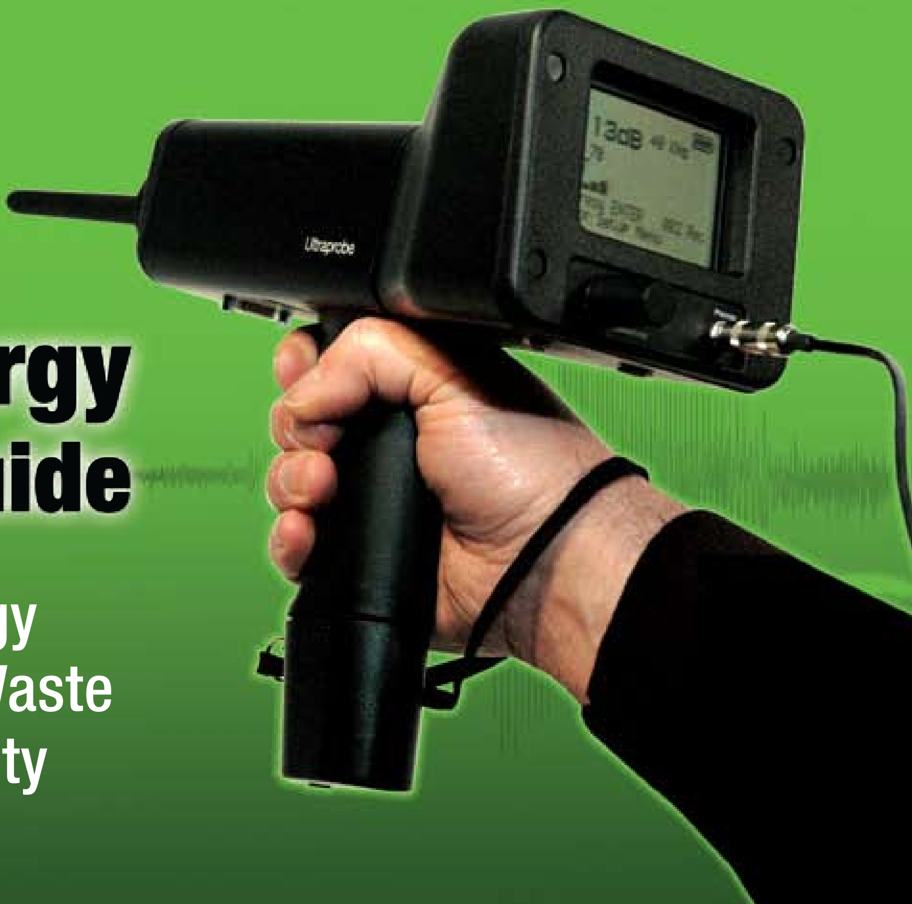

Ultrasonic Energy Conservation Guide

How Ultrasound Technology Helps To Reduce Energy Waste & Improve Plant Profitability

Increase Productivity and Energy Efficiency Through Ultrasound

Ultrasound technology offers many opportunities for industrial and commercial users to dramatically cut energy consumption and improve their bottom line while improving upon their "carbon footprint".

Four common areas are:

1. Compressed Air

2. Steam

3. Air Infiltration

4. Mechanical efficiencies

Compressed air and steam are two of the most costly utilities in plants today. Often the bottom line is negatively affected as energy costs rise. For those companies who utilize these utilities as part of their production, the end product can be damaged, contaminated or lost when these systems do not operate efficiently.

Ultrasound condition monitoring is the most effective, accurate, and safe method for locating sources of energy waste and for preventing unplanned downtime.

When it comes to improved productivity, it is important to understand that the more efficient a system, the less energy used. By setting up routine inspection schedules for your utilities (compressed air and steam) as well as for your mechanical and electrical equipment, problems can be identified and corrected early to maintain efficient operations. This will lower operating costs and keep energy waste at a minimum thus improving the profitability of a plant.

The key to maintaining or reducing energy consumption is to incorporate reliability practices that will maintain all of your plant equipment at optimal running condition. While ultrasound can be used to note problems with mechanical and electrical problems within your plant, this guide will focus on compressed air and steam systems. It will provide you with an overview for conducting compressed air and steam surveys, some useful tips regarding these utilities, how to calculate potential savings from your surveys and suggestions for reporting your results.

This guide will be divided into two sections:

Section 1: Compressed Air

Section 2: Steam and Steam Traps

Compressed Air: The Problem

Compressed air isn't free. Compressed air systems account for 10% of all electricity used in U.S. manufacturing industries. Most of these systems provide compressed air to drive a variety of equipment within a given plant, including machine tools, painting booths, materials handling, and HVAC controls.

The average facility loses an average of 30% of its compressed air to leaks; much of which is undetectable by ear, to touch or sight. At of the close of 2007, the DOE reported that as many as 57% of facilities have taken little to no action to fix this problem.

There are also excess costs that go way beyond wasted energy. Some of these problems are:

- Fluctuating system pressure: Inconsistent or faulty performance of air tools and other air-operated and powered equipment.
- Excess compressor capacity: higher than necessary equipment and maintenance costs. Plants buy on calculated demand without considering how leaks affect performance.
- Excess load on supply equipment. Increased maintenance costs, decreased service life.
- Thwarting other system efficiency efforts. It's impossible to optimize system pressure and compressor control schemes with excessive leaks.
- Wet air: While letting air out, leaks let moisture in. For example, valves on drain legs are left cracked open because too much water is coming into the equipment.

Before starting a compressed air survey, it is important to review & note what some of the most common contributors to energy loss are:

- Couplings
- Hoses
- Tubing
- Fittings
- Pipe Joints
- Quick-disconnects
- Filter/regulator/lubricator (FRL) units
- Valves
- Flanges
- Packings
- Thread sealants
- Point-of-use devices
- Open condensate traps
- Open shut-off valves

As you review these items, check to see if they are being used correctly, installed correctly, operating as expected or are inappropriate for the application. Once you understand the operating condition of these components, then it is time to plan a leak detection survey to start saving energy and improving production immediately.

Top 11 Targets of a Compressed Air Audit

Following the recommendations of an audit usually pays for itself in a short time by saving tens of thousands of dollars in operating expenses.

The 11 most typical, highest payback audit items are:

1. Plug leaks – set up a short-term leak inspection program through ultrasound so that every sector of the plant is inspected at least once a quarter to identify and repair leaks.

2. Down with overpressurization – excessive pressure increases leaks and wastes money. Overpressurization will amplify problems, not solve them.

3. Double-check air requirements – production often overestimates the amount of air it needs. Plants need to change their focus from maintaining air supply to supplying air to meet demand. More air and more pressure is simply more cost.

4. Angle connections: all teed off – replace tee connections with directional angel entry connections.

5. Bad piping – convoluted piping, piping restrictions, old pipes and incorrect pipe sizes often lead to pressure loss.

6. Get rid of obsolete restrictions – clogged filter elements, forgotten manual drain traps and neglected separator cartridges can cause significant drops in pressure and negatively impact capacity and reliability, not to mention creating air-quality issues.

7. Insufficient storage – the value of an appropriately sized air receiver and appropriate compressed air piping is underestimated. All air systems will do better with storage between the user and the process. The amount of effective storage for any system is where the operating control band is equalized by the back pressure in the system.

8. Inappropriate use – unregulated use of compressed air, and using compressed air for inappropriate purposes, wastes a lot of energy. Considering it costs eight times as much to use air as it does to use electricity, you may want to reevaluate unregulated air-powered cabinet coolers, blow-offs, vacuum generators, mechanical pumps, air motors and hoists, vibrators, aeration, spraying and a host of other equipment.

9. Watch those pumps – if air-operated pumps must be used, consider adding controls to shut them off when are not needed.

10. Maintain the system – poor air quality adversely affects overall plant operations.

11. Poor maintenance also affects efficiency. Make sure you have a planned route and are consistently conducting compressed air survey's in order to ensure your plant is running as efficiently as possible.

Many plants can benefit from a more sophisticated analysis by professional auditors or via training classes on condition monitoring, routinely provided by UE Systems. Log on to the UE Systems website at **www.uesystems.com** for training information.

Compressed Air: Pre-Leak Detection Survey

According to the U.S. Department of Energy (DOE), over 50 percent of all compressed air systems have energy efficiency challenges that can be corrected.

There are 7 critical steps in evaluating system leakage and energy waste. They are:

1. Evaluation (leaks, pressure and compressor controls)

2. Detection (involve operators)

3. Identification (tagging)

4. Tracking

5. Repair

6. Verification

7. Re-evaluation

In order to ensure you are following these steps, it is essential that you develop a systematic approach for your maintenance program in order to maintain operating efficiencies.

Every plant could save 10- 20% of their current energy waste by implementing these recommended steps and conducting a proper energy audit periodically.

- Walk through your plant. While you walk, pay attention to obvious problems such as loud leaks that you can spot and tag without the aid of an ultrasonic detector. Observe misuse of air such as valves left wide open, rags placed over pipes to reduce the noise level of large leaks, unattended machines left on with air blowing all over the place. Check and repair all drain traps, do not leave them "cracked" open. Check defective tools, are hoses stored correctly to prevent the handles from cracking open, check quick connect fittings, etc.

- As you walk through your route, try to determine the best route for inspection. If possible, use a print of the compressed air piping system, make a simple sketch, or digitally photograph the compressed air system section by section. These graphics will help you inventory all components of the system and identify leaks making it easier to find them for repair.

- Use an Ultraprobe® to scan for leaks. Always wear your headphones. If you have difficulty determining direction, reduce your sensitivity. Follow the sound to the loudest point.

- For consistency, start at the compressor/supply side and work your way to the use side.

- When you begin your inspection, create a series of inspection "zones". This will help organize your approach and prevent the possibility of overlooking a section and missing some leaks. Move from one "zone" to the next in a planned organized manner.

• Tag all leaks. The tag will make it easy to spot the leaks for repair. (When leak location prohibits tagging such as in a ceiling, note the spot with a marker under the leak and use a digital photograph to identify the location.)

• Test all leaks after they have been repaired. Sometimes leaks can be fixed and new ones created inadvertently.

• Be ready to fix as you go. Carry tools you'll need for leak repair (wrench, sealant, tape, etc). A lot of them can be repaired on the spot.

• Calculate your savings using cfm charts and formulas accompanying this guide.

• Report your results. Let management know how much money you are saving.

• Keep everyone aware & involved. Just as with other programs, hang signs to educate about the cost of leaks such as "1/4 in. leak -= $8,000/year." Or an awareness sign "Report compressed air leaks…They cost $$$"

• Maintain a program to reduce compressed air use and eliminate the use of unneeded compressors. Most plants would lower energy costs greatly if they were able to just turn unused compressors off, instead of buying new ones.

When planning a survey, do not attempt to test the whole system at once. Break the survey schedule down into small, workable sections.

When creating a report, try to consider the logistics of the leak repair. Break the leak repair down into manageable units. If a maintenance department is given a large number of leaks to repair in the report, the reaction might not be positive since there are usually many other maintenance activities to complete. Instead, prioritize the leaks so that the most costly are repaired first; the next most costly second, etc.

Calculate Your Savings – Compressed Air

When conducting a compressed air or steam trap survey, you should always calculate your savings. Energy savings mean big dollar savings as well as a significant increase in production, asset availability and product value. Energy savings, or "cost avoidance" is not only important to your company's bottom line, it will help management understand the contributions of your department to the company's success.

Calculating compressed air loss
Energy accounts for as much as 75% of the total cost of a simple compressed air system.

A poorly maintained or leaking system will never fulfill demand, continually drain resources and have a negative impact on energy. Furthermore, an inefficient compressed air system hurts our environment through additional and unnecessary greenhouse gas emissions.

According to the U.S. Department of Energy, average systems waste between 25% and 35% of their air to leaks alone. In a 1,000 SCFM system, a 30% leakage translates into 300 SCFM. Eliminating that type of leak is equivalent to saving more than $45,000 annually (depending on plant location and region's energy cost). It is important to note this cost will rise as energy costs rise.

Develop a formula for detecting your loss
In the field of leak detection there are many confusing elements that appear when two or more people try to convey the type or size of loss that they need to detect. One way to resolve this is to convert all forms of leak loss descriptions into one common format.

Below is a formula that converts a divergence of leak descriptions into the term: "CFM or cubic feet per minute. The formula is :

$$\frac{\left(\frac{\text{Pressure Loss}}{\text{1 Atmosphere}}\right) \times \text{Volume in ft3}}{\text{Time in minutes}} = \text{CFM}$$

MAKE SURE IT IS THE SAME FORMULA AS COMPRESSED AIR GUIDE

The formula is universal, in that one can use any form of leak measurement. To use the formula factors, refer to the chart that explains what one atmosphere is for a particular measurement unit. This measurement unit can be PSI, Inches of Mercury, Feet of Water or Bars.

Conversion Chart
1 Cubic Foot = 1728 cubic inches
1 Atmosphere = 14.7 PSI
= 29.9 inches of HG (Mercury)

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EXAMPLE:
A leak in a system of 300 cubic feet is losing 10 psi in 2 minutes. The system pressure is 100 PSI.

NOTE: the system pressure will almost always be given. It is not to be used in this formula. The only reason it is given in this example is to alert you to the fact that it is not necessary even when provided.

Formula

$$\text{CFM} = \frac{\frac{10}{14.7} \times 300}{2} = \frac{.680 \times 300}{2} = 102 \text{ CFM}$$

Air Leak Cost

Diameter Of Leak	Cubic Feet/Minute	Cubic Feet/Day	Loss/Day Dollars	Loss/Month Dollars	Loss/Year Dollars
1/64"	.45	576	$0.13	$4.00	$48.00
I/32"	1.60	2,304	$0.51	$15.50	$186.00
3/64"	3.66	5,270	$1.16	$35.30	$424.00
1/16"	6.45	9,288	$2.04	$62.00	$744.00
3/32"	14.50	20,880	$4.59	$139.50	$1,674.00
1/8"	25.80	37,152	$8.17	$248.40	$2,981.00
3/16"	58.30	83,952	$18.47	$561.50	$6,738.00
1/4"	103.00	148,320	$32.63	$992.00	$11,904.00
5/16"	162.00	233,280	$51.32	$1,560.00	$18,721.00
3/8"	234.00	336,960	$74.13	$2,253.60	$27,036.00

Based on 100 PSIG, $ 0.22/MCF, 8,760 Hours/Year

Air Leak Cost

Diameter of Leak	Cubic Feet/Minute	Cubic Feet/Day	Loss/Day Dollars	Loss/Month Dollars	Loss/Year Dollars
1/64"	.45	576	$0.18	$5.50	$66.00
1/32"	1.60	2,304	$0.71	$21.60	$259.00
3/64"	3.66	5,270	$1.63	$49.60	$595.00
1/16"	6.45	9,288	$2.886	$87.60	$1,051.00
3/32"	14.50	20,880	$6.47	$196.70	$2,360.00
1/8"	25.80	37,152	$11.52	$350.20	$4,202.00
3/16"	58.30	83,952	$26.03	$791.30	$9,496.00
1/4"	103.00	148,320	$45.98	$1,397.80	$16,744.00

Based on 100 PSIG, $0.31/MCF, 8,760 Hours/Year

Calculating the cost of air per thousand cubic feet (MCF)

To get the cost of air per thousand cubic feet (MCF), use the following formula:

$$\frac{\left(\frac{\text{BPH X 0.746}}{0.90}\right)\left(\text{\$/KWH}\right)}{\left(\frac{\text{CFM X 60}}{1000}\right)}$$

0.746 KW/BHP (Kilowatts per Break Horse Power)
Average efficiency = 0.90
4.2 CFM/BHP (an average of CFM per Break Horse Power suggested from Compressor Manufacturers)

The breakdown:

$$\text{KWH (To run the Compressor)} = \frac{\text{BHP of Compressor x 0.746}}{0.90}$$

KWH x $ / KWH = Cost of running Compressor for one hour

$$\frac{\text{CFM of Compressor x 60}}{1000} = \text{MCF / Hour}$$

$$\frac{\text{Cost of running Compressor for one hour}}{\text{MCF / Hour}} = \text{\$ / MCF}$$

How to Calculate Your CFM Loss as Dollar Loss Per Year

The basic calculation of a leak cost in terms of CFM can be determined using the following formula.

$$\frac{\text{(CFM x 60) (8760) x MCF}}{1000} = \text{Leak Cost per year}$$

1. Convert your CFM into Cubic Feet per hour
CFM x 60
Example: 3.6 cfm x 60 = 216 cubic feet per hour

2. Calculate Cubic feet per year. Multiply the number of hours the system is in use by the hourly figure.
Example: 216 x 8760 (hours per year) = 1892160 cubic feet per year

3. To determine the cost per year, determine the cost of compressed air. This is usually represented in MCF(Thousand Cubic Feet). First divide the hourly figure by 1000 and then multiply by the MCF cost figure.

Example: MCF cost is $0.22
1892160 ÷ 1000 = 1892.16
1892.16 x $.22 = $416.28 cost per year

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Quantifying Compressed Air Loss and Savings From a Survey

The going estimate in the field is that about 30% of all compressed air is wasted through leaks.

Here's a simple formula that can be used to estimate the loss/savings of your compressed air survey.
S=(L/4.2)(0.746)(T)(C) ÷ 0.90

S = Annual Savings, $
L= Air loss, cfm
4.2 = average number of cfm/bhp. This is based on manufacturers' equipment data*
0.746 = average power requirement in kW/bhp to generate one bhp
T = hours of operation
C = Cost per kWh
0.90 = motor efficiency factor

Example: 100-hp air compressor produces 450 cfm of air
Electrical cost of $0.08/kWh
Air leaks amount to 25%.

25%(leaks) of 450 cfm = 112.5 cfm (this is L)

112.5/4.2 cfm/bhp = 26.8 bhp

26.8bhp x 0.746kW/bhp = 19.9928 (kW)

19.9928kW x 8760 hrs (24 hrs/day, 365days/year) = 175136.9 kWh

175136.9 x $0.08/kWh = $14010.95

$14010.95 ÷ .90 = $15,567.72

***This number varies with equipment type. For specific information, consult a compressed air handbook or a manufacturer's data sheet.**

Steam Traps: The Problem

Leaking steam traps can raise a company's operating expenses by as much as one-third! This is why many energy conservation programs start with a steam trap survey.

Steam system inefficiencies result in wasted energy, faulty product runs, environmental pollution and a dramatic loss of revenues. A major part of system efficiency is properly functioning steam traps and valves.

For example, if one trap with a 3/32" orifice operating at 100 psi can lose almost 30 lbs. of steam per hour. At $8/1,000 lbs. of steam, that can result in a loss of over $2,000 a year from each faulty trap of that type.

Experts estimate that in a plant with no active steam trap testing and repair program, 50% of the traps are blowing steam. With accurate inspection and diagnosis on a monthly basis with prompt repair, this figure can be reduced to under 3%.

Historically, diagnostic methods have included devices ranging from sonic and gross temperature measures to more sophisticated infrared and ultrasound technology. Typically, a combination of ultrasound and infrared technologies have proven to be the most effective way of testing steam traps. All of these can give an indication of flow, but some can become inaccurate as system conditions change.

Ultrasound inspection is ideally suited for on-line steam system inspection, which would include leaks around fittings as well as through valves and steam traps. Ultrasound is a short wave signal that is very localized. This enables users to listen to the translated ultrasound signal produced by trap and valve operation in a "real-time" basis and evaluate trap/valve condition. Leaks can be readily heard, blockage recognized and outright blow-by clearly detected.

As you review the information in this section, you will learn how to effectively utilize ultrasound detection equipment in reducing steam energy waste while improving product quality and profitability.

Targets of a Steam Trap Audit

A recommended first step in determining what your plant might be wasting as a result of faulty traps is to conduct a steam trap survey. Part of this process should involve a review of the steam system itself.

Remember, only an energy efficient steam system that has been properly designed and maintained will produce and use only the amount of steam needed to get the job done.

Here are a few examples of system neglect:

- ***Oversized and misapplied steam traps***: this condition can cause blowing, leaking and plugging caused by dirt.
- ***Control valves that have been wiredrawn:*** The valves may be unable to shut as a result of wet steam.
- ***High back pressure in condensate lines due to blowing traps***: A situation that can be as hazardous as it is wasteful.
- ***Low steam temperatures*****:** Due to traps that are discharging into flooded condensate lines.
- ***Uninsulated valves, strainers, flanges and even whole sections of steam system piping***: This can be a major cause of energy waste.
- ***Low percentage of condensate return:*** A condition that could escalate the costs of boiler fuel, chemicals, water and sewerage.

Here are a few examples of warning signs resulting in system failure:

- An abnormally warm boiler room
- A condensate receiver is venting excessive steam
- A condensate pump water seal is failing prematurely
- The conditioned space is overheating or under heating
- Boiler operating pressure is difficult to maintain
- Vacuum in return lines is difficult to maintain
- Water hammer

The message is clear. Maintaining an efficient steam system will result in savings of energy dollars that can far exceed the costs involved in modifying the existing system.

Creating Energy Efficient Steam Trap Survey's

Steam has many performance advantages that make it an indispensable means of delivering energy. These advantages include low toxicity, ease of transportability, high efficiency, high heat capacity, and low cost with respect to the other alternatives.

Traps that fail open result in a loss of steam and its energy. Traps that fail closed can significantly reduce heating capacity, resulting in product contamination, corrosion, or damage to the steam heating equipment.

Closed loop systems are preferred because it is more energy efficient and cost-effective. Hot water costs less to heat than cold water, in addition, water is conserved as opposed to being lost down the drain.

Monitoring equipment will help determine the condition of steam traps and valves by identifying whether a trap is failed open or closed. Traps failing in an open position allow steam to pass continuously, as long as the system is energized. The rate of energy loss can be estimated based on a number of factors such as : orifice size, steam pressure and hours of operation.

In the estimation below, it is assumed that makeup water is available at an average temperature of 60ºF.*

Estimating steam loss example:

Assume: 3/8-inch-diameter orifice steam trap, 50% blocked, 60 psia saturated steam system, steam system energized 4,380 h/yr (50% of year), boiler efficiency 75%.
For 3/8 inch orifice and 60 psia steam, steam loss = 2,500 million Btu/yr
Assuming trap is 50% blocked, annual steam loss estimate = 1,250 million Btu/yr
Assuming steam system is energized 50% of the year, energy loss = 625 million Btu/yr
Annual fuel loss including boiler losses = [(625 million Btu/yr)/(75% efficiency)] = 833 million Btu/yr

*** Footnote- EERE**

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Steam Trap and Valve Energy Conservation Tips

Steam leaks can exist anywhere in a system. Steam may be escaping through external or Internal leaks in fittings, valves or controls, from oversized steam traps, or traps that are blowing, leaking or plugged with dirt. Steam may be lost through uninsulated valves, flanges, sections of steam pipe, or through high back pressure in condensate lines caused by blowing traps. A control valve unable to close because of "wiredrawing" or undersized steam and condensate lines with no provision for utilizing flash steam could all be sources of wasted energy.

As energy prices continue to escalate, we must re-visit all opportunities for reducing our energy costs. Here are some more **Energy Conservation Tips from Spence Engineering, manufacturer of Nicholson Steam Traps:**

- Assure steam traps are functioning properly.
- Assure maximum removal of condensate and prevent premature cooling of steam.
- Prevent failed open steam traps from wasting valuable steam.
- Prevent or correct water hammer conditions (a major safety hazard) as a result of failed closed steam traps.
- Clean and Blow down integral steam trap strainers and in line strainers.
- Maintain maximum thermal efficiency.
- The average steam trap life is approximately 5 years. Therefore, if not maintained and inspected regularly, over time, at any given moment a plant may have 20% of their steam traps failing, causing energy inefficiencies and waste.

Additional Testing Tips For Common Problem Areas From Enercheck Systems

Most Exchangers, Boiler Casings or Shutoff Valves

It is essential to know how each steam trap or valve works under specific conditions in order to be able to diagnose a problem correctly. To determine leakage or blockage, touch the ultrasonic instrument upstream of the valve or trap and reduce the sensitivity of the detector until the meter reads about 50 percent of scale. If you need to hear the specific sound quality of the fluid, simply tune the frequency until the sound you would expect to hear becomes clear. Next touch downstream of the valve or trap and compare intensity levels and, for traps, sound pattern levels. If the sound level is louder downstream, then fluid is passing through. If the sound level is low, then the valve or trap is closed.

Check Valves

When check valves are placed closer than three feet downstream of blast action traps (such as Inverted bucket or thermodynamic types) flappers may loosen or even break free. Damaged check valves will usually become noisy. When control valves are grossly oversized they are forced to work close to their seats. High velocity wet steam acts almost as sandpaper, cutting the seat when a mixture of steam and water is forced through the tiny crevice. With an ultrasonic instrument you can distinguish between normal machine noises and sounds that spell trouble. To verify data, use the instrument to test nearby units and compare.

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Control Valves/Pressure-Reducing Valves
Air operated control valves may be leaking at or around their diaphragms. Scan the exterior sections listening for the turbulent sounds created by a leak. Test ultrasonically for internal leakage as you would for any other valve. It will be necessary to momentarily close the valve to perform definitive testing. For those valves with diaphragms, listen for leakage at the small bleed hole. This is a dead giveaway that a rupture has taken place.

Solenoids
Listen for leakage through solenoids that are in a closed position. You will be able to detect which valve is leaking even when it is part of a large bank of valves. If you are in doubt about a judgment call, compare with similar valves.

Relief Valve
In a steam system, relief valves that have opened by excess pressure may not reseat properly. Some with softer seats may be chattering or may suffer microscopic steam and water cuffing. Ultrasonic testing will detect the turbulent passage of steam or vapor as it moves through the leak site. Touch the instrument's stethoscope at the point on the valve closest to the orifice and then touch the downstream piping. Leaking and blowing valves are easily identified. Augment your test with a hand-held infrared thermometer for temperature differentials.

Condensate Return Pumps
Listen for the static noise indicating a vaporization bubble collapsing around the impeller. If in doubt, test similar pumps and compare. Remember to test volute pump casing temperatures with an infrared thermometer.

Pressure Powered Pump Needle Valves
The needle valves on steam or air powered condensate movers, like any other mechanism, will deteriorate over time. Listen for seepage of steam through worn valves, usually indicated by a high pitched whistling sound. When more then one pump exists, comparisons can be useful.

Valve, Piping and Gland Leakage
Use the ultrasonic Instrument to scan all parts of the steam system for the sounds of turbulence. It will be a reality check to find out how many areas are actually leaking.

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Steam Traps: Setting Up A Steam Trap Survey

When conducting a survey using ultrasound, each trap's number, location, application, size, manufacturer and model number are logged in. After thorough documentation, the trap is ultrasonically tested. Ultrasound heterodynes the operational sound of the steam trap and actually allows us to hear the trap's operation. It is the only positive test available, which accurately and instantaneously allows a performance evaluation of the trap to be made.

After an ultrasonic test is completed, infrared temperature readings can be taken at the inlet and outlet of the trap. The data is then documented for later calculation of inlet and outlet pressures.

During testing, it is important that the following steps are taken:

- Locate, identify and tag all of the steam traps located within your facility.
- Before your inspection begins, create an organizational map (trap map) or some diagram of the location of all the steam traps and valves in a facility. All traps should be tagged and coded and referenced on the map/diagram. In addition, the trap inventory should include the trap model, type, size, manufacturer, and application.
- Tag all traps with an identification number or code that will match their identity and location on the trap map.
- Once record keeping has been put in order, various methods of inspection should be considered. The most common are a combination of visual inspection, temperature and ultrasonic testers. Ultrasonic testers help users isolate sounds of trap and valve operation to readily identify leaks or component malfunction.
- Instruct plant maintenance personnel in proper testing methods.
- Schedule inspection for small sections of your route at a time allowing you to be more efficient during your inspection routine. Trying to accomplish too much at a time can lead to mistakes and negatively impact on the program.
- Note specific problems such as trap condition (blowing, stuck shut), water hammer, improper sizing of condensate return systems and poorly designed piping configurations.
- Provide a report of surveyed traps, including operating status, condition of each trap, those traps needing repair or replacement, and inlet and outlet pressures.
- Develop a testing schedule for maintenance personnel including a Steam Trap Maintenance Record to assist in establishing a continuing Preventive Maintenance Program. An organized approach will produce continued energy savings.

Before starting a steam trap survey, it is important to review and note the types of traps that will be tested. They are organized below according to function and acoustic properties.

Intermittent Flow – these traps will discharge condensate and hold steam in an open/closed fashion

- Inverted bucket
- Bucket
- Thermodynamic (disk)
- Bi-metallic
- Thermostatic

Continuous Flow – a failure usually occurs in the open position causing a constant rushing sound. Failure most often occurs in the closed position where the trap will be cold and silent..

- Float
- Float and Thermostatic
- Thermostatic (bellows)

While there are a variety of traps available in the market place, for purposes of inspection, there are basically two main types: continuous flow and intermittent (on/off).

"On-Off" Traps
On/off traps will have a basic hold-discharge-hold pattern. Typical of this type are:

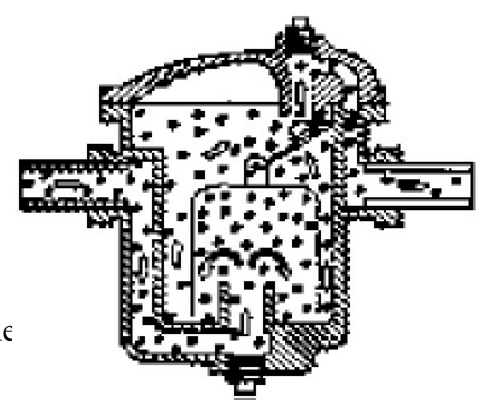
Inverted Buckets
Thermodynamic
Thermostatic (Bellows)
Bi-Metallic

Continuous Flow Traps
Continuous flow traps discharge condensate continuously. The most common are:
Float and Thermostatic trap, and Fixed Orifice

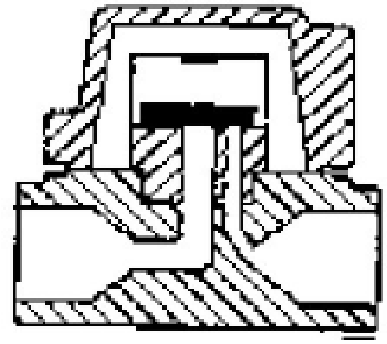
Each type of trap has its' own unique pattern that is described below. It is recommended that you listen to a number of traps to determine a "normal" operation in your particular situation before you proceed with your survey. Generally, when checking a trap ultrasonically, a continuous rushing sound will often be the key indicator of live steam passing through. Sound samples of different trap types can be heard on UE Systems web site: www.uesystems.com.

The most common method for testing a steam trap ultrasonically is to touch the trap on the downstream side. Adjust the sensitivity to the point where the trap sounds are heard. This is usually a setting in which the meter intensity indicator is at a mid-line position. Do not reduce the sensitivity too low or too high for in either setting, the trap sounds will be difficult to hear. If frequency tuning is available on your instrument, choose 25 kHz.

INVERTED BUCKET TRAPS (intermittent trap) normally fail in the open position because the trap loses its prime. This condition means a complete blow-through, not a partial loss. The trap will no longer operate intermittently. Aside from a continuous rushing sound, another clue for steam blow-through is the sound of the bucket clanging against the side of the trap. Leaking steam, not a total blow through, will have a continuous, but slight hissing sound. An early warning signal of potential leakage or blow-through in this type of trap will be the rattling sound of the linkage. This indicates linkage looseness that can lead to steam loss.

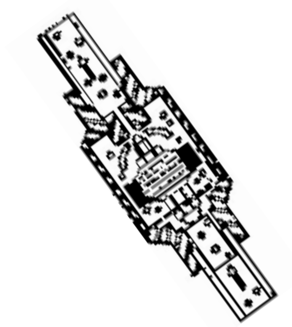


THERMODYNAMIC (DISC) TRAPS (intermittent trap) work on the difference in dynamic response to velocity change in flow of compressible and incompressible fluids. As steam enters, static pressure above the disc forces the disc against the valve seat. The static pressure over a large area overcomes the high inlet pressure of the steam. As the steam starts to condense, the pressure against the disc lessens and the trap cycles. A good disc trap should cycle (hold-discharge-hold) 4 – 10 times per minute.



It usually fails in the open position, allowing for a continuous blow-through of steam. While a trap operating in good condition will have a distinctive shut off between discharges, a leaking trap will never shut and will produce a slight hissing sound. Should the disc become worn, a condition referred to as "motor boating" or "machine gunning" can occur. This produces a very rapid rattling sound that closely resembles the above descriptive terms. This condition allows steam to leak through and is a predictor of more severe problems to come

THERMOSTATIC TRAPS (intermittent trap) (bellows and bimetallic) operate on a difference in temperature between condensate and steam. They build up condensate so that the temperature of condensate drops down to a certain level below saturation temperature in order for the trap to open.

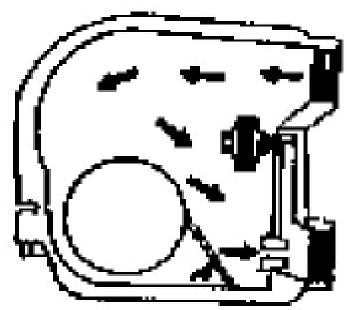


By backing up condensate, the trap will tend to modulate open or closed dependng on the load. These traps will have a hold-discharge-hold pattern. They can take a long time before discharging when there is little condensate build up. At times of high condensate, such as in start up they will stay open continuously (for that period in which the condensate is present). For this reason, it is best not to test these traps during start up. When closed, these traps will be silent; a slight hissing sound will indicate leakage. Blow-through will have a high amplitude rushing sound.

Should the bellows in a bellows trap become compressed by water hammer, the trap will not function properly. The occurrence of a leak will prevent the balanced pressure action of these traps. When either condition occurs, the trap will fail in its natural position either opened or closed. If the trap fails closed, condensate will back up and no sound will be heard. If the trap fails open, continuous rushing of live steam will be heard.

Bimetallic traps have plates that, when exposed to heat from steam will set and discharge as they cool in the presence of condensate. An improper set will prevent the plates from closing completely and allows steam to pass through. This will be heard as a constant rushing sound.

FLOAT AND THERMOSTATIC TRAPS (continuous flow) contain two elements: a ball float and a thermostatic element (similar to that found in a thermostatic trap). When operating properly, the trap ball floats up and down on a bed of condensate, which keeps the discharge valve open.



When listening to this condition, a modulating sound of the discharging condensate will be heard. This type of trap normally fails in the "closed" position. A pinhole leak produced in the ball float will cause the float to be weighted down or water hammer will collapse the ball float. Since the trap is totally closed, no sound will be heard and the trap will be cold. In addition, check the thermostatic element in the float and thermostatic trap. If the trap is operating correctly, this element is usually quiet. Its main function is to remove air from the steam system at start up. If a rushing sound is heard, this will indicate steam blowing through the air vent since it will be in a state that will not differentiate between either fluid. This indicates that the vent has failed in the open position and is wasting energy. Should the mechanical linkage become loose it will effect the operation of the discharge valve and can eventually lead to steam leakage. This will be heard as a clanging, rattling sound.

FIXED ORIFICE TRAPS (continuous flow)

These traps contain a narrow orifice designed to create a "venturi" effect. Basically, pressure differentials occur due to the temperature differentials between steam, hot and cold condensate. When cold condensate enters the trap, steam pressure forces condensate and air through the orifice. In theory, when hot condensate or steam reaches the trap, the pressure drop across the orifice produces flash steam that blocks the flow of live steam. As the load on the steam system falls, the condensate temperature increases and so does the amount of flash steam. The sounds of a modulating condensate flow in normal conditions will be a sign of a properly functioning trap. Contamination may cause the trap fail closed. If this does happen, there will be no sound and the trap will be cold. Should the trap blow live steam due to possible changes within the trap body, this will be heard as a high-pitched, continuous rushing sound.

Once you have established trap condition, the next step is to be able to report your energy savings. The following charts should help you.

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Calculating Steam Trap Loss

How much energy can be saved from a steam trap survey?

A rule of thumb states that if there has been no steam trap survey or maintenance program, upwards of 50% of a system's traps can be blowing live steam. If a survey is performed annually, this figure drops to about 25%. A bi-annual survey will reduce this even further to less than 12%.

Use the guide below to estimate the amount of loss steam leaks are costing your company.

Steam Flow Through Steam Trap Orifice Table

To establish the approximate dollar loss, take the lb./hr figure X 24 hours (for a year X 8760) and multiply by your cost of steam. Ex: 1/8" orifice @ 50 psi = 29.8 X 8760 = 261048. At a cost of $5.00/1000 lb.: 261048 X .005 = $1305.24

Orifice Diameter	2 psi	5 psi	10 psi	15 psi	25 psi	50 psi	75 psi
			Steam Loss, lb. /hr				
1/32"	0.31	0.49	0.7	0.85	1.14	1.86	2.58
1/16"	1.25	1.97	2.8	3.4	4.6	7.4	10.3
3/32"	2.81	4.44	6.3	7.7	10.3	16.7	15.4
1/8"	4.5	7.9	11.2	13.7	18.3	29.8	41.3
5/32"	7.8	12.3	17.4	21.3	28.5	46.5	64.5
3/16"	11.2	17.7	25.1	30.7	41.4	67	93
7/32"	15.3	24.2	34.2	41.9	55.9	91.2	126
1/4"	20	31.6	44.6	54.7	73.1	119	165
9/32"	25.2	39.9	56.5	69.2	92.5	151	209
5/16"	31.2	49.3	69.7	85.4	114	186	258
11/32"	37.7	59.6	84.4	103	138	225	312
3/8"	44.9	71	100	123	164	268	371
13/32"	52.7	83.3	118	144	193	314	436
7/16"	61.1	96.6	137	167	224	365	506
15/32"	70.2	111	157	192	257	419	580
1/2"	79.8	126	179	219	292	476	660

Steam Flow Through Steam Trap Orifice Table

To establish the approximate dollar loss, take the lb./hr figure X 24 hours (for a year X 8760) and multiply by your cost of steam. Ex: 1/8" orifice @ 100 psi = 52.8 X 8760 = 462528. At a cost of $5.00/1000 lb.: 462528 X .005 = $2312.64.

Orifice Diameter	100 psi	125 psi	150 psi	200 psi	250 psi	300 psi
			Steam Loss, lb. /hr			
1/32"	3.3	4.02	4.74	6.17	7.67	4.05
1/16"	13.2	16.1	18.9	24.7	30.4	36.2
3/32"	29.7	36.2	42.6	55.6	68.5	81.5
1/8"	52.8	65.3	75.8	99	122	145
5/32"	82.5	100	118	154	190	226
3/16"	119	145	170	222	274	326
7/32"	162	197	232	303	373	443
1/4"	211	257	303	395	487	579
9/32"	267	325	384	500	617	733
5/16"	330	402	474	617	761	905
11/32"	399	486	573	747	921	1095
3/8"	475	578	682	889	1096	1303
13/32"	557	679	800	1043	1286	1529
7/16"	674	787	928	1210	1492	1774
15/32"	742	904	1065	1389	1713	2037
1/2"	844	1028	1212	1580	1949	2317

Manage Your Steam Trap Maintenance Program

There are also several steam trap audit software products available on the market to help you manage and analyze your steam system, and steam traps. These programs will analyze steam loss, maintenance cost, failure trends and more.

Some links to software product web sites include:

www.conserve-it.com/products.htm
www.steamsolutions.com
www.bitherm.com/traphelp.htm
www.armstrong-hunt.com/steam-system-testing-monitoring-steamstar
www.p2pays.org/ref%5C08/07612.pdf
www.maintenancesources.com/productsshowcase/trapbase.htm

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Resources

Below, please find a list of resources and UE partners where you can find out more information on energy conservation and plant maintenance technology.

Steam Trap Manufacturers:

Spence Nicholson
www.nicholsonsteamtrap.com

Spirax Sarco
www.spiraxsarco.com

Armstrong Intelligent System Solutions
www.armstronginteractional.com

Sterling
www.sterlco.com/steam-traps.html

Watson McDaniel
www.watsonmcdaniel.com

Compressor Manufacturers:

Kaeser Compressors, Inc.
www.kaeser.com

Ingersoll Rand
www.company.ingersollrand.com

Atlas Copco
www.atlascopco.com

AMETEK
www.ametek.com

Gast Group
www.gastgroup.com

Resources

Consultants:

Compressed Air Leak Detection Consultants:
www.uesystems.com/partners_search.asp

Compressed Air System Survey Consultants:
www.uesystems.com/partners_search.asp

Steam Trap Survey Consultants
www.uesystems.com/partners_search.asp

Magazines:

Plant Services
www.plantservices.com

Compressed Air Best Practices
www.airbestpractices.com

Plant Engineering
www.plantengineering.com

Industrial Maintenance & Plant Operation (IMPO)
www.impomag.com

Reliable Plant
www.reliableplant.com

MRO
www.mromagazine.com

MRO Today
www.mrotoday.com

Organizations/Associations:

Energy Efficiency and Renewable Energy (US Department of Energy)
http://www.eere.energy.gov/industry

14 Hayes Street, Elmsford NY 10523, U.S.
W: UESystems.com • E: Info@uesystems.com • P: 800.223.1325

Energy Intensive Industries from the EERE
http://www1.eere.energy.gov/industry/technologies/industries.html

The Society for Maintenance and Reliability Professionals
http://www.smrp.org/

Alliance to Save Energy
http://www.ase.org/

Tennessee Valley Authority
www.tva.gov

UE Systems World-Class Certified Training Programs:

Level I and Level II Certified Courses
www.uesystems.com/training_course_info.asp

2 ½ Day Technology Implementation Course
www.uesystems.com/2_day_technology_implementation_course.asp

Steam Examiner Steam Trap Testing Course
www.uesystems.com/training_course_steam.asp

Contact Us

For more information on UE Systems products and services as well as energy conservation tools and tips, please contact us:

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800.223.1325
info@uesystems.com
www.uesystems.com
www.uesoundadvice.com