Steam and Condensate Leakage – Costs and Solutions

Steam and condensate leaks cost industrial plants millions of dollars in lost energy, while increasing emissions, creating safety hazards, and lowering the reliability of plant operations.

Steam leaks result in the loss of both latent and sensible energy. While plant personnel would be well advised to pay attention to all utility losses, greater attention should be paid to the costs and problems associated with losses related to steam. Steam leaks result in higher energy losses than comparable compressed air leaks, as shown in the following example:

Steam leak = $3,591.00
100 psig
1/8 in.
$10.00 per thousand lbs. of steam

Compressed air = $2,095.00
100 psig
1/8 in.
$0.05 per kWh

Leaks in the steam and condensate system can contribute to significant energy losses—as great as 19 percent of the overall energy consumption—in a plant's operations. In fact, due to the high cost of these energy losses, the correction of steam and condensate leaks offers very lucrative paybacks. The greatest benefit of a proactive steam and condensate leakage correction program is that most leaks can be corrected without expending capital.

What Are the Major Causes of Steam Leaks?

Swagelok Energy Advisors (SEA) has conducted hundreds of steam system audits and has found that the following are the most common contributors to steam leaks in plants:

1. Threaded Pipe Connections

The number one cause of steam and condensate leaks is the use of threaded pipe connections in a steam and condensate system. Pipe threads are prone to fail with the expansion and contraction of the steam and condensate during system startup, operation, and shutdown. Using different types of materials on the threaded connection to prevent leakage has limited success.

Solution: Use other connection methods in the steam and condensate system, such as welded connections or tube-type connections.

2. Packing on Standard Type Valves
Without a proactive maintenance program, standard packing on steam isolation valves will fail and leak steam during operation.

Solution: Use other types of valves that have corrected the sealing problems encountered in steam and condensate. Commonly used valves include ball valves and butterfly valves (in some applications).

3. Carbonic Acid
The carbonic acid found in most systems will attack the components of a steam and condensate system. The carbonic acid deterioration will be noticeable at the thinnest part of the pipe, which is the threaded connection.

Solution: Use other connections methods in the steam and condensate system, such as welded connections or tube-type connections that will resist the carbonic acid or CO2 corrosion. In the condensate system, use stainless steel to provide maintenance-free operation.

4. Water Hammer
The water hammer in the steam and condensate system can produce pipe connection failures that result in system leaks.

Solution: Water hammer should not occur in the steam and condensate system. If water hammer exists, the issue must be resolved. Causes and solutions to water hammer can be reviewed in SEA's Best Practice No. 11 "The Number One Problem in a Steam System – Water Hammer."

How to Determine Losses from Steam Leaks

Steam flow through a leak can be calculated using an orifice equation, which is based on the diameter of the leak, pressure at the inlet of the orifice, and pressure at the outlet (atmosphere).

Steam Flow = f (orifice diameter, inlet pressure, atmospheric pressure)

However, SEA historically has identified the following leak characteristics in steam and condensate systems:

1. The leak path is not a perfect orifice.
2. Determining the diameter of the passage is difficult because the leak is not a perfect circle.
3. Pressure at P1 may not be measured and may have to be calculated based on flows and pressure drops.

How to determine the diameter of the leak path — Even for most experienced plant personnel, determining the diameter of the leak path is difficult at best. Steam is extremely hot, and trying to measure the diameter of the path can be dangerous.

SEA recommends that plant personnel be trained with different tools to help visually determine the steam leak diameter from a safe distance. To determine steam leak volume by plume length is extremely difficult and not very accurate.

How to Determine the Inlet Pressure (P1) — P1 is determine by the steam system operating pressure. If the pressure is unknown and the steam is saturated vs. superheated then the task of determining "P1" is accomplished easily by using infrared temperature measurement devices. Saturated steam at a given temperature directly correlates to saturated steam pressure.

Using other SEA Best Practices regarding piping in steam and condensate systems will assist in eliminating leaks. Also, using SEA Best Practices on steam valves will help resolve valve failures.

What are the Emissions?

The table below lists emission levels for the most common pollutants derived from fossil fuels. Remember that in addition to saving money, a proactive program to resolve steam and condensate leakage will reduce emissions. If plant personnel calculate the total energy loss (in terms of BTU/hr) which results from their steam losses, they can use the tables below to calculate the reduction in emissions that would result from reducing the amount of steam leakage.

How Much Do Steam Leaks Cost?

Through its research and testing, SEA has found that by adding a leak constant to the Napier orifice equation, it can estimate a conservative flow and energy loss from steam leaks.

Roadmap for Steam Leaks

1. Correct all steam leaks in the plant
2. Reduce or eliminate threaded connections
3. Eliminate any waterhammer issues
4. Review steam valve selection process
5. Review material selection for condensate systems

What Are the Costs?

1/16 in. Leak								
Pressure	Abs Pressure	Constant	Diameter	D^2	Steam Loss (pph)	Cost / Hour	Days / Year	Cost / Year
250	264.696	22.88	**0.0625**	0.003906	23.7	0.24	**365.00**	**$2,072.37**
100	114.696	22.88	**0.0625**	0.003906	10.3	0.10	**365.00**	**$897.98**
70	84.696	22.88	**0.0625**	0.003906	7.6	0.08	**365.00**	**$663.11**
40	54.696	22.88	**0.0625**	0.003906	4.9	0.05	**365.00**	**$428.23**
30	44.696	22.88	**0.0625**	0.003906	4.0	0.04	**365.00**	**$349.94**
15	29.696	22.88	**0.0625**	0.003906	2.7	0.03	**365.00**	**$232.50**
0	19.696	22.88	**0.0625**	0.003906	1.8	0.02	**365.00**	**$154.20**

1/8 in. Leak								
Pressure	Abs Pressure	Constant	Diameter	D^2	Steam Loss (pph)	Cost / Hour	Days / Year	Cost / Year
250	264.696	22.88	**0.125**	0.015625	94.6	0.95	**365.00**	**$8,289.48**
100	114.696	22.88	**0.125**	0.015625	41.0	0.40	**365.00**	**$3,591.93**
70	84.696	22.88	**0.125**	0.015625	30.3	0.30	**365.00**	**$2,652.42**
40	54.696	22.88	**0.125**	0.015625	19.6	0.20	**365.00**	**$1,712.91**
30	44.696	22.88	**0.125**	0.015625	16.0	0.16	**365.00**	**$1,399.74**
15	29.696	22.88	**0.125**	0.015625	10.6	0.11	**365.00**	**$929.99**
0	19.696	22.88	**0.125**	0.015625	7.0	0.07	**365.00**	**$616.82**

3/16 in. Leak								
Pressure	Abs Pressure	Constant	Diameter	D^2	Steam Loss (pph)	Cost / Hour	Days / Year	Cost / Year
250	264.696	22.88	**0.1875**	0.035156	212.9	2.13	**365.00**	**$18,651.34**
150	164.696	22.88	**0.1875**	0.035156	132.5	1.32	**365.00**	**$11,605.02**
100	114.696	22.88	**0.1875**	0.035156	92.3	0.92	**365.00**	**$8081.85**
70	84.696	22.88	**0.1875**	0.035156	68.1	0.68	**365.00**	**$5,967.96**
40	54.696	22.88	**0.1875**	0.035156	44.0	0.44	**365.00**	**$3,854.06**
30	44.696	22.88	**0.1875**	0.035156	36.0	0.36	**365.00**	**$3,149.43**
15	29.696	22.88	**0.1875**	0.035156	23.9	0.24	**365.00**	**$2,092.48**
5	19.696	22.88	**0.1875**	0.035156	15.8	0.16	**365.00**	**$1,387.84**