BEST PRACTICE NO. 52

» STEAM AND CONDENSATE SYSTEM LEAKS ARE UNACCEPTABLE

IN TODAY'S STEAM SYSTEM OPERATIONS:

Leaks are unacceptable in today's industrial steam and condensate system. In fact, steam leakage is considered abnormal in daily plant operations. Yet 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.

Figure 1: Steam Leakage at a Connection

One of the highest returns on a plant's investment is correcting steam and condensate leakage and instituting operational changes to prevent any leakage from occurring again in the system. Changes that can eliminate leakage can include (but are not limited to) the following:

- component selection,
- installation practices,
- design,
- plant specifications,
- material selection, and
- operational practices.

Steam and condensate leakage is one of the top five opportunities for reducing energy and increasing reliability and safety in plant operations. Steam leakage results in the loss of both latent and sensible energy, while condensate leakage is the loss of sensible energy. Though plant personnel should pay attention to all utility losses, they should pay even greater attention to the costs and problems associated with those losses related to steam.

Steam and condensate leakage in the system can contribute to significant energy losses—as high as 9% 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 leakage 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.

1. WHAT ARE THE MAJOR CAUSES OF STEAM LEAKS?

Inveno Engineering, LLC has conducted hundreds of steam system audits and has found that the following

Figure 2: Threaded Connection Leakage

items are the most common contributors to steam and condensate leakage in plants.

1.1. Threaded Pipe Connections

The number one cause of steam and condensate leaks is the use of threaded pipe connections (National Pipe Thread (NPT) connections) in a steam and condensate system. Pipe threads were developed in 1864 and have achieved very few improvements over time. The threads are prone to fail due to several issues that occur in a steam/condensate system.

One issue is the quality of the thread on the components. All threaded components need to be quality checked to ensure the thread meets the proper standard. There are many different thread standards: NPT, NPTF, BSP, BSPP, etc. When plants mix these standards, it will negatively affect installation and operation.

Expansion and contraction of the steam/condensate piping during system startup, operation, and shutdown can also cause leaks. The expansion and contraction can exceed a few inches in some cases, thus putting more demands on the threaded connection.

Oxygen and carbon acid corrosion in the system will attack the threaded connections. The result of the corrosion attack will be loss of the thread material, which will result in a leakage point.

The plant must carefully select lubricants for the threaded surfaces to ensure that they are compatible with system media and that they are able to perform at the temperatures found in the system. Often, during installation, threaded lubrications can negatively affect the process fluids or cause problems with process components. Using different types of lubrication materials on the threaded connections to prevent leakage has limited success.

1.2. Flanged Connections

When adding flanges to the steam system, consider the following three items for their installation and operation.

1. Flange gasket materials: The gasket materials need to be rated for the maximum pressure and temperature.

2. Expansion and contraction: Flanges are not designed to withstand significant side loading. Pipe guides should be used to ensure that flanges are only subject to axial movement.

3. Torque specifications and torque sequence: It is crucial to know the proper torque specification for flanged connections prior to installation. Improper torque can damage the gasket and/or flange. It is also important to know the tightening pattern of the fasteners responsible for holding the flanged connection together. Failing to torque the fasteners in the correct order can lead to connection damage and failure.

1.3. Standard Type Valves

For a long time, gate and globe valves have been one of the most common valve styles used worldwide for flow control of the steam and condensate system media. The first gate valve was patented in 1839, with the last change in design in the 1940s.

Standard valves should never be based purchased on price but rather on operational considerations.

In recent years, technology in ball and butterfly valves has greatly improved, allowing these valves to operate at higher pressures and temperatures. Also, ball and butterfly valves have standard leakage rates that are extremely low compared to other valves and are tested or documented to the different internal leakage standards.

1.4. Internal Leakage

The first and most important consideration when selecting a valve for steam service is the valve's internal steam leak rate. Any valve in an isolation service for steam and condensate must be able to provide a tight shutoff in a closed position. The

Figure 3: Internal Valve Leakage

plant needs an approved, consistent method for documenting the internal leakage rate.

- *American Petroleum Institute (API) 598, Valve Inspection and Test*: This is the most widely used test specification in the world. It covers many types of valves but was developed primarily for consideration of isolation valves. The standard includes leakage rates and testing criteria for both metal-seated and resilient-seated valves.

- *Manufacturers Standardization Society (MSS) SP61, Hydrostatic Testing of Steel Valves*: This standard is similar to API 598 but has subtle differences in test holding times and leakage rates. It was developed to provide a uniform means of testing valves commonly used in the "full open" and "full closed" type of service. It is not intended for use with control valves. Refer to standard ANSI/FCI 70-2 for Control Valves.

- *American National Standards Institute (ANSI/FCI)*: ANSI has defined six permissible steam leak rates for valves. As the valve's class number increases, less steam leakage is observed across the valve. Any valve considered for steam service must have no less than an ANSI/FCI Class IV rating. Whenever possible, a Class VI rating is highly advised for positive shutoff.

1.5. Valve Packing

Standard gate and globe valves that use an older method of sealing the actuating stem from the internal steam/condensate flow areas to the outside operation of the valve (valve handle or stem) have a high leakage rate during steam/condensate leakage assessments.

Figure 4: Valve Packing Leakage

Standard gate and globe valves are unsupported in any position other than fully closed, at which time the seat surrounds the bottom end of the valve. Since the globe or gate is supported at the top by the valve stem and unsupported at the bottom, the force exerted by the system pressure causes the globe or gate to have movements other than a straight up and down. These different types of movements will damage the valve packing. As the valve packing is exposed to the steam or condensate media, it will result in valve leakage. The normal location of the steam or condensate leakage presents a safety hazard to personnel because the flow is directed toward the operating handle of the valve.

Without a proactive maintenance program, standard packing on steam isolation valves will fail and leak steam or condensate during operation. And steam valve failures will lead to energy losses and production issues.

1.6. Water Hammer

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 Inveno Engineering, LLC's Best Practice 11, "The Number One Problem in a Steam System—Water Hammer."

1.7. Other Causes

Erosion can also cause steam leaks. Steam is very erosive. The term "wiredraw" refers to the ability of the steam to actually cut metal. Plant personnel must be very proactive with steam leakage because of the risks of erosion: as equipment erodes over time, steam leaks will increase, causing an even more serious issue.

2. OTHER ISSUES

The overall reliability of the steam system is affected by steam and condensate leakage. Attention must be paid to selecting the proper components and materials. Steam system managers must be sure to specify appropriate components that provide a tight shutoff. This is done by selecting the proper style of connections, valves, steam trap stations, etc. and making sure materials are appropriately rated for the pressure and temperature of the given system.

Steam leaks can also affect production. If the needed system pressure cannot be maintained because pressure and temperature are directly related (saturated steam), the plant will not be able to maintain the required process temperatures.
Finally, while energy losses, productivity, and reliability are all very important, the safety of plant personnel is the most important. Steam leaks can burn, foggy conditions can cause wrecks in traffic areas, and water vapor vented from failed steam traps can settle on walking and driving surfaces where it will freeze in cold weather, causing slippery conditions.

3. SOLUTIONS TO PREVENT LEAKAGE

Steam and condensate leakage is abnormal in today's steam and condensate system operation. The solutions to prevent steam and condensate leakage can be easily achieved if the plant accepts changes to the system.

A. Institute connection methods other than standard threaded connections. Using the following methods will eliminate leakage.

1. *Welded connections:* Follow the proper welding method codes, and weld connections will not leak.

2. *Tube connectors:* Today's industrial tube connectors are guaranteed not to leak.

Figure 5: Leak-Free Steam System

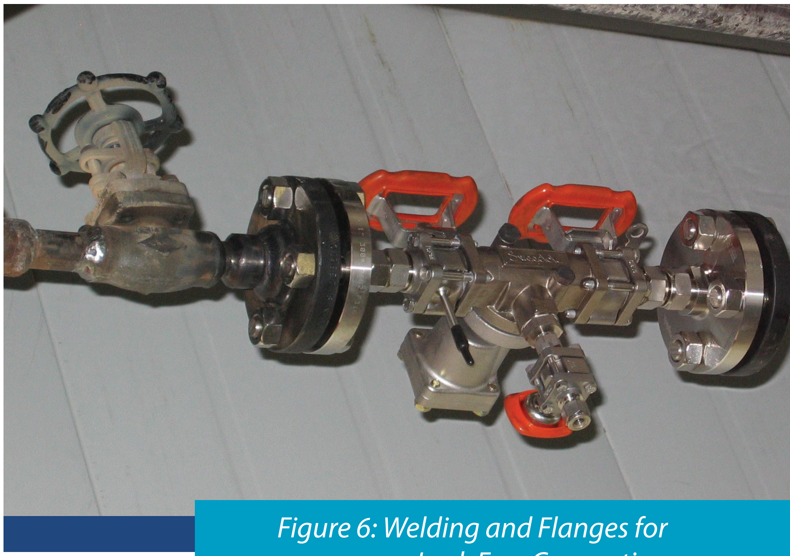

Figure 6: Welding and Flanges for a Leak Free Connection

Figure 7; shows the use of tube connectors for a typical steam trap station that will provide a leak free operation

Figure 7: Swagelok Tube Connectors for a Typical Steam Trap Station Installation for a Leak Free Operation

Figure 8: Steam Isolation Ball Valve before the Control Valve

3. *Flanges:* By following proper selection and installation procedures, flanges will provide a long, leak-free operational life.

B. Using new technology in steam and condensate valves, such as ball or butterfly valves, will prevent valve stem leakage problems as shown in **Figure No. 8.**

C. Institute an internal leakage standard that all valves used in steam or condensate systems must meet the standards listed in this technical paper.

D. Establish root cause analysis for all steam and condensate leaks.