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TRACING THE CAUSES OF HEAT MAINTENANCE ISSUES

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ABSTRACT

Steam tracing and other thermal maintenance applications are critical to production, but heated fluids can suffer from low temperatures, non-ideal viscosity, and resultant stagnated flow issues. The cause can often be attributed to design or routing of tracing methods, or that the steam traps used may not provide optimal application performance. This presentation reviews key factors for design or existing installation improvements. Focus is on tube/enhanced tube/channel tracing, or jacketed pipe heating for process fluid transport, such as in sulfur or resid lines, asphalt tanks, sulfur pits/submerged coils/seal legs/tanks, and paraxylene chutes or related manufacturing products.

TELLTALE SIGNS - ISSUES - CAUSES - ACTIONS

Tracers: Role and Importance

In industrial plants, significant attention is given to process applications, but often steam tracing lines are treated almost as simple plumbing. Unfortunately, it is not uncommon in new plant construction that detailed drawings for running steam tracer lines are not even provided and the design is left to the installation contractor.

Δ **Figure 1.** Multiple tracers installed to obtain high heat transfer.

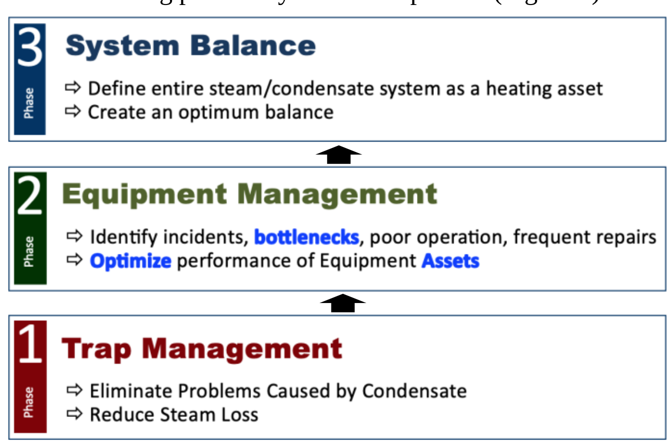
Consider that tracers can represent 50% - 80% of the applications for steam traps in a typical refinery or chemical plant, and that their purpose is to maintain desired process product viscosity or control instrumentation viability. If heat transfer from tracing is inadequate, multiple issues can result including product freeze-ups, or even plant shutdown from a single misapplied installation or non-performing steam trap. It follows that additional understanding of tracer characteristics and methods to sustain high heat quality is warranted. While impractical to review every application, this paper provides insights into historical events and the considerations that followed to help achieve improvement (Figure 1).

Where to Begin?

There are often telltale signs of trace heat issues well in advance of serious problems developing. Every open bleed from a traced line may be indicative of incorrect trapping for condensate drainage, so operations personnel may simply open bleeders to help remove the condensate and increase heat supply. However, in addition to wasting energy, this practice can create multiple issues; including burn risk, poor visibility obscuring equipment, and slip hazard from ground algae or ice. It follows that if heat from the tracing system were adequate, bleeding steam most likely would not be required (Figure 2) *(1)*.

Δ **Figure 2.** Opened bleeds are a sign of poor heat transfer.

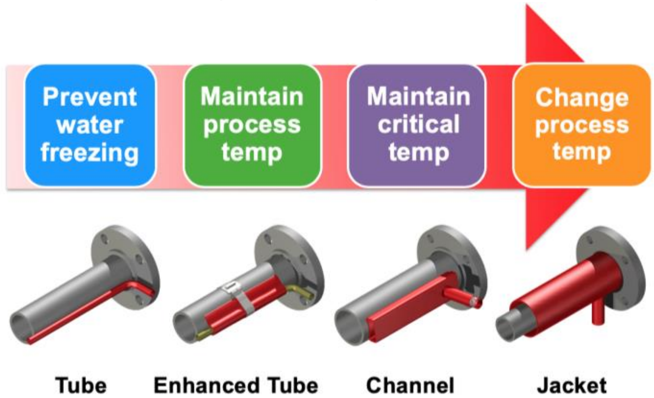
When implementing a Steam System Optimization Program (SSOP®), equipment asset management plays a critical role to production performance. Poor product transport can negatively impact production, so significant focus must be given to mitigating bottlenecks and optimizing system performance. But these goals cannot be accomplished when freeze-ups or viscosity issues are prevalent, so control of external heating product systems is important (Figure 3).



Δ **Figure 3.** Steam system optimization requires focus in three phases. Heat maintenance is mostly handled by Phase 2 actions.

Four Outer Heat/Temperature Maintenance Methods

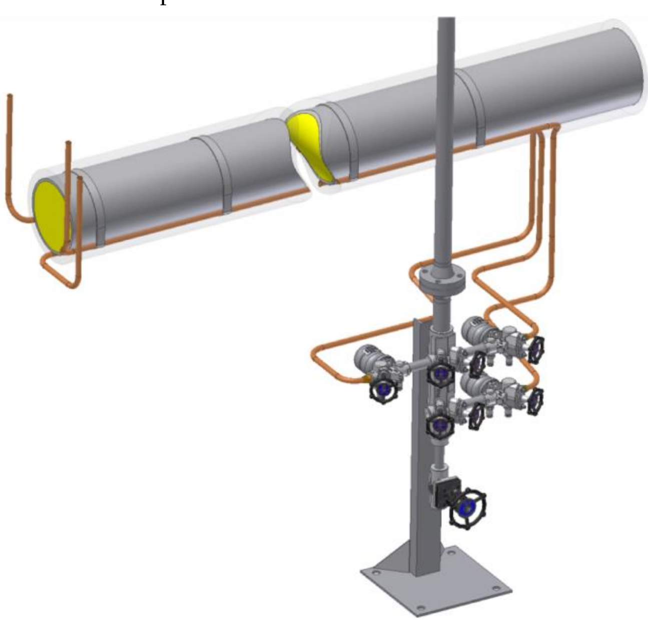
There are four common methods to apply external steam heat to process piping or chutes (Figure 4).



Δ **Figure 4.** These are the four types of external steam heat transfer methods used to heat product piping.

1. **Tube Tracer** is used for simple heating, such as preventing water from freezing. For additional heating, special heat transfer cement can be applied as well.
2. **Enhanced Tube Tracer** is useful for even greater heat transfer from a tube. An example might be to maintain desired viscosity in residual oil transport.
3. **Channel** partially jackets a heated product line with steam to impart much more heat transfer, commonly used on sulfur lines.
4. **Jacket** is needed when the goal is to increase the process temperature or eliminate corrosion, requiring even greater heat.

The appropriate selection and installation of steam traps for effective condensate drainage from these heating methods plays a crucial role in affecting the heat transfer achieved with each. It is important for sustainable operation to have traps easily accessible to inspect and maintain them to manufacturers' specifications. Using manifolds for the steam supply and condensate return is a useful way to accomplish this goal.



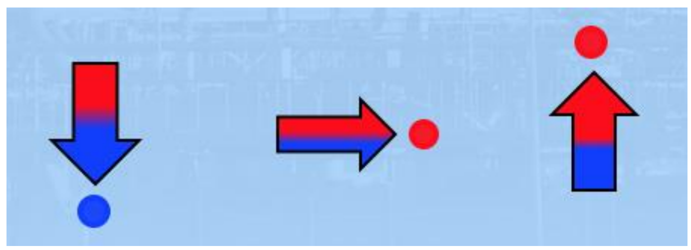
Δ **Figure 5.** Expectation for typical tracing system with condensate collection manifold.

A compact manifold installation should provide for easy maintenance access and also consider unit ingress and egress while occupying the smallest footprint possible (Figure 5).

What Else Should be Considered?

Once the correct traps are selected and the trace heating method installed, site personnel may think the installation is optimized. However, this may not be the case because the orientation of both steam and condensate flows within the external heating system also needs to be considered.

Specifically, it is useful to determine if condensate ALWAYS flows downward to the trap–maintaining a water seal at the trap inlet, or if there are instances where condensate must rise to reach the trap. When condensate elevates, it is common that steam can fill some vertical portion of the piping and sit above incoming condensate. When steam rests above condensate at the trap inlet, it can restrict the trap's discharge operation. Flow arrows can be used as a simple way to determine if steam is ever above the condensate level during normal flow into a trap (Figure 6).

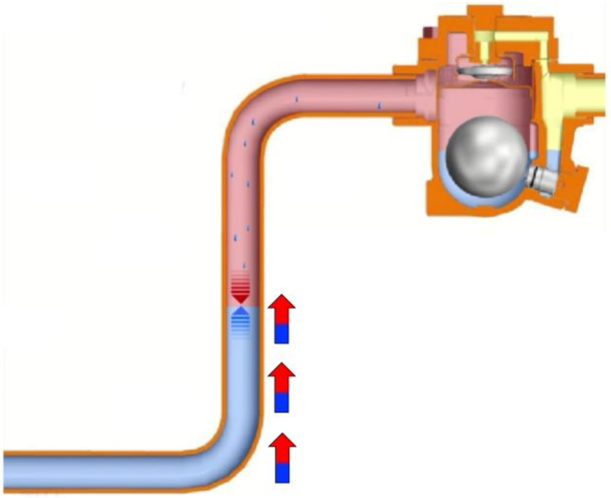


Δ **Figure 6. Notice:** Consider condensate flow entering the trap. If the piping allows steam over condensate, a steam lock can occur.

The reason for this restricted flow when steam resides over condensate at the trap inlet is more readily understood by reviewing the three basic functions of a steam trap, with emphasis on the first two (Figure 7).

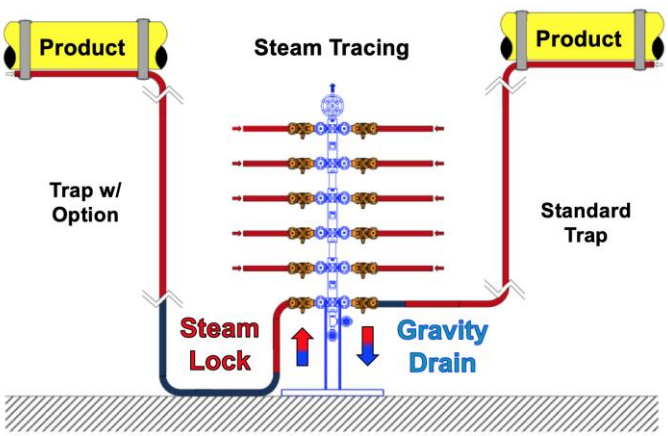
Δ **Figure 7.** A steam trap has 3 functions, but this article deals mostly with the first two.

A steam trap needs to "trap steam," preventing steam leakage, while performing its most important role–to discharge condensate. But when steam rests at the trap inlet, the trap can lock shut, preventing condensate flow while steam is present. This phenomenon is known as a "steam lock" and can occur commonly when condensate is lifted to the trap (Figure 8) *(2,3)*.



∆ Figure 8. Upward condensate lifts can create a steam lock condition on traps, restricting discharge until steam condenses.

When a steam lock occurs, condensate may not reach the trap to be discharged until such time passes that the locking steam condenses and the flow interruption dissipates. For this reason, it is generally recommended to install external heating methods with condensate flowing downward as shown on the righthand-side tracer in the following graphic, rather than having upward flow if it can be avoided. When upward flow to the trap cannot be eliminated–as shown on the left side, it may be useful to select a trap that incorporates an optional feature that helps mitigate the steam lock (Figure 9). This method of either eliminating or handling steam lock instances can be applied for each of the four methods of externally-applied heat.

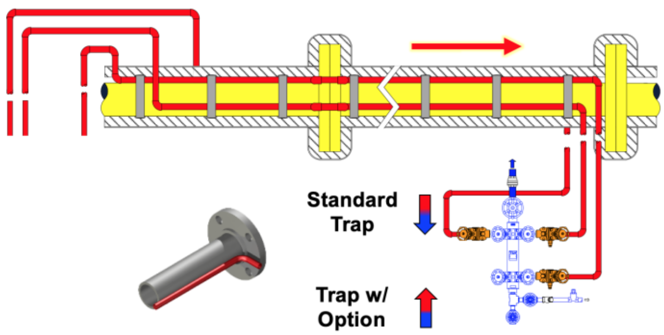


∆ Figure 9. Route condensate downward to a standard trap on manifold. If uplifting, a trap with internal bypass may be needed.

Tube Tracing

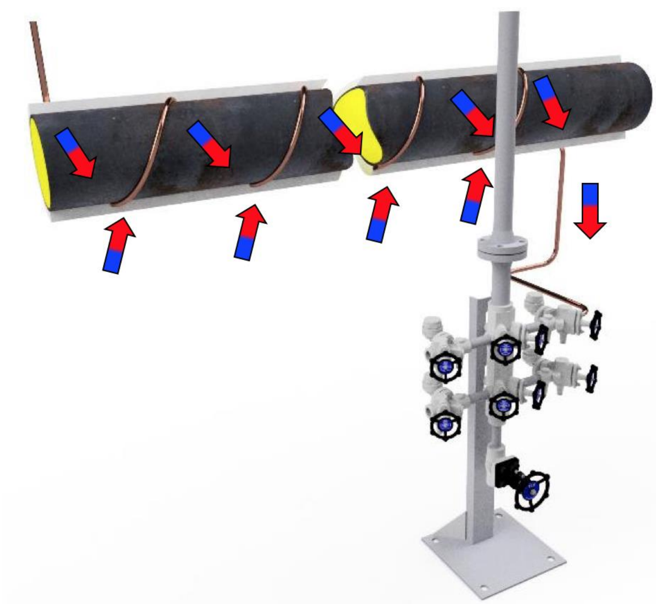
For example, tube tracers can use a standard model trap intended for the application whenever the condensate flows down by gravity and condensate is at the bottommost tip of the flow arrow.

However, when there may be steam at the tip of the flow arrow due to an uplift, then the decision has to be made as to the criticality of heat or temperature maintenance. Specifically, the effect on traced product has to be evaluated as to what happens if the trap stays shut for a period of time until the steam lock dissipates and allows condensate discharge. During the steam lock period, is there any serious effect on the traced product viscosity, temperature, or heat content? If not a key consideration, then even with an uplift it may be possible to use a standard trap. However, if there is any doubt, then a trap with the optional feature to mitigate the steam lock should be selected (Figure 10).



∆ Figure 10. Tube tracers used for warming effects may or may not be significantly affected by upward lifts.

Installers who do not have experience with steam tracing may erroneously wrap tubing around horizontal piping as shown. This creates a serious steam lock issue (Figure 11).

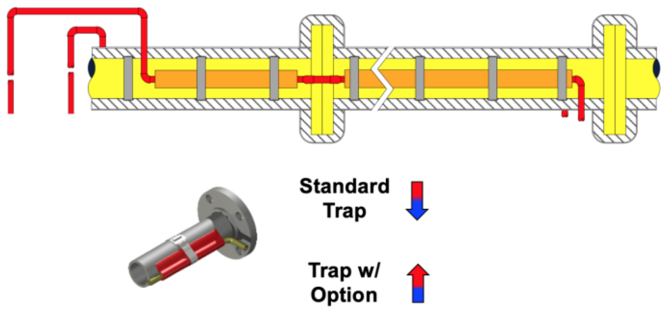


∆ Figure 11. Warning: DO NOT wrap steam trace tubing around horizontal pipe. This creates steam pockets that cause locking.

Enhanced Tube Tracing

Whereas tube tracing may commonly be employed for simple winterization, enhanced tube tracing represents a more crucial product temperature maintenance requirement. Residual oil tracing might be one such example.

Because the criticality of heat transfer is increased, closer attention to the condensate flow direction is warranted-with elimination of as many upwards lifts as possible (Figure 12).



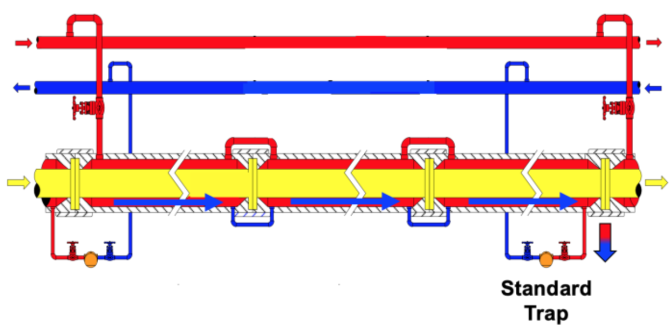
Δ **Figure 12.** Enhanced tube tracers are typically used for temperature maintenance of important process products.

Jacketed Pipe Heating

It is far more capital-intensive to install a system using jacketed piping, so this heating method is reserved for product flows requiring large heat transfer capability. The goal may be to increase the product temperature, or to help ensure that the idea product temperature/viscosity will be maintained. Sulfur transport is one such example.

Interestingly, although jacketed pipe itself is significantly expensive, common connections that transfer steam and condensate throughout the jacket circuit may actually hinder the effectiveness of the heat transfer received.

Consider an installation where steam and condensate are transferred from one jacket section to the next, using a sort of daisy chain connection. Steam flows throughout the jacket and into the jumpers on the top of the piping, while condensate flows easily along the bottom of the jacket (Figure 13).

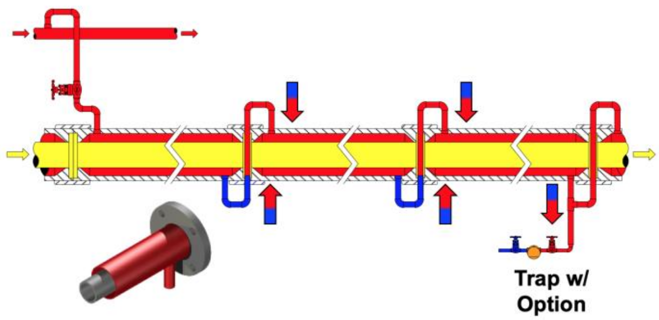


Δ **Figure 13.** Jacketed pipe with steam connected at the top, condensate flowing along the bottom, and gravity drainage to trap can prevent instances of steam locking.

Even though there is a small uplift, condensate fills the lower loops by manometer effect and little, if any, steam passes through the bottom connectors. This is an ideal condensate flow arrangement, which regrettably is not commonly utilized.

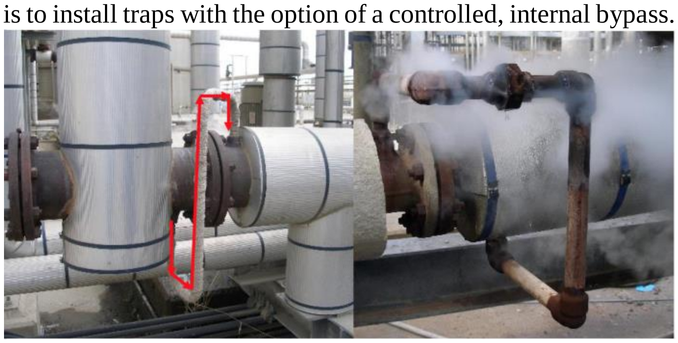
Typical Jacketed Pipe Installation

Unfortunately, much jacketed piping is installed using "S" loop connector design. A single bottom connection at the end of one jacket section is used to transport both steam and condensate to a single connection at the top of the next jacket section. Several sections of jacketed pipe may be connected together in this manner. This arrangement requires both condensate and steam to flow through that connecting piping, invariably with steam pockets sometimes being caught between the condensate and trap on the last piping section in the series (Figure 14).



Δ **Figure 14.** Jacketed pipe for high heat typically uses "S" loops to connect sections, and can require traps with internal bypass.

The "S" connector design red-highlighted in the following photo is a common cause that results in steam locking being mitigated by operations members opening bleed valves, blowdown valves, or pipe unions *(4)*. Whenever "S" connector loops are installed, it is possible that either heat transfer is not meeting requirements, or there is steam being discharged to the atmosphere (Figure 15). A method to mitigate the steam locking is to install traps with the option of a controlled, internal bypass.

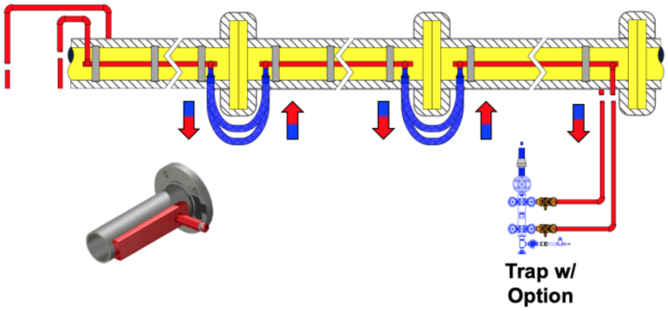


Δ **Figure 15.** If standard traps are used on jacketed pipe with "S" loop connectors, steam bleeds likely indicate heating issues.

Channel Tracing

Channel tracing is another way to achieve significant heat transfer, but at a lower installed cost than jacketed pipe. It is common to see channel tracing used on sulfur lines due to the critical heat required for this service.

One steam-condensate flow consideration is that "U" loops are employed to connect sections of channel tracing in a manner similar to jacketed pipe. In this case, a single connection at the end of one channel is used transport both steam and condensate to a single connection at the next channel (through the "U' loop). The arrangement causes both condensate and steam to flow through that loop, invariably with steam sometimes being caught between the condensate and the trap on the last piping section in the series. Similar to jacketed pipe, a method to mitigate the steam locking is to install traps with the option of a controlled, internal bypass (Figure 16).

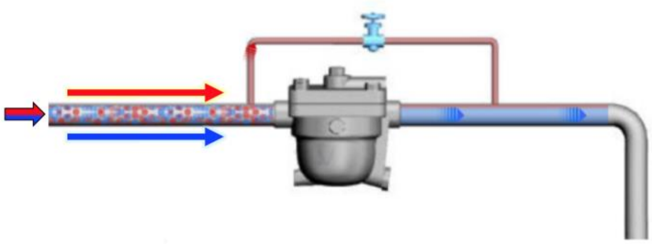


∆ **Figure 16.** Strap-on channel jacketing helps maintain critical process temperature, and can require traps with internal bypass.

Methods to Handle Steam Locking

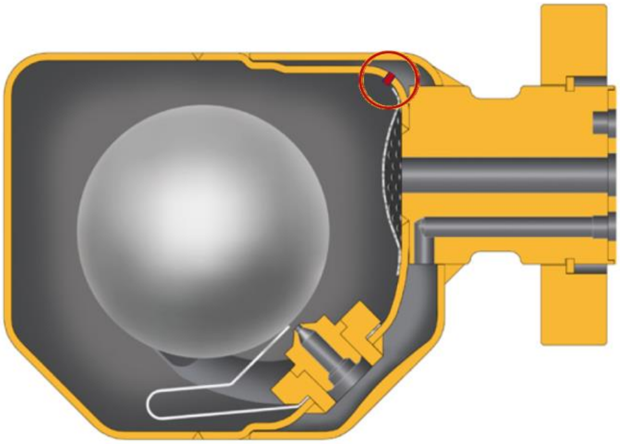
As previously explained, a steam lock can occur when steam is present at the trap inlet, with condensate building up and being unable to be discharged because the trap has shut due to the presence of steam.

A steam lock naturally dissipates when the steam condenses, but this may require too much time relative to the heat transfer criticality of the process fluid being traced. When it is necessary to break a steam lock quickly, this can be done by using an external bypass arrangement (Figure 17) *(2)*.



∆ **Figure 17.** An external bypass can be installed to handle a steam locking condition, but this can add unnecessarily cost.

However, an external bypass can be costly to install and easy to abuse with excessive steam bleeding. For that reason, a low-cost internal bypass arrangement is preferred (Figure 18).

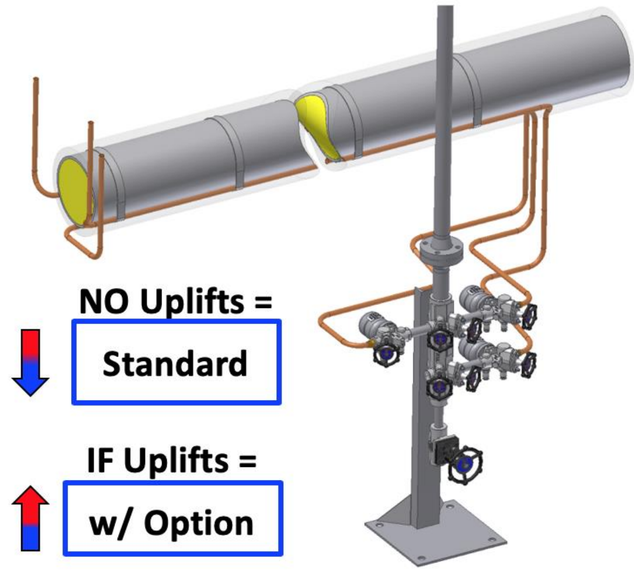


∆ **Figure 18.** A trap containing a controlled, small internal bypass (shown within the red circle) can help break a steam lock.

Manifolded Traps Summary

If condensate always precedes steam at the trap inlet due to gravity flow, then a standard steam trap is selected.

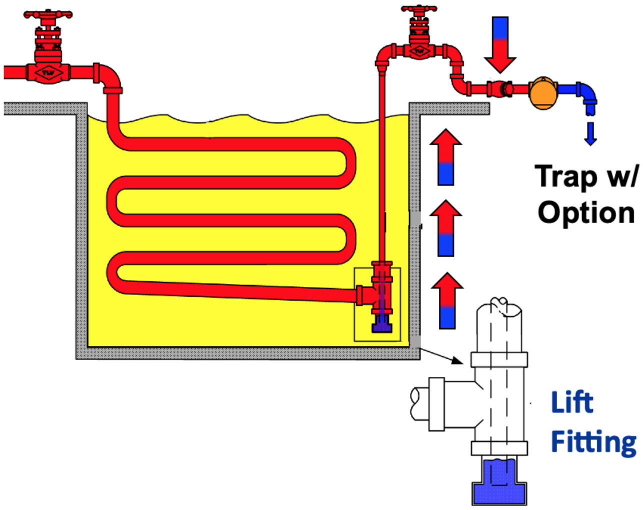
If there is the chance that a steam pocket can flow to the trap inlet before condensate, such as due to an uplift condition, then a trap with internal bypass option is a consideration depending on the temperature maintenance criticality of the product being heated (Figure 19).



∆ **Figure 19. Manifold Summary:** When draining by gravity, use standard traps. For uplift, consider traps with internal bypass.

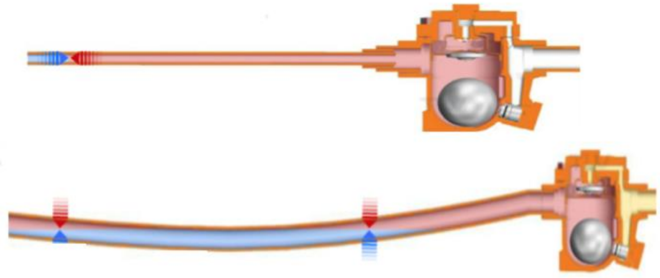
Other Applications That Can Suffer from Steam Locking

Sulfur pits are notorious for difficulties with draining condensate from the bottom coils. Even if appropriate lift fittings are used, there are still times when steam pockets will precede condensate up the riser piping and cause steam locking at the trap inlet. This effect can be somewhat mitigated by installing a drop-down at the trap inlet, but still a trap with internal bypass option is recommended (Figure 20).



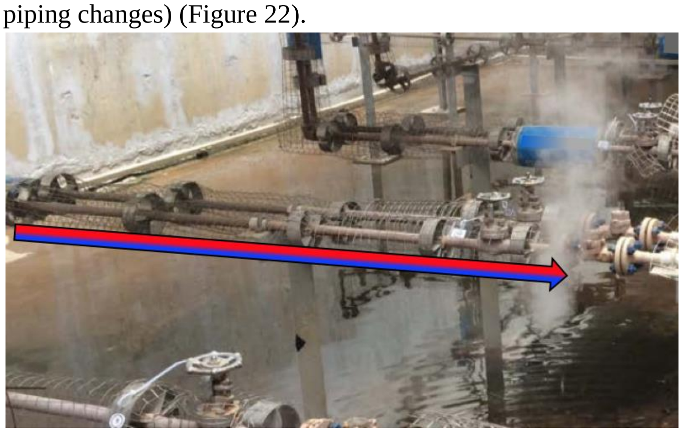
∆ **Figure 20.** Lift fittings push steam and condensate up. Even with a drop down to the trap, an internal bypass can be helpful.

Long horizontal runs at the trap inlet can also create a steam locking instance, as well as when the trap's inlet piping has a dip (Figure 21). In the top example, it is better to move the trap closer to the application and install a small drop-down to the trap inlet as shown in Figure 20. The same recommendations apply to the bottom example, with the addition of correcting the dip in the piping *(2)*.



Δ **Figure 21.** Long horizontal runs or dips in horizontal piping can create steam locking issues and should be avoided.

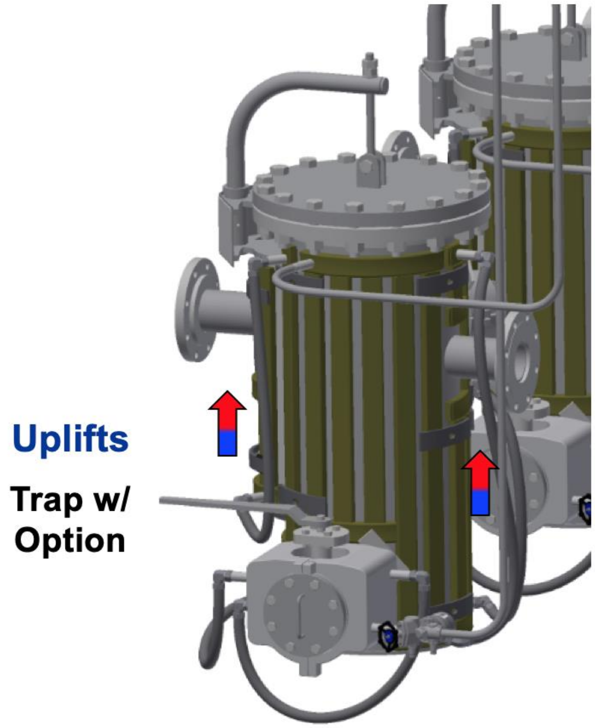
A real-world example of steam locking is shown in the photo below. The in-ground sulfur seal leg was experiencing heating issues–caused by the traps being located on a horizontal plane too far away from the vertical down feed. Steam locking was the result that could be mitigated by either moving the traps closer to the vertical, or installing traps with an internal bypass (which was the recommendation in this instance to avoid major piping changes) (Figure 22).



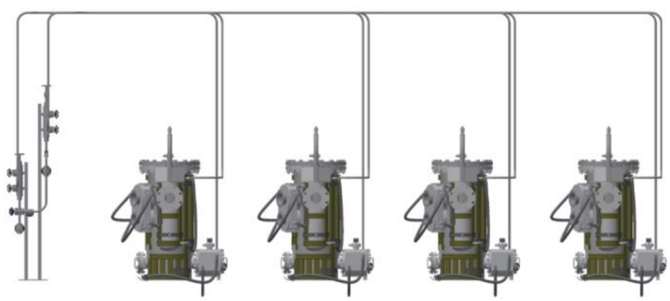
Δ **Figure 22.** Long horizontal piping runs to the traps created steam locking issues, needing internal bypass models to resolve.

One of the newest and preferred methods for creating a seal leg is to use an above-ground sulfur seal unit *(5)*. These seal pots are heated using multiple sections of channel tracing with steam and condensate flow transferred from one channel to the next using connector hoses. There can be a lot of upward steam and condensate flow, so steam traps with an internal bypass are the recommended selection (Figure 23 & Figure 24).

The beauty of above-ground sulfur seal units is that multiple pots can be located close together and require a just a very small footprint. However, the units do require cleaning and other maintenance, so a layout that considers egress and ingress can be useful (Figure 24).



Δ **Figure 23.** Above-ground sulfur seal units can have uplifts and benefit from traps with internal bypass.



Δ **Figure 24.** When using above-ground sulfur seal units, design for proper egress and cleaning around the units.

Other Tracing or Heat Maintenance Issues

Copper Leaching

When copper tube tracing has deteriorated over time or from chemical treatment issues, a result can be copper leaching into a solution of hot condensate. As the condensate is discharged through a steam trap's orifice, some percentage of it will flash, leaving behind copper precipitate that can stick to surfaces-such as the trap orifice outlet canal. Regardless of orifice material, a precipitate build-up can occur, thereby creating a blockage (Figure 25).

There are several steam trapping methods to mitigate the effects of copper leaching and precipitate build-up.

1. **High Subcooling Traps** can be used to lower the condensate temperature if the heating need is not high. By using traps with high subcooling, flash is reduced or

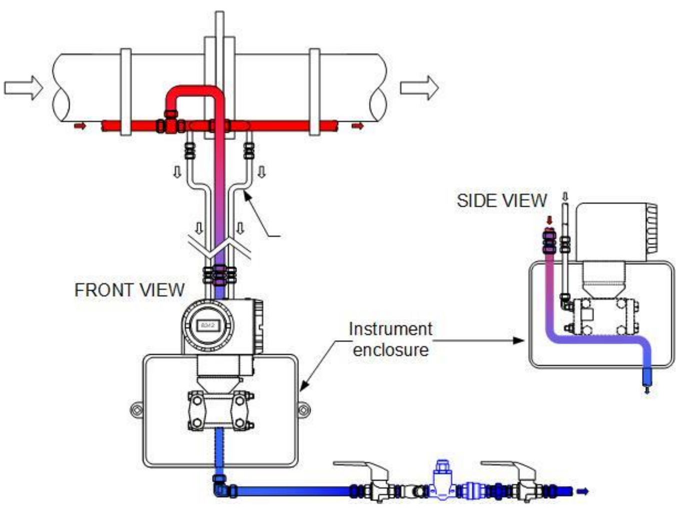
Δ **Figure 25.** Leached copper from tracing lines can fall out of solution during condensate flashing and block a trap's orifice.

eliminated, which can prevent much of the precipitate from being produced at the trap's orifice.

2. **Dirt Channel Design** improvements, such as widened discharge passages in steam traps, can reduce build-up.
3. **Auger Feature** installed on some traps can remove copper precipitate without removing the traps from the line.

Instrument Enclosures

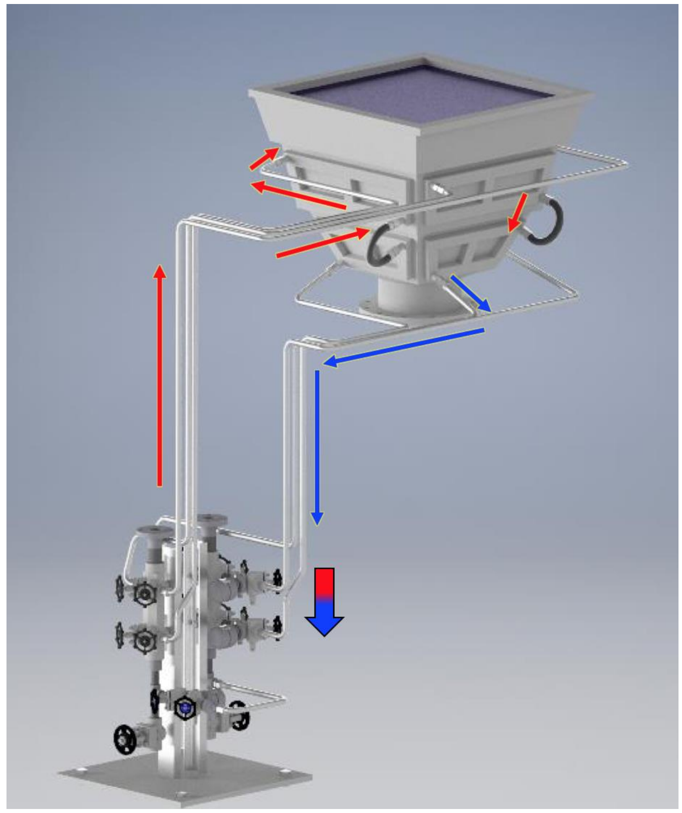
Control instrumentation just needs warming and must be shielded from excessive temperature above specification limits. Steam traps with high subcooling characteristics can be used to provide heating in the enclosure's trace tubing with warm condensate rather than steam (Figure 26).



Δ **Figure 26.** Instruments need warming, but not high temperature. Select traps with very high subcooling capability.

Chute Heating

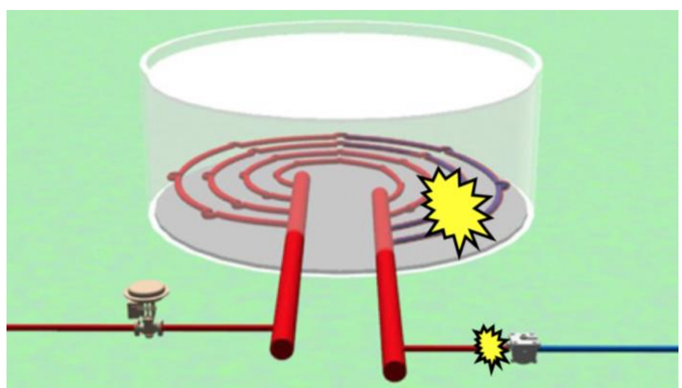
Some chute geometries create stagnated flow on the edges. With certain products such as paraxylene, this can result in multiple process interruptions throughout the year. Adding high heat through the use of properly-installed channel tracing can help, as well as utilizing both steam and condensate manifolds in a small footprint to optimize the heat transfer (Figure 27).



Δ **Figure 27.** Paraxylene chute had blocking issues unresolved with electric tracing. Channel heating provided relief.

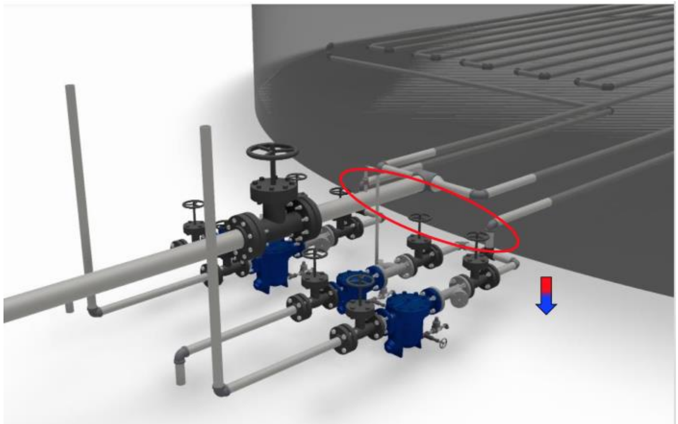
Storage Tank Heating

A steam lock can occur when steam traps are located on the same horizontal plane as the tank coil outlet. As steam condenses within a coil, its volume becomes significantly smaller, usually at least 100 times less. That allows steam to flow over condensate in the coil and reach the trap simultaneously with the condensate. The phenomenon of steam over condensate can cause a steam lock and resulting significant water hammer and shock in the coil (Figure 28).



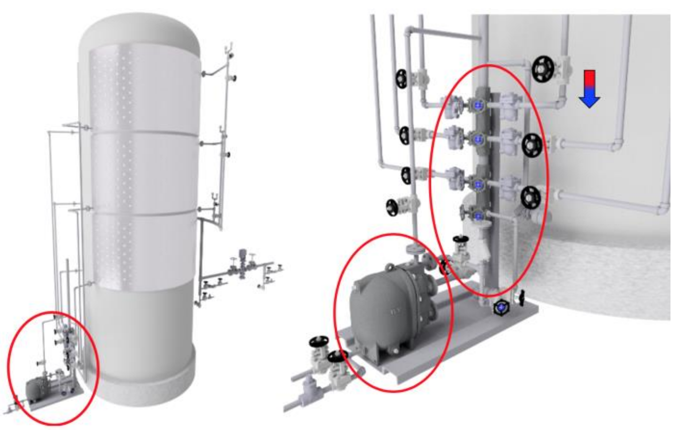
Δ **Figure 28.** Storage tanks can have water hammer issues caused by steam locking when the trap is not lower than the coil outlet.

It is possible to eliminate steam locking at the coil outlet by simply installing the traps with a drop-down on the trap inlet (Figure 29) *(6)*.



∆ **Figure 29.** Installing a drop-down in the piping before the trap can help eliminate steam locking.

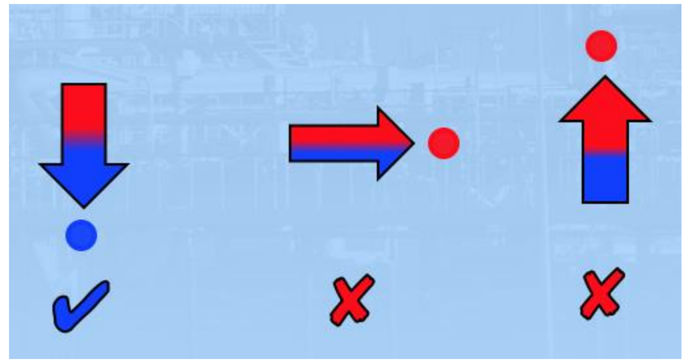
As a separate topic, many storage tanks' internal or external skin heater coils have modulating steam control on their supply. Back pressure in the condensate return can cause back-up and hammering, so if back pressure is a consideration, then a simple pumping system should be used to recover condensate. Commonly, the loads may be small enough to drain the condensate into a manifold which can also be used to vent flash. The result is a compact trapping, collection, and return system (Figure 30).



∆ **Figure 30.** Drain skin heaters' condensate by gravity through traps to a compact return and pumping station.

CLOSING THOUGHTS

1. **If condensate always flows downward by gravity**, it is expected to reach the trap inlet first and then a standard steam trap model can be selected (Figure 31).
2. **If condensate flows sideways for a long distance or upward**, it is expected that a steam pocket can reach the trap before the condensate and cause a steam locking issue. Then a trap with an internal bypass may be the best selection depending on the required product heat or temperature maintenance needed.
3. **External heating methods are capital-intensive, and their performance should be optimized by:**
   - Proper system design, eliminating condensate uplifts wherever possible.
   - Selecting traps with internal bypass whenever uplifts or long horizontal inlet runs to the traps cannot be eliminated.



∆ **Figure 31.** Standard traps are used when condensate is at the tip of flow, otherwise traps with internal bypass may be needed.

Careful consideration in the design of external heating methods and steam trap selection can return significant production benefits from improved product viscosity and transport reliability.

ACKNOWLEDGMENT

Special thanks to CSI Ametek for use of graphics pertaining to above-ground sulfur seal units and the 4 outer heat maintenance methods, as well as TLV's Andrew Mohr, Justin McFarland, Alec Newell, and Nick Skahill for creating the custom illustrations used herein.

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Additional Resources

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