KEEP YOUR TRAP SHUT OR GET
THE CONDENSATE OUT

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Introduction

Keep your trap shut or get the condensate out. Which way is it? Can you have it both ways? Which way is best? What is the purpose of a trap? Does it really matter what kind of trap you have in your dry kilns? What is a steam trap anyway? What is it supposed to do? Basically a steam trap is an automatic control valve designed to meet several purposes. The purpose of a steam trap is to accomplish the following tasks.

Automatically removes condensate from the heat exchange space.
*Why*: Energy content of steam is greater than that of condensate. The heat of vaporization, or latent heat, is released to the kilns as the steam condenses. Generally you get 900 BTU/lb. of steam when it condenses to water at the same temperature. To get the same amount of heat out of water you would have to cool 90 lbs or 10 gallons of water by 10F. That is why steam is so useful.

Automatically removes non-condensable gasses from the heat exchange space.
*Why*: Non-condensable gases, mainly air, are sucked into the piping system as well as CO₂ generated in the boiler. There is no usable energy in non-condensable gases. Air has excellent insulating capabilities. Most insulation works by trapping a layer of air which slows the heat transfer from one place to the other.

Automatically prevents passage of steam.
*Why*: Making steam costs money. Passing live steam is very costly. It is like passing unburned gasoline through the tailpipe of your car.

Able to withstand corrosion/erosion for long service life.
*Why*: Costs. Steam traps are not inexpensive devices. They are automatic control valves that perform a difficult task in a hostile environment. It is even more costly to have traps not function at all.

Able to withstand scale and crud that develop in steam systems.
*Why*: Dirt forms easily in batch system like a dry kiln where the system is frequently charged and cooled. This is the perfect environment for rust and corrosion.

A helpful system that I have found for evaluating choices is the “4 C’s”. They are
1. Consider the options.
2. Compare to other successful systems.
3. Commit to implementing the best, based on the realities of your particular situation.
Consider the Options

In steam heated dry kilns there are several major components, the coils for transferring heat to the circulated air, the control valve which controls the amount of steam put in the coils and the traps that regulate the discharge of the condensate. The control valves I call the "goes-into" and the traps the "goes-outa". There are several different kinds of traps to control the "goes-outa".

*Thermodynamic traps* operate on the energy differences between steam & condensate.

Simplest trap is the orifice trap. As condensate at saturated temperature passes through the first orifice in the trap there is an accompanying pressure drop. As the pressure drops, a percentage of the condensate flashes to steam. As little as 1% of the flash steam occupies the same volume as the 99% of the condensate. This high volume flash steam is used to "choke the flow" by filling the chamber, preventing the passage of live steam. The use of the energy of the flash steam closes the flow automatically. This type of trap operates over a small range of conditions and are not appropriate for dry kilns.

The most common thermodynamic trap is the disc trap. It has only one moving part and to operate, it uses Bernoulli's principle. As velocity increases over a surface there is a corresponding pressure decrease. The velocity of condensate is generally low but the velocity of flash steam being formed at the orifice is very fast, up to 100 mph. This flash steam reduces the pressure under the disc, while loading the space above the disc with an increased volume of flash steam at approximately upstream pressure. Because of the greater area on top of the disc as compared of the high pressure area under the disc, this results in a closing force that brings the disc down to the seat, closing the valve. The valve stays closed until the "loading" steam on top of the disc condenses and the pressure reduces, allowing the disc to then lift off of the seat and flow condensate until it flashes and re-seats the disc again. A disc trap is not a good gas passer. It can't differentiate between steam and air. To make it handle air, there are micro fine grooves machined into the seat to allow air to pass through the trap. One trap manufacturer uses this design as a liquid removal device from compressed air.

*Thermostatic traps* operate on the difference in the temperatures of steam and condensate. As condensate is formed and further removed from the steam/condensate interface, the condensate begins to cool as the surrounding material soaks up the heat in the condensate. The result is that the condensate is not at saturated temperature. These temperature differences are used to operate the valves on the different traps. There are several types but the most common are the bi-metallic and the filled pressure balanced elements.

Bi-metallic traps have dissimilar metal elements that expand and contract at different rates with temperature changes. When they cool they flex one way to open the trap valve. When they heat up with the presence of steam, they flex the other direction to close the trap valve. They generally are slow to respond to changes in the condensate load as the cooling can be substantially below the saturated steam temperatures. The traps should be installed sufficiently far away from the process and not have the piping insulated leading to the trap. This acts as a cooling leg for the backed up condensate. With cooler condensate the trap can operate faster.
Pressure balanced filled element traps use a small pressure vessel with flexible walls that are filled with a liquid that has a boiling point less than water. This is achieved by the addition of alcohol or ether or other liquid with a low vapor pressure compared to water. When the element is surrounded with cool condensate the filled liquid remains in a liquid state and the element remains at its retracted position. As steam heats the element past the vapor pressure of the liquid filling, it begins to boil. The small amount of vapor created inside the element changes the volume and the element increases in length, closing the main trap valve. The exposed element is subject to steam hammer and stress cracking. When the seal is broken the trap fails at the relaxed length of the bellows. Depending on construction, this may be either closed or open. In some traps the bellows is placed in a cage to protect it from all but most destructive forces.

*Mechanical traps* operate on the different densities of steam and condensate. A float of some design rises with the presence of liquid in the trap and this motion is used to open the main valve, discharging the condensate. As steam enters the trap, the float lowers, and the valve closes. The mechanical trap you are most familiar with is the inverted bucket trap. Its operation is as follows. When there is only condensate present the bucket sinks pulling the valve off of the seat. The condensate flows around the outside of the bucket and out. When steam enters the trap the bucket floats. This closes the valve preventing the loss of live steam. Air is vented through the orifice in the top of the bucket to pass the non-condensable gases. The total volume of air has to pass through that little hole with only a 1-2 " water column pressure differential. In a large volume heat exchanger like kiln coils this can be a long time getting up to temperature.

*Hybrid traps* of the different types are also used. The most common are the float and thermostatic traps. They use a closed float that keeps the discharge valve submerged. To pass the non-condensable gases that would build up in the body, a thermostatic vent must be added in the upper area of the float chamber. Less common are the thermostatic and thermodynamic combinations. Examples are the Bestobell bi-metallic trap and the Yarway 151. The trap has two ports of valve orifices in it. The first is the pilot orifice that is controlled buy a thermostatic element. When the pilot valve is open the condensate and non-condensable gases are passed up around the walls of the piston and down through the center orifice. If the flow is greater than the pilot can handle the hydraulic forces push the piston up off of the second or primary seat. This is how the trap has a dual capacity capability. As steam and flash condensate arrive at the trap, the flashing occurs in the control chamber above the piston and forces the piston down, closing the valve. In many ways this resembles a piloted solenoid valve that automatically senses the presence of condensate and opens the main valve and closes in the presence of steam.

Selecting the trap means knowing which trap types are appropriate for dry kiln applications. Historically the trap of choice is the inverted bucket trap. It is very dependable, able to handle dirt better than most other technologies, and handle wide load swings from just a trickle to maximum flow. It is easy to trouble shoot and repair, and is just about immune to the forces associated with water hammer. They have been the trap of choice forever. The brands installed are Clarks, Wright/Austin, Armstrong, and Sarco.

There are changes to make I.B.'s work better in dry kiln applications. These are to modify the vent size in the bucket by increasing it to approximately 1/2 the diameter
of the trap main valve orifice. A main valve orifice of 1/4" would need a 1/8" vent hole in the top of the bucket. This allows the gasses to pass quicker. In some applications, (low pressure kilns with extremely large diameter piping) the buckets use a bi-metallic strip to open a large air vent for faster startup performance.

Other selections that make sense and have performed well are the thermostatic/thermodynamic hybrid that can pass high volumes of gas, handle wide load swings, operate against high backpressure often found in undersized return systems, and exceeds capacity of bucket traps w/dual range capability. One of the most successful is the Yanway 151. They have been installed on several kilns and have performed successfully over time. One operator I spoke with had a carbonate scale problem in his steam system. He found that if the element got dirty or scaled he would remove it and soak it in vinegar to clean it. Then he would put it back in and the trap would take off like new. He stated that this trap would bring the kilns up to temperature 2 hours faster than the kilns that had IB traps. Because of this he converted all of the IB kilns to this style and figured that he had a very short return on investment due to reduced kiln dwell time.

Compare to Other Successful Systems

An air heater (steam-to-air heat exchanger) is the closest comparable system to a dry kiln. The following system design components should be in a single coil system

- Air vents for quick startup located high in the steam space.
- Gravity drain to the traps at least 3 ft. below bottom of the coils.
- Vacuum breakers for modulating steam control situations to allow the condensate to drain to the trap.
- Check valves installed after the traps to prevent backflow from the return system.
- Not allowing group trapping which would allow "short circuiting " of the steam. Some coils would be hot while others would flood out and be cold.

The following operating conditions are peculiar to dry kilns and need to be involved in the selection process.

- Dry kilns are a batch process w/ frequent cold starts, while air heaters are a continuous process. Dry kilns have heavy amounts of air to purge on startup and they warm-up from a dead cold start.
- Dry kilns have widely variable condensate/heat loads. The flow rate of steam at the start of the cycle can be magnitudes greater than the flow rates at the end of the cycle or during conditioning. Most air heaters also have widely variable loads.
- Kiln coil construction is primarily of steel fin pipe. In the moist hot environment of the kilns rust, scale, and crud formation is predictable. Air heaters are usually constructed of copper or stainless steel tube w/ aluminum fins and are less prone to corrosion.
Commit to Implementing the Best

There are certain realities that wont allow for the ideal application of the perfect system in dry kilns. The best approach is to compromise as dictated by the realities of the kilns design and access. The best approach is to be flexible yet not violate the laws of physics.

What are the realities of your particular situation?

Air vent at the top of the coil. Is this practical in a dry kiln? No. There are too many coils and the access for checking them is difficult. The results if they fail is the same as leaky coils. The addition of excess moisture causing problems in drying. It is easier to have a longer startup time than it is to deal with a failed open air vent putting thousands of pounds of steam on the lumber at a critical part of the drying schedule.

Gravity drain to and away from the traps. Water does not flow up hill. Trap should be mounted below the coils. This is usually not a problem, but I have seen traps mounted above bottom header of center coils in a double track. This makes it hard to get the condensate out.

Dry kilns are a batch process with wide load swings from cold startup to conditioning at the end of the schedule. Chose the trap that will meet the needs of the system by venting the non-condensables quickly for improved startup and operate on light as well as heavy condensate loads.

Multiple coils should not be group trapped. True, but the reality is, that the coils are generally overhead and they are all operated off of the same header supply line and the pressures are roughly the same from coil to coil. There is more than the 3 ft. drop from the bottom of the coils to the traps. Gravity plays a big factor here since water/condensate flows downhill. Slope the return system toward trap. Generally 1" to 2"for every 10 ft.of pipe will flow the condensate to the trap fast enough to prevent flooding of the most remote coils.

Size return header in kilns large enough to handle storage of condensate on startup heavy loads until the trap can respond and clear the condensate. Use piping as large as practical and reduce it at the trap. If you have a 3/4" trap, try to bring the return piping as close to the trap as large as possible. A return header of 3" would be great.

Installation requirements must be followed. Even the best trap won't work correctly if it is installed incorrectly or the common piping practices are not followed. To optimize the performance of the trap follow the common guidelines provided with the trap from the manufacturer. He knows what is necessary for the traps to function correctly.

Strainers should be installed to protect the trap from the scale and crud formed in the line. Proper maintenance would require an annual inspection/cleaning of the strainer.

Isolation valves, test valves, and bypass valves should be installed to allow troubleshooting and repair work to be done without having to change piping.

Install check valves to prevent condensate and/or flash steam from flowing back into the coils. One location had 5 psi backpressure on the return system and no
check valves or isolation valves at the traps. The coils were "hot" all of the time. They couldn't isolate the coil from flash steam to work on leaking coils.

Return system considerations affect the traps and how they operate. The elevation and size of the return line need to take into consideration the volume of flash steam formed. I have seen return systems where extra tracks have been added on and the return line was configured like a dogs hind leg. It was mounted above the traps, had several jogs up and down, and didn't allow for the passage of flash steam. The line size was only 1 1/2" and the pipe jumped and banged from steam hammer. The line should have been at least 3". A properly designed system would have a gravity drain system that would be adequately sized for the flash steam and condensate.

Condensate return pump location is critical for the operation of the kilns. The best place for the pump is in the pit at the lowest point in the return system. Make sure the vent discharges to a safe area. The condensate should be pushed back to the boiler or deaerator tank. There are some realities that may require the pump be above grade. They should be avoided if at all possible because of potential flooding in the return header. It is really hard on systems to suck the condensate out of the return header or use discharge pressure from the traps to lift the condensate out of the trench.

Count on Improved Performance

You can count on improved kiln performance if -

- the traps are the correct choice for the application,
- the condensate is gravity drained to the traps,
- the traps are in the correct location & orientation for the application,
- the return system is designed to handle the flash steam, and gravity drained to and away from the traps to a condensate collection/pumping system,
- you are not using system pressure to lift condensate to the pump,

Conclusions

Traps are only a component of the dry kiln system. They are an often overlooked component that take the brunt of the blame for dry kiln lack of performance. Properly installed traps in a properly designed system will perform well, answering all of the purposes required. In conclusion Consider the options, Compare to other successful systems, Commit to implementing the best possible trap and return system that will fit your particular kiln, and Count on improved performance with your kilns.

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