

## **BACKSTREAMING TRAPS FOR OIL-SEALED PUMPS**

In many of today's stringent processes, it's becoming more and more recognized that system and process cleanliness is more critical than in previous years. When the analysis of a vacuum process indicates that the possibility of oil backstreaming from an oil-sealed mechanical pump is a potential process killer, the obvious question that arises is what to do about it. Is it necessary to replace the pump with an oil-free pump, or will a backstreaming trap solve the real or potential problem of oil contamination of the process?

The answer is a resounding: "that depends." It depends upon a lot of factors, but mainly upon a rational assessment of the potential cost of a small amount of oil contamination on either the system or process. If the cost is going to be high enough, the decision is simple. Replace the oil-sealed pump with an oil-free pump. If the economics are such that it's possible to consider adding a backstreaming trap, a fuller understanding of the commercially available traps can be used to make a "go/no go" decision.

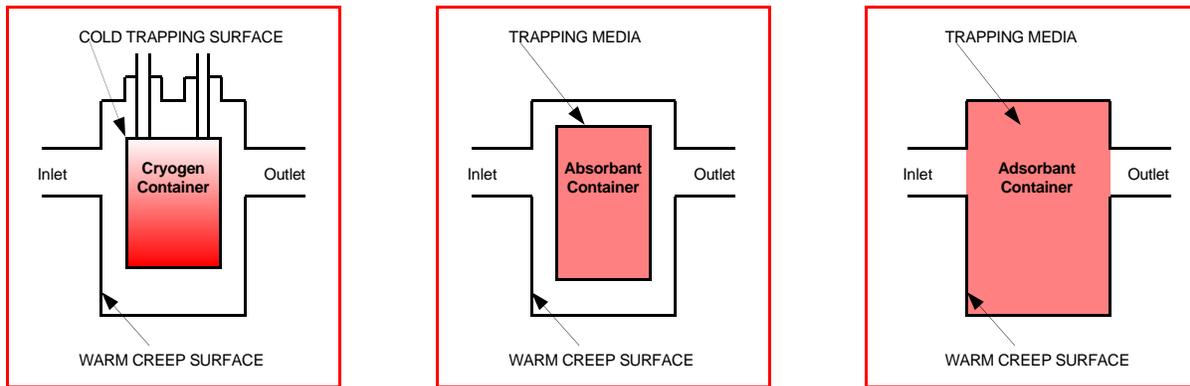
Backstreaming or foreline traps can be divided into three main groups:

1. Condensation,
2. Absorbent, and
3. Adsorbent.

All three types are designed with a single basic purpose in mind: to stop oil vapor emanating from an oil-sealed mechanical pump from entering the process chamber. Ideally, a trap should take any and all oil molecules that enter it and stop them, hold them, and hold them forever in such a manner that they cannot and will not enter the vacuum chamber. All three types do this to some extent and with varying degrees of success, but each type uses a different trapping mechanism. The figure shows that all three types have a warm surface creep path that can allow liquid oil to creep through the trap body into the pumping line and then into the chamber. Each type, then, needs to be considered in turn.

### **Condensation Traps**

Condensation traps are often called cold traps since they all provide some sort of cold surface that will condense the oil vapor to a liquid or solid on the cold surface. Designs can vary widely from a simple U-tube pumping



line stuck into a container of cold fluid to the more common contemporary bucket design shown in the figure. Coolant media includes water/ice, CO<sub>2</sub> (dry-ice/slurry), or liquid nitrogen (LN<sub>2</sub>) with LN<sub>2</sub> being the more common. Oil vapor that enters the trap will impact upon the cold surface of the bucket, and in the case of LN<sub>2</sub>, will condense as solid on the surface. The condensed oil vapor will remain on the surface as long as that surface remains at a constant cold temperature. As the LN<sub>2</sub> boils merrily away inside the bucket, the liquid level will drop; when the level drops, the upper part of the trapping surface on the bucket will warm up. When this happens, some of the condensed oil can return to the vapor state, and some of it will leave the trap and enter the chamber. This problem is usually avoided by fitting the trap with a liquid level sensor and automatic filling device with the caveat that an adequate supply of LN<sub>2</sub> is kept available. A trap that runs “dry” and warms up can release all of the trapped oil that has collected into the chamber with catastrophic results.

An additional consideration is the fact that any condensable gas that enters the trap from the chamber will be co-condensed along with the oil. Water vapor, freezing out as solid ice on the cold surface, is the most common problem. In systems that are cycled frequently to atmosphere, the water vapor load can be considerable. It's not uncommon to see a spot of condensation haze on the outside body of a trap where the internal ice buildup is forming a thermal short to the outside due to the bolus of ice that has formed. At this point, the trap is loaded and regeneration is required by warming it up to room temperature. If the trap is warmed *in situ* while still under vacuum, the trapped material will partially enter the chamber. This can be avoided by providing a N<sub>2</sub> gas flush from upstream while still pumping; better yet, remove the trap from the pumping line entirely. Many traps are designed such that the bucket can be quickly and easily removed from the trap body while still cold, so that the bucket can be externally warmed up and cleaned without releasing its contaminants into the system.

### Absorbent Traps

Absorbent traps depend upon the property of a material to absorb oil vapor molecules and to retain them within the material's body. A common

design of absorbent trap is shown in the figure. Molecular sieve or alumina balls are common absorbant materials with molecular sieve being the most common.

A common commercial design is composed of a stainless steel mesh cage contains an array of 13-X molecular sieve pellets with a pore size to match the diameter of the oil molecules so that the oil is trapped and held within the pores. Fresh, pre-baked molecular sieve will trap and hold large quantities of oil efficiently, but the sieve will also trap water molecules which enter the trap during pumpdown of the chamber. Since water molecules are physically smaller than oil molecules, the water can be selectively absorbed and cause displacement of the oil which can then easily enter the chamber. In a system that is cycled between vacuum and atmospheric pressure regularly, the amount of water pumped can saturate the trap long before it is saturated with oil.

Most commercial traps are fitted with an internal heater to regenerate the trap by heating while the trap is being pumped upon. As is the case with condensation traps, oil vapor being cooked out of the trap can easily migrate upstream, so the trap should be flushed with N<sub>2</sub> from upstream. Better yet, replace the molecular sieve each time it becomes saturated, since the cost is low and the penalties for a contaminated chamber are high. Oil saturated molecular sieve will take on a slightly yellowish appearance. An additional problem is that the molecular sieve material will liberate dust during thermal expansion/contraction cycles. The fine dust can enter the pump where it forms an abrasive slurry in the pump oil and causes wear within the pump. If the trap is at atmospheric pressure and is then vented into a chamber that's under vacuum, molecular sieve dust can be blown into the chamber.

### **Adsorbent Traps**

Adsorbent traps rely on the property of oleophilic (oil loving) surfaces to trap and hold oil molecules. Commonly, fine copper turnings are held in a trap body as shown in the figure. When the large total surface area of copper is finally covered with oil molecules, the traps can sometimes be solvent cleaned. They have the advantage over condensation or absorbent traps in that they need neither cooling media nor bakeout. As with absorbent traps, it's often a sounder practice to replace the trapping media instead of attempting to regenerate it by solvent cleaning.

### **Effects on Pumping Speed**

None of the traps provide any loss of pumping speed due to gas flow constriction when the pumpdown is in the viscous flow regime, but flow constriction will result in large pumping speed losses when the pressure drops into the molecular flow regime. Variations in design will provide differing degrees of constriction caused by the physical design of a

particular commercial trap, but cases where the entire outer body is filled with trapping media can cause severe losses in pumping speed. Since a mechanical pump's speed begins to drop as molecular flow is reached, the effects upon total pumpdown time and ultimate attainable pressure can be greatly affected by the trap's constriction.

### **Conclusion**

Backstreaming traps can be effective if the right trap is chosen to match the application and proper care is taken in the operation and regeneration of the trap. Knowledge of the trap's trapping properties along with its drawbacks can often allow their application without the need to use oil-free pumps to avoid oil contamination of a system or process. If, however, the application is so sensitive that the process will not allow a mistake in trap operation, and oil-free pump is probably the most economic solution.