MIDWEST TUNGSTEN SERVICE

# Tips

## Diffusion Pumps

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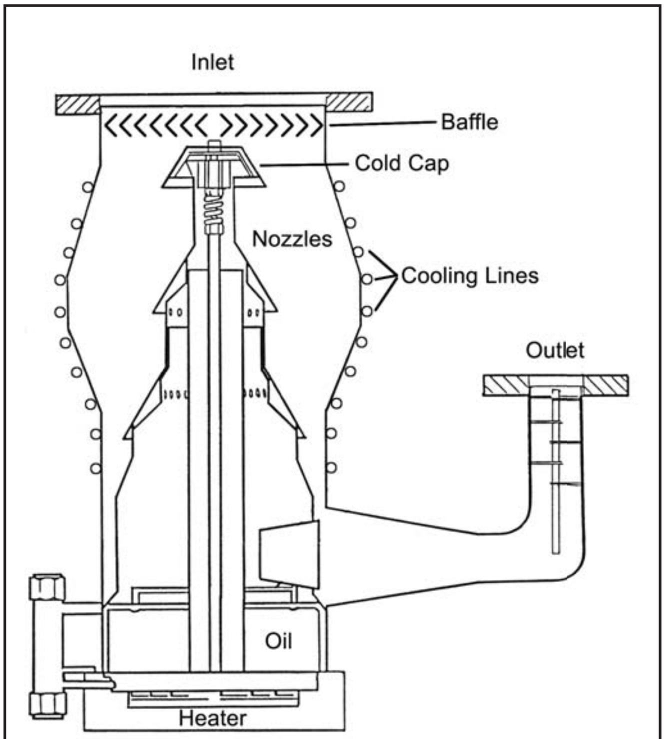
The diffusion pump is sometimes confusing to people because it has no moving parts. It operates quite differently than a gas displacement pump, such as a mechanical pump. A mechanical pump scoops up air and pushes it out of the chamber by mechanical means such as pistons, fins, or lobes. The diffusion pump is known as a fluid entrainment pump and works in a completely different manner. The diffusion pump uses the vapor of a boiling fluid to capture air molecules. The fluid is then moved to another location and cooled. The cooling forces the air molecules to be released. The combination of gravity and the downward direction of the vapors move the air molecules toward the bottom of the pump. Please note that in these TIPS, we will use the terms "oil" and "fluid" interchangably.

Look at the cutaway diagram below. At the bottom you can see the heaters that sit just below the oil. When the oil becomes hot enough to vaporize, the oil vapors rise up the center of the pump and exit the nozzles at a downward angle. These nozzles are in a ring and form a curtain or "skirt" of vapor that extends from the nozzles to the pump wall. Any air molecules that wander into the inlet meet the vapors are captured. When the oil vapor hits the water-cooled walls of the pump, the oil cools as it runs down the sides of the pump. By the time the oil reaches the reservior once again, it has given off its trapped gas and is ready to begin the cycle anew. Any gas molecule that tries to wander upward is caught by the vapor "skirt" above it and forced downward again. By continually forcing the air molecules downward, we create an area at the bottom of the pump that is higher in pressure than the top of the pump. In other words, when the pump is in operation the pressure is higher below each oil skirt than it is above that skirt. At the bottom of the pump, the pressure is high enough for the gas to be pumped out by a standard mechanical pump.




Although oil vapor is directed downward, it is possible for some of it to wander toward the top of the pump. To avoid having this oil migrate into the chamber, a cold cap can be fitted at the top of the nozzle assembly to condense vapor in that area. A concentric circular chevron baffle at the mouth of the pump allows air molecules to wander in, but traps the heavier oil vapors as they try to escape.

Today we typically use a silicone oil as the diffusion pump fluid because of its high vapor point and stability. While expensive, silicone oil will perform well over long periods of time with little to no degradation. There are several formulas available. The oil is also relatively safe from the standpoint of toxicity and flammability. The only caution when using silicone oil is that it must not be exposed to air when it is heated or the oil will gel.

Silicone oil was not always the fluid of choice, however. In the early days, diffusion pumps used mercury as the operating fluid. As you might imagine, such a thing would be frowned upon today due to the toxicity of mercury vapors. Today, the use of mercury in diffusion pumps is essentially zero. To replace mercury, hydrocarbon oils were used as the working fluid. These had two major drawbacks. They were not always made from a single component or the oil would break down into lighter fractions during use. The lighter fractions would want to exit via the top nozzle where the liklihood was greater that they might escape the pump. A modification to the pump created separate channels to each level of nozzles which resulted in the lighter fractions always exiting from the lowest nozzle set. This design was known as the fractionating diffusion pump. With hydrocarbon fluids, the danger of explosion also existed, particularly in an environment where an ignition source such as hot tungsten filaments were used and the chamber was accidentally vented to atmosphere at the wrong time. Today, hydrocarbons are seldom used.

Two other types of fluid bear mention. They are polyphenyl ether and perfluoro polyether. Polyphenyl ether has a very low vapor point and is resistant to electron bombardment, making it ideal for certain applications. It is more costly than silicone oil, but less expensive than perfluoro polyether. Perfluoro polyether is a hydrocarbon that has had all of its hydrogen atoms replaced with fluorine atoms. This gives it a much higher molecular weight than the original hydrocarbom. It also is inert to oxygen, halogens, and acids. When it breaks down, it decomposes to a gas, so the main fluid is not compromised. However, the decomposition gas is toxic, so proper precautions must be taken.

In general, the operation of a diffusion pump requires little attention. There are some things to consider. First, use a high quality oil. Doing so will maximize the performance of your system and will minimize the need for maintenance. We offer several excellent products. Second, match the oil to the vacuum level you will be reaching. There is no benefit to getting an oil rated for a lower pressure than you require and the cost will increase significantly. For most decorative metallizers, a 702 type oil is sufficient. For optical coaters, a 704 is a good choice. Very high quality, low vacuum applications such as semiconductor or laboratory work might require a 705 oil. Third, keep track of the waterflow through the cooling lines. Check the inlet and outlet water temperature as well as the flow rate. Lines can become clogged or corroded over time. Finally, check periodically to assure that all the electric heaters at the bottom of the pump are reaching the proper temperature.

Call us if you need more information on diffusion pumps or fluids or to purchase silicone diffusion pump oil.

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**MIDWEST TUNGSTEN SERVICE, INC.**

**800-626-0226** **fax: 630-325-3571**

**630-325-1001** **www.tungsten.com**

**7101 S. Adams St. #6, Willowbrook, IL 60527**