PREFERRED RELIABILITY PRACTICES

Oil-Free Vacuum Pumps in the LOX/LH2 Transfer System

Practice:

Oil-free pumping is the latest state of art in vacuum pump technology. At Kennedy Space Center, this technology is used to maintain approximate 650 sections of the LOX/LH2 vacuum jacketed transfer lines, at a pressure between 0-1000 Torr. This insures the capability to deliver cryogenic propellants on time and at a pre-defined temperature and pressure to the Shuttle vehicle.

The use of oil-free pumps eliminates the risk of contaminating the LOX/LH2 transfer system (vacuum jacketed lines). It enhances the reliability of the vacuum pumping system.

Benefits:

The major benefits for the use of oil-free vacuum pumps in the LOX/LH2 transfer system is that these pumps eliminate the danger of oil or oil molecule contamination and can be safely operated unmanned. This results in both cost saving and a reliability improvement in the pumping process.

Programs Which Certify Use:

The Shuttle Main Propulsion System (LOX/LH2) Ground Support Equipment.

Center to Contact for More Information:

Kennedy Space Center (KSC)

Implementation Method:

The implementation of oil-free vacuum pumps has resulted in eliminating the danger of oil contaminants, increased reliability and has resulted in a reduced support costs.

Technical Rationale:

Oil-free pumps offer many advantages over the oil sealed pumps. The oil-free pumps are light-weight, truly portable, highly versatile, and the absence of fluids means the pump can be operated in any orientation - sideways or upside down.

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There are a number of considerations that affect the decision of whether to use an oil-free or an oil-sealed pump. First, and most important, is the determination of whether the application is sensitive to oil contamination. If it is determined that the application is oil sensitive, the next consideration is whether or not a foreline trap is sufficient to prevent the backstreaming oil from entering the process chamber in quantities that will cause contamination problems, if not then consideration should be given to use of oil-free pump.

Oil-Sealed Type Pumps:

The foreline traps (oil-sealed mechanical pump) is one type of pumping system that the LOX/LH2 system engineers considered for use in the LOX/LH2 transfer system vacuum jacketed lines. The following paragraphs discuss some of the characteristics of the foreline trap pump and figures 1, 2, and 3 show the creeping surface that can cause oil contamination.

Foreline or roughing traps have been used for a number of years in an attempt to stop or reduce the oil backstreaming from oil-sealed mechanical pumps. Although they have had great commercial success in terms of number of units used, they have a number of problems that need be weighed carefully if they are to be considered as a method of stopping the pump oil from entering the chamber.

Three types of foreline traps are commercially available:

1. Condensation traps, Cryogenic

2. Absorption traps, absorbent trapping medium

3. Absorption traps, active surface trapping medium

All have a potential problem that needs constant consideration. They have room temperature walls which will allow liquid oil to coat the inner surfaces and once the oil has passed through into the system side of the trap, it becomes a vapor source that can no longer be prevented from entering the system. The amount of time required for the surface oil to work its way through the trap will vary with the application. The best way of determining when oil is passing through is to occasionally remove the trap from the pumping line and placing a drop of water inside the tubulation on the system side to see whether it beads or spreads. Once oil is detected on the system side, it's time to solvent clean the trap or to bake out the entire trap, walls and all.

The time to fully penetrate through the trap will be extended if the mechanical pump is shut off and the trap (fore or roughing line) is air released when the pump is not being used.

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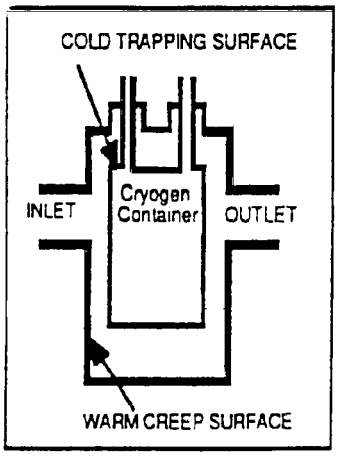

Figure 1. Condensation Trap

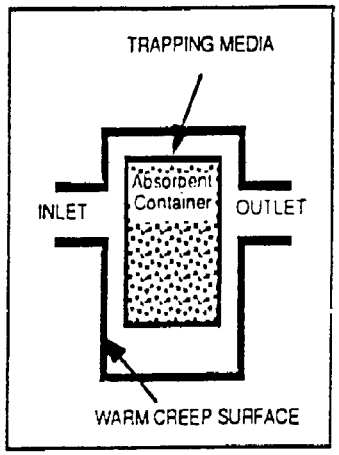

Figure 2. Absorbent Trap

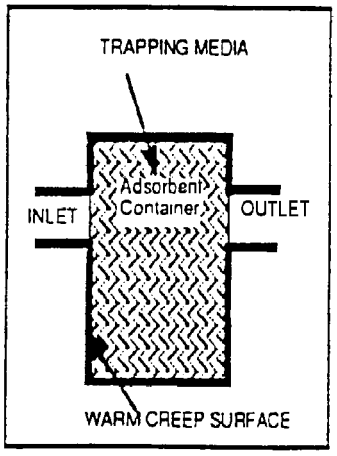

Figure 3. Adsorbent Trap

The LOX/LH2 System Engineers selected the oil-free type pump shown in figure 4, because this pump incorporates new vibration isolation techniques, new 3-stage pumping technology, simplified construction for easy maintenance and increased reliability. This type pump will probably have higher initial costs than an oil-sealed mechanical pump. Figure 4, shows a picture and Block Diagram of an oil-free pump.

Oil-Free Pumps

The following paragraphs briefly discuss some of the characteristics and advantages of an oil-free pump.

Unique design: The key to this type pump performance is a unique three-stage design, which incorporates a molecular drag module backed by two customized diaphragm modules to provide a constant, dynamic flow of gas. Each module functions selectively in series, automatically carrying the pumping burden within its own pressure/flow envelope. As each successive stage acquires the primary pumping burden, the previous stage continues pumping in a support capacity.

Entirely oil-free: Since no module uses pump fluids, roughing or backing with this type pump introduces no oil to backstream into a system. They require no traps, oil filtration accessories, or special oils as all mechanical pumps do. Since traps are unnecessary, oil-free pumps without a trap can deliver their full pumping speed. Mechanical pumps with traps inevitably experience speed losses.

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Clean, efficient backing: These type pumps provide highly efficient backing for turbo or diffusion pumps, improving their performance by providing a lower foreline pressure. In most cases, an oil-free pump will help achieve vacuum up to an order of magnitude higher than mechanical type pump.

Versatile: Oil-free pumps will pump any gas, including hydrogen and helium, and any condensables, e.g., solvents or water vapor. They never load up with "memory" gases.

Easy to use and repair: The oil-free pump requires no cryogenic or bakeout procedures. Because the molecular drag and diaphragm modules are separate, each can be easily repaired in the field or, if necessary, completely replaced.

Impact of Nonpractice:

- All oil-sealed mechanical pumps backstream oil to some extent. As the oil becomes hot from the operation of the pump and the pressure falls into the molecular flow regime hydrocarbon vapors will rise from the pump.

- Surface creep will also occur right out of the pump itself with the oil reservoir within the pump acting as the source. In many cases, this constant surface flow of oil from the mechanical pumps are the greatest single source of hydrocarbons that can enter the vacuum chamber.

- Oil-sealed pumps can go into "hydraulic lockup" if a power outage would occur and the pumps have to be constantly manned.

- The use of an oil operated type vacuum pump has disadvantages from both a cost and reliability stand point. A single vacuum jacketed section recently contaminated cost $4,031 when returned to the vendor for oil removal. This was the vendor's charge only, and did not include shipping, removal and replace or testing cost.

References:

KSC Problem Report Number S70-0817-00-001-0553, dated 5/9/89

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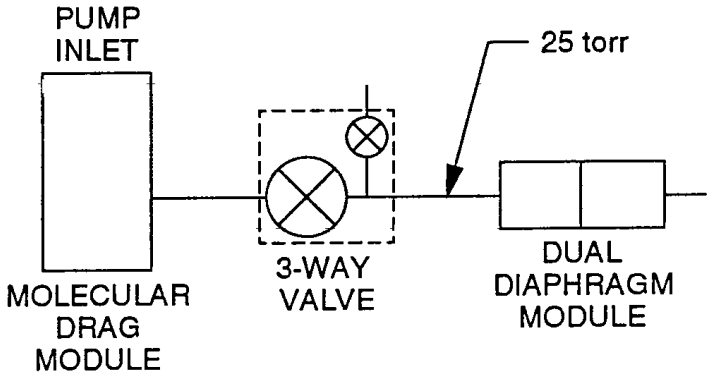

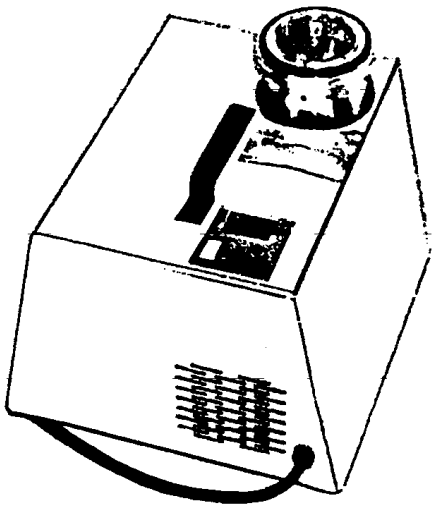

FIGURE 4. PICTURE AND BLOCK DIAGRAM OF AN OIL-FREE PUMP