

**PUMP RELIABILITY & MAINTENANCE '98**  
**RETROFIT OF OIL MIST LUBRICATION SYSTEMS**

Fred Paben  
Manager of Technical Services  
Lubrication Systems Company  
Houston, Texas 77043  
(713) 464-6266

## **ABSTRACT**

This paper reviews the operating principles and advances in reliability that has been achieved in oil mist applications for pumps and their drivers. The recent advances in system design and methods for applying Pure Oil Mist (Dry Sump) and Purge Oil Mist (Wet Sump) to API and ANSI pumps. Users report 90% reduction in bearing failures after converting to Pure Oil Mist.

## **GENERAL DESCRIPTION**

An oil mist system is a centralized system that is an efficient and cost effective method of providing lubrication to several different classes of rotating equipment. The oil mist system uses the energy of compressed gas, usually instrument air, to atomize lubricating oil into tiny particles of 1 to 3 microns in size. These particles are then conveyed by the air continuously, throughout a low-pressure piping distribution system to multiple points of lubrication. Turbulence is introduced near the point of lubrication where the airborne oil particles coalesce to produce larger particles that will wet the interacting surfaces of a bearing and other machined surfaces with a light coating of oil.

This small amount of oil is sufficient to lubricate operating anti-friction bearings as well as provide a needed film of oil on machined internal components for corrosion protection of stand by the stored equipment. This method of lubrication for process equipment has proven to be a cost-effective means of lubrication that increases bearing life by 6 times over the traditional oil sump method of lubrication. The reduction of bearing failures attributed to oil mist lubrication sump method of lubrication. The reduction of bearing failures attributed to oil mist lubrication allows for time to be spent, by maintenance personnel, on more cost effective maintenance planning and practices.

The oil mist lubrication system consists of the oil mist generator (OMG), the lubricant bulk oil supply/tank (BST), the air supply piping from a valved plant source to the OMG and BST, the bulk oil supply piping from the BST to the OMG, the oil mist distribution header system with drop piping to each application, an oil mist application fitting sized to the specific application and related system components necessary to meet the specific requirements of the equipment to be lubricated and the area where the equipment is located.

Typical oil mist applications include API & ANSI pumps, electric motors, gearboxes, turbines and pillow block bearings.

(Figure 1 shows a typical layout of an oil mist system for reference purposes. This layout sketch includes the OMG, BST and the oil mist piping/distribution system.)

## **WHY OIL MIST LUBRICATION**

Lubrication is simplified by centralized systems that are more easily managed and are less maintenance intensive than typical methods of lubrication. Most bearing failures are caused by lubrication related problems, hence improved lubrication techniques have a dramatic effect on bearing life. Maintenance of a correct oil level in each bearing housing is crucial in preventing bearing failures with conventional lubrication and is manpower intensive.

Oil mist lubrication particles, 1 to 3 microns in size, are entrained in air and conveyed throughout a piping system. These tiny particles are not large enough to carry particulates that would be detrimental to bearing surfaces, only fresh clean oil is applied to the equipment being lubricated.

The small amount of oil consumed in the continuous air flow typically reduces oil consumption up to 40% when pure oil mist is used. Oil sump change intervals are extended to 2 and 3 years on equipment requiring oil sumps. Optional oil recovery systems reduce oil consumption up to 90%.

A pure oil mist system eliminates oil oxidation and the recirculation of wear debris over bearings. Oil deterioration due to oxidation is time and temperature dependent when sump lubrication is utilized, wear debris also accumulates in the oil sump and is recirculated over the bearing surfaces which accelerates bearing deterioration. This deterioration causes the bearing temperature to increase and promotes oil oxidation. Removing the oil sump, with pure oil mist, eliminates oxidation of the oil and the carrier for wear debris. The requirement for periodic oil changes is also eliminated.

Bearings run approximately 35°F cooler when lubricated by pure oil mist. Elimination of the oil sump allows the bearings to operate cooler; bearing fatigue life is shortened approximately 11% for every 10° F increase in bearing temperature.

Bearing cooling water can be deleted from virtually all centrifugal pumps, regardless of the pump product temperature. Experience shows that uncooled bearings will often operate more reliably than bearings cooled by water.

Pure oil mist deposits a wear resistant carbonaceous, dry film, layer on the wearing surface in rolling element bearings. Research conducted by Texas A&M University has found that this deposit is not formed with the conventional sump lubrication and that bearing life is extended up to 6 times when pure oil mist lubrication is used.

Oil mist systems that are properly maintained have demonstrated incredibly high service factors and reliability. Contrary to a maintenance person's intuition, loss of oil mist to a pump or motor is not likely to cause an immediate and catastrophic failure. Tests by various oil mist users have proven that bearings operating within their load and temperature limits can continue to operate without problems for periods in excess of eight hours.

## **TYPES OF OIL MIST SYSTEMS**

There are two types of oil mist systems; One-way and Closed-loop. Both systems have the same basic oil mist system components i.e. OMG, BST and piping/distribution system. The difference is in the piping/distribution systems. The one-way system has a single pipe header and drop pipe with no provision for the return/recovery of coalesced oil from the equipment being lubricated. The closed-loop system has a dual header system with the second header acting as the return header for coalesced oil and stray mist.

**ONE-WAY SYSTEMS:** The one-way system is the basic oil mist system that has been installed in the Refining and Petrochemical Industries since the 1950's. All oil after being atomized and sent into the distribution system goes to the equipment being lubricated and is then lost, hence the term one-way. Past experiences have the coalesced oil from the bearing housings going directly to oily water sewers or a small spent oil collection device. When the oil is collected, it is normally performed manually and the oil is then disposed of.

Oil consumption of the one-way system is still minimal when compared to the traditional sump lubrication that is common to many facilities. Oil consumption for a large scale oil mist system operating at maximum capacity, 30 SCFM, is approximately 2 gallons of oil per 24 hours of operation. To achieve maximum capacity of 30 SCFM, approximately 60 to 70 pumps and drivers must be lubricated by the system.

**CLOSED-LOOP SYSTEMS:** The closed-loop system is new technology that has been developed in the past 5 to 6 years. The closed-loop system assists process facilities in meeting their goals of a clean environment and zero (0) emissions. Virtually all oil that is atomized into oil mist and conveyed into the piping header system is collected/recovered and reused through the system. This technology is used extensively in the fabrics and fibers industry where no oil or oil mist is tolerated on the finished product. As environmental and safety regulations are tightened the closed-loop system allows the maintenance department to maintain maximum lubrication reliability from oil mist with minimal manpower involvement.

This system has the standard oil mist related equipment with a few special components that are unique to the closed-loop system. The most important items in the closed-loop design are the oil collection containers with hand pumps, the demisting vessel and the second or return header pipe. These three items play important roles in the operation of the closed-loop oil mist system.

General operation of the closed-loop has the atomized oil being conveyed throughout the header system and down to the equipment being lubricated. At that point it vents/drains into the oil collection containers, located below the equipment, where it is routed back into the return header system and eventually back to the demisting vessel which is the BST equipped with a demisting filter.

The coalesced oil collected in the collection containers is pumped, manual operation, back into the return header and the stray mist is drafted back, via tubing, into the return header. The return header allows the coalesced oil to gravity drain back into the BST and the stray mist is drafted into the demisting filter where it is coalesced and return into the bulk oil supply. Approximately 95% of the oil and stray mist is returned to the bulk oil supply for reuse in the oil mist system, only make up oil must be added to the bulk supply as required.

## **APPLICATION OF OIL MIST**

There are two methods of lubrication with oil mist, pure and purge. Both methods may be used within a common system; the type of equipment being lubricated determines which method should be used. Reliability of oil mist units, systems and installation practices have improved considerably since the 1950's and 1960's when oil mist was a new concept, the highly reliable modern oil mist systems has made pure oil mist the preferred method for lubricating rotating equipment.

## **PURE OIL MIST**

Pure oil mist is often referred to as dry sump oil mist, which indicates that no oil level is maintained in the equipment being serviced. The bearings are lubricated directly and continuously by a supply of fresh, clean oil condensation. Lubrication occurs from coalescence of oil mist, caused by turbulence, created by the mist application fittings and bearing rotation as the oil mist passes through the rolling elements. The mist application fittings (reclassifiers) are sized to the individual bearings or the equipment being lubricated, should more than one rolling element be involved, to insure the proper amount of lubricant is applied. While pure oil mist is the primary means of lubrication for operating equipment it also acts to preserve the stand-by equipment that is alongside the operating equipment.

The equipment to receive pure oil mist is typically pumps, motors, pillow block bearings or other types of equipment where rolling element bearings are used. Pure oil mist is preferred by oil mist users and is the recommended method used in grass root projects where oil mist is specified and in retrofit systems on existing equipment. Pure mist is the most effective means of oil mist lubrication in both reliability of rotating equipment and cost economics.

## **PURGE OIL MIST**

Purge oil mist is often referred to as wet sump oil mist, which indicates that an oil level is maintained in the equipment being serviced. The oil mist is applied on top of the oil sump which creates a slight positive pressure that prevents thermal cycling of the cavity and eliminates the intrusion of airborne contaminants. Purge oil mist is not the primary means of lubrication for operating equipment but it is extremely effective in preventing water build up and corrosion in stand-by, idled and stored equipment.

The equipment outfitted for purge oil mist is typically gearboxes, turbines with sleeve bearings, motors with sleeve bearings and oil reservoirs of lube oil systems. The continuous film of oil that is applied to internal machined surfaces prevents corrosion from forming and causing premature equipment failure. Purge oil mist on cooling tower fan gearboxes is very effective in preventing water contamination and extending the oil change interval. Documented experience with this application has shown a 75% reduction of gear failures on cooling towers after purge oil mist was applied.

## **TYPES OF PUMP APPLICATIONS**

When evaluating the method of applying oil mist to pumps several things need to be considered. When the bearing housing has rolling element bearings (ball or roller) pure oil mist is the preferred method. When the bearing housing has plain bearings (sleeve type) purge mist will be applied, as this application requires a sump of oil for lubrication. Purge misting may be required on pumps with anti-friction bearings if they are operating at 3600 RPM with over a 200 HP driver and are subject to either cavitating or recirculating which will cause abnormal thrust bearing load.

### **ORIGINAL APPLICATION**

Retrofitting pure oil mist to overhung pumps built to ANSI and API 610 1 thru 6<sup>th</sup> edition can be accomplished by draining the oil from the sump and injecting oil mist into the fill connection. The single point connection allows the oil mist to flow into the bearing housing and through the radial and thrust bearings with the carrier air venting along the shaft, as described in the section below titled Venting. By drilling a 1/8" hole in the drain plug the coalesced oil will drain from the bearing housing as well as maintain a slight back pressure in the bearing housing to insure a flow of oil mist through the bearings. Recent installations have incorporated a one-ounce oil sight bottle in the drain opening which overflows into a collection container. No other modifications are required. (see figure 2)

### **HYBRID APPLICATION**

Overhung pumps that are candidates for being retrofitted the original way but are operating at 3600 RPM with over a 200 HP driver will need to have a second oil mist injection point added. To increase the lubricant to the thrust bearings on these applications a second mist inlet was established in the end cap out board of the thrust bearings. A second reclassifier sized for the double row bearing is installed to supply oil mist directly to this lube point. The openings around the thrust bearings are plugged to insure that the oil mist flows through the rolling elements. This is Goulds recommended way of applying pure oil mist to the model 3700 pump. (see figure 3)

### **API 610 APPLICATION**

Overhung pumps that are manufactured per the API 610 7<sup>th</sup> and 8<sup>th</sup> edition specifications have three 1/4" NPT taped openings on top of the bearing housing and a drain opening on the center bottom. When these pumps are ordered for pure oil mist lubrication the oil slingers and drain back ports under the

bearings are eliminated and the oil mist is injected in the two openings between the end caps and the bearings and the top center opening is plugged. This will direct the flow of oil mist through the bearings and out the low point drain. Two reclassifiers will supply mist to the two mist inlets. However, when these pumps are not ordered for pure oil mist, they will be equipped with constant level oilers. The constant level oiler will be removed and the opening plugged, then the pump will be connected to the oil mist system as described above. (see figure 4)

Between bearing pumps that are API 610 7<sup>th</sup> or 8<sup>th</sup> edition with rolling element bearings and ordered for pure oil mist will have one oil mist inlet and one vent opening on top of the bearing housing and low point drain on bottom. Oil mist must be injected on one side of the bearings and flow through and out the low point drain. The vent on top of the housing must be removed and the opening plugged. However, not all pumps are ordered for pure oil mist, most are built for sump lubrication. To insure adequate lubrication it is recommended that directional reclassifiers be installed in the bearing housing on all between bearing pumps. The directional reclassifiers will guarantee that an adequate amount of oil mist will pass through the rolling elements of the bearings. (see figure 5)

### **PURGE MIST APPLICATION**

The main purpose of purge mist is to provide a small, positive pressure in the bearing housing to prevent intrusion of atmospheric contaminants. The oil mist injection point must be above the oil sump with an unobstructed flow path to a vent, also above the oil level. This can be accomplished by using two separate openings on top of the housing, or by using a vent fill assembly in a single opening. The vent fill assembly incorporates a mist injection tube, connection for venting and a removal cap for adding oil to the sump. The pressure above and below the oil level must be balanced by using an oil level sight assembly or a constant level oiler with balance line. An overflow tube incorporated in the oil level sight assembly and constant level oiler is adjusted to allow excessive oil buildup to overflow to the collection container and to vent the bearing housing. The top of the overflow tube should be set ¼" above the desired oil level. (see figure 6)

### **VENTING**

Venting of carrier air from closed housing is required to permit the continuous flow of oil mist into the housing. Although it is not always necessary to insure through-flow of oil mist for single for single-row

radial bearings, it is nevertheless good practice to do so. On thrust-loaded rolling element bearings, the oil mist should always be routed through the bearing rolling elements in order to insure that complete lubrication occurs. It is always prudent to review the bearing housing configuration so the correctness of venting or mist through-flow can be ascertained.

When applying pure oil mist to existing overhung pumps, using one inlet on top of the housing (Original Application); vented mist must be visible escaping through the shaft seals. Labyrinth seals will allow this to happen, but if lip seals or vapor barrier seals are installed, they must be notched or a small hole (1/8") must be drilled in the seal or the adjacent enclosure.

### **OIL RINGS**

Many times the question is asked "do we recommend removing the oil rings when converting from sump lubrication to pure mist/dry sump". Our answer to the question is "No, it is not necessary to remove the rings or slingers when retrofitting pumps in service". However, we do recommend removing the rings or slingers when retrofitting pumps in service". However, we do recommend removing the rings or slingers when the pumps are taken out of service and sent to the shop for reworking. It is a known fact that pumps last longer on dry sump oil mist. Therefore, users would immediately achieve significant reduction in bearing failures and if one or two pumps failed because of oil rings, they were way ahead on major reduction in bearing failures. Experience has shown this to be the right decision and very few pump failures have been reported in all the years that we have been following this practice.

### **RECORDING TEMPERATURES**

When applying pure oil mist to running equipment it is advisable to monitor the bearing temperatures before and after draining the oil from the sump. The ambient temperature needs to be recorded each time the bearing temperatures are taken because the housing temperature increases and decreases as the ambient temperature changes. Bearing temperatures should be taken on the housing near the thrust and radial bearings 15 minutes after draining the oil and again at 1 hour and 24 hours. The temperature should remain constant for the first hour and then drop within 24 hours. It is not uncommon to see the temperature drop as much as 35 degrees F. If the bearing temperature rises more than the ambient in the first hour, replace the oil in the sump and schedule the pump for inspection as the bearings are probably nearing their life span. (see figure 7)

## CASE HISTORIES

1. Olefins Plants – two plants each with 200 pumps. The original plant was not equipped with oil mist; the second plant came on 5 years later and had oil mist installed during construction. Tracking of both plants for 10 years showed that the second plant had approximately 40 failures less per year.
2. Crude Unit – Oil mist was installed as a retrofit system in January 1990 with 1989 records showing approximately \$36,000 for bearing repair cost. Repair cost records for the following seven years averaged \$6,500 or an average savings of approximately \$29,000 per year. Installation cost of the oil mist system is estimated at \$80,000.
3. Annual pump bearing repair costs before and after oil mist lubrication was installed. Three units having an average annual bearing repair cost of \$74,100 each prior to oil mist lubrication. The year after oil mist was installed the average repair cost went down to \$25,600 per unit. The average savings being approximately \$48,500 or 66%.
4. Alky Unit – Oil mist was installed as a retrofit system in October 1990. The bearing failure rate increased from 18 to 19 for 1991. Through 1993 the bearing failure rate went from 19 in 1991 to 2 in 1993; a reduction of 89% overall. Mechanical seal failures were also tracked; the failure rate on seals were reduced by 68% after oil mist was installed. Improved lubrication techniques increases bearing life and has a definite impact on improving mechanical seal life.

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