OIL MIST LUBRICATION

Presentation to STLE – Houston Section

May, 2014

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Phillips 66 Lubricants

DISCUSSION TOPICS

- Advantages of mist lubrication
- Oils used for mist systems
- Types of mist systems
- System basics and design
- Maintenance of mist systems

WHAT IS MIST LUBRICATION

- Oil-Mist is centralized lubrication *system that continuously atomizes oil into small particles and then conveys* and delivers the correct amount of the pressurized lubricant to the *surfaces requiring lubrication. Oil mist can be used to continuously lubricate several different classes of operating or stand-by equipment* in widely dispersed physical locations within the same facility using only one type of lubricant.

- *Oil mist is considered a "best practice" by many companies* in the process industries. Many mist systems are retrofits on existing oil lubricated applications pumps and motors. Oil mist was *developed in Europe in the early 1900's* to replace grease and circulating oil systems on high speed spindle bearings. It was then introduced to the *US industry in 1948 with the steel industry* being the first to use. As of December *2012 over 100,000 process centrifugal pumps are operating with oil mist* as the sole bearing lubricant. The estimated number of electric motors on pure oil mist exceeds 10,000.

SATISFIES THE FOUR “R”S

- Right amount
- Right place
- Right time
- Right type

INDUSTRIES WHICH CAN USE MIST SYSTEMS

- Paper manufacturing
- Refineries/petrochemical
- Steel mills

ADVANTAGES OF MIST SYSTEMS
WHY USE OIL MIST?

- Reduce energy consumption (bearings operate in a thin film of oil instead of a pool of oil, typically 3 percent)
- Bearing failures reduced 50-90%
- Positive pressure prevents ingression of contamination
- Lower friction, no oil churning, reduced bearing temperatures (typically 10°F and often 20°F)
- Very slight cooling by air
- Application without contamination in dirty environment
- Automated system ensures the right amount of lubricant all the time
- Rust and corrosion protection of non-running pumps (maintains an oil fog environment)
- Elimination of thermal cycling in idle equipment
- Better lubricant properties, because the oil on the bearings is always new (not so with closed loop systems)
- No oil changes, less maintenance
- Reduction in cooling water usage, elimination of cooling water in bearing housing
- Increases safety – eliminates hand labor next to moving machines
- Reduced lubricant consumption (up to 40 percent compared to sump lubrication)
- Low maintenance (no moving parts, lubes difficult areas, no need to check individual housings)

EQUIPMENT APPROPRIATE FOR OIL MIST

- Pumps (most common application)
- Motors with roller bearings (common application)
- Pillow block bearings
- Gear boxes
- Steam turbines
- Cams
- Chains
- Fans
- Other miscellaneous rotating and sliding equipment

MISTABLE LUBRICANTS

- **Mineral oils**
  - paraffin free to prevent plugging of the reclassifier orifices
- **Synthetic fluids**
  - Suggested at ambient temperatures below 40° F
  - Closed loop systems allow collection and reuse of oil
- **R&O oils**
- **Gear oils**

- *Oil selection is normally made to satisfy lubrication requirements of the most demanding component within system. R&O and gear oils are often used.*
- *The oil must mist well and not produce excessive stray mist. Pour point should be 20F above the lowest anticipated temperature.*
- *Ball bearings in electric motors and pumps commonly use a bearing oil of 100 to 150 cSt for summer use and 32 cSt for colder months.*

LUBRICANTS SPECIFIC TO MIST SYSTEMS

- Phillips 66 Extra Duty Gear Oil 220M and 460M
- Phillips 66 Syncon Mist Oil
- Mobil Mist Lube Series

- Specifically formulated mist oils *contain additives to improve atomization and promote condensation on rotating surfaces. They also minimize fogging and stray mist* in the surroundings.

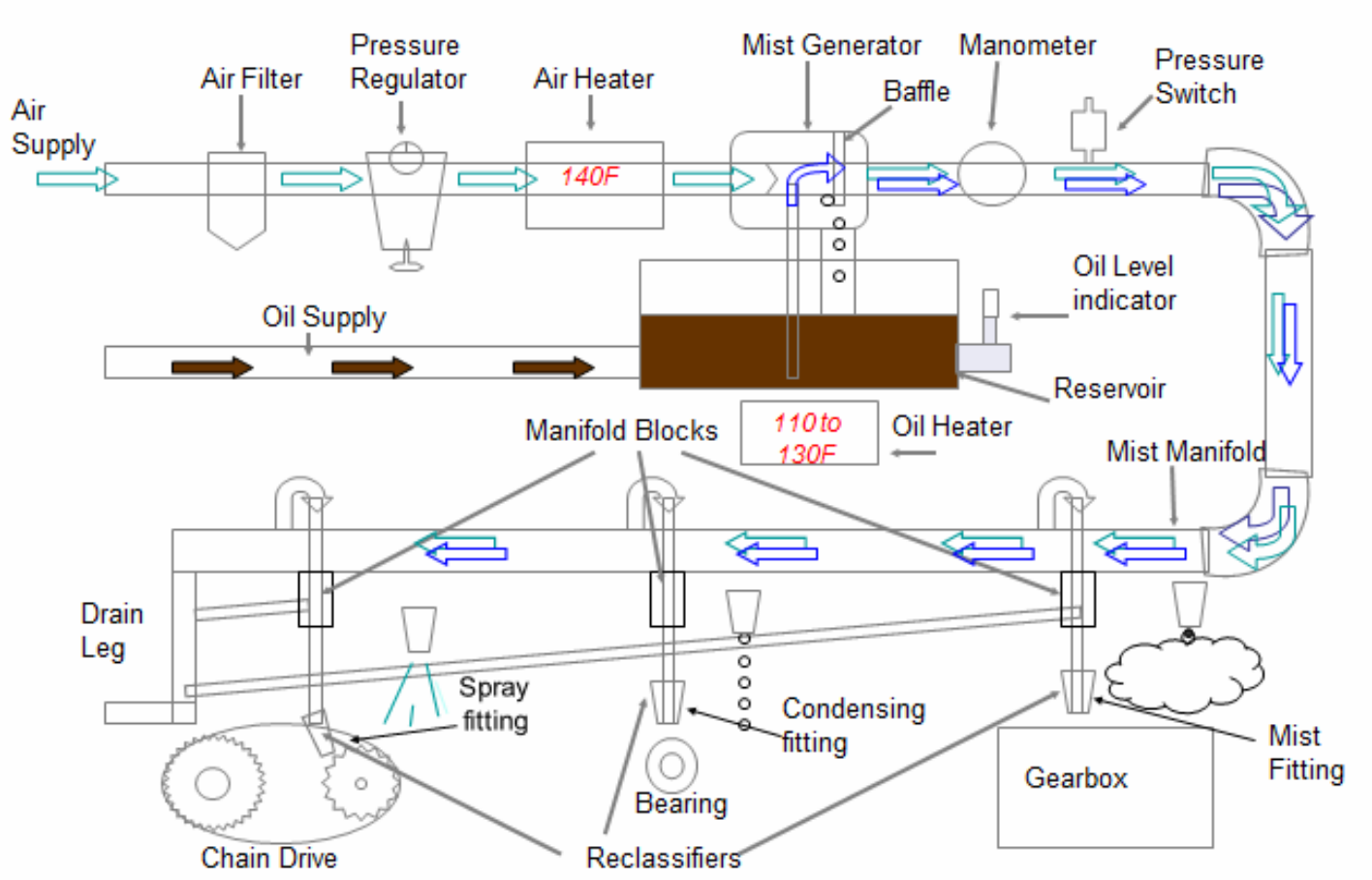
MIST LUBRICATION PROCESS

- Dry air passes through a venturi at very high speed; oil is introduced into the air stream by siphoning from a reservoir
- Oil is atomized into oil droplets of mostly less than three-microns
- Atomized Oil is mixed with air in a ratio of about 1:200,000 (below the lean limits and will not support combustion)
- Mist is moved out to the pumps through two-inch to four-inch piping in a low-pressure (less than 1 psi) and low velocity (less than 20 ft/s) under laminar flow
- At the component, mist is inserted into each pump bearing housing through a small-diameter application fitting or reclassifier
- Reclassifier greatly increases the mist velocity (to introduce turbulence), causing the droplets to collide and coalesce into larger liquid drops of oil
- Larger liquid drops passes into the housing where some of it contacts and lubricates the bearings
- Much of the liquid drops falls straight through to the bottom of the housing and is collected.

SYSTEM BASICS AND DESIGN

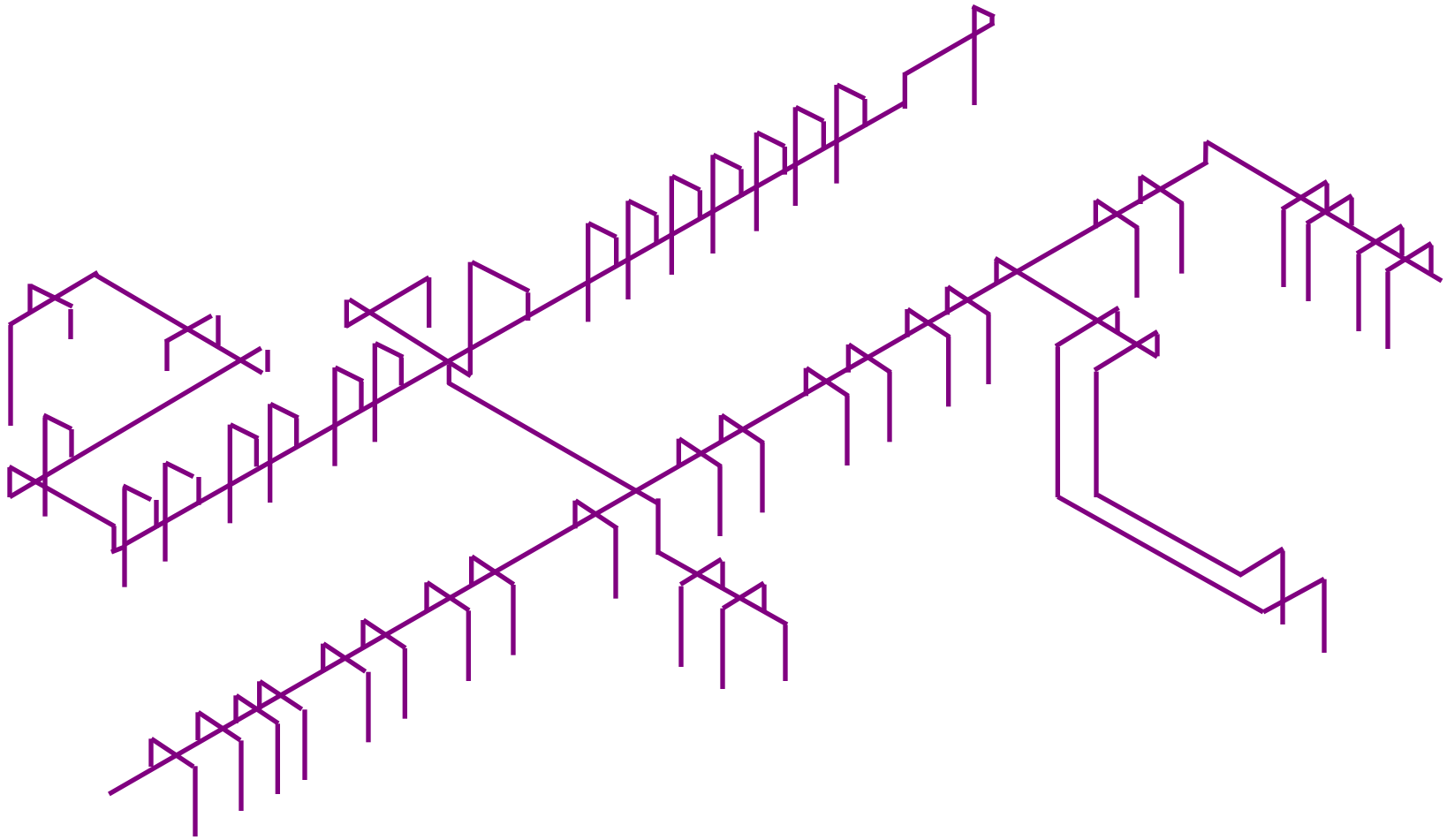
- Source of compressed dry air
- Mist generator
- Mist distribution pipelines
- Manifold blocks
- Reclassifiers
- Collection system
- Controls and alarms

SCHEMATIC VIEW OF OIL-MIST SYSTEM



Once produced, the oil mist will migrate in unheated, uninsulated header pipes to the point(s) of application.

TYPICAL OIL MIST SYSTEM LAYOUT



GENERATOR

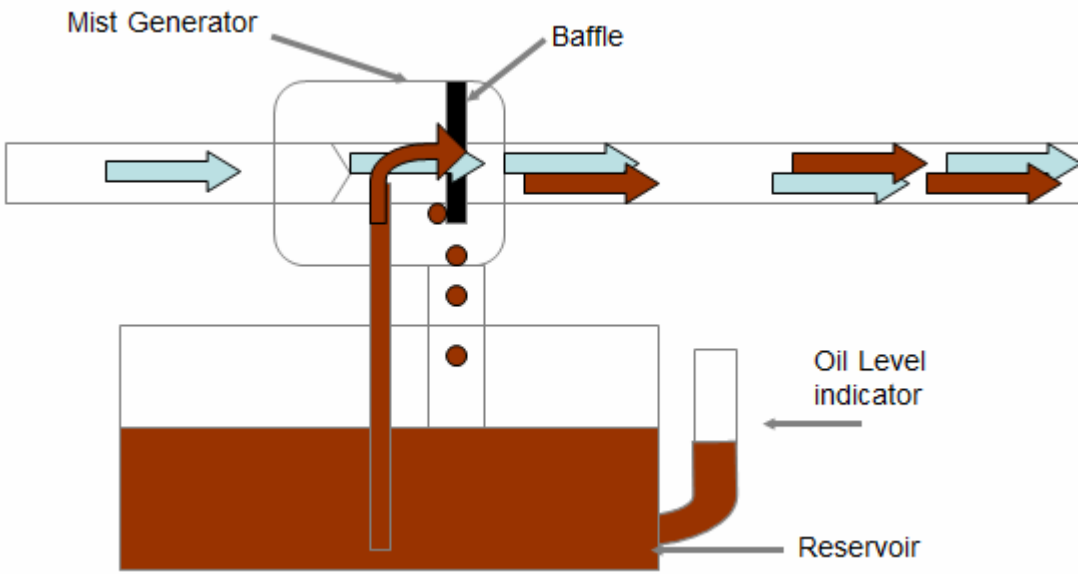
- Forms oil mist or fog (2-5μ)
- Two types: Venturi, Vortex
- Right size for application

Mist is generated by passing compressed air through a venturi or vortex, creates low pressure, causing oil to be siphoned from a small central reservoir and introduced into the high velocity air stream where the oil is atomized (identical to the operation of a carburetor).

Pressure of this inlet air is regulated to properly deliver the oil. *Droplets larger than about five to seven microns are not easily transported by the air stream, and are intercepted by a baffle for return to the reservoir.*

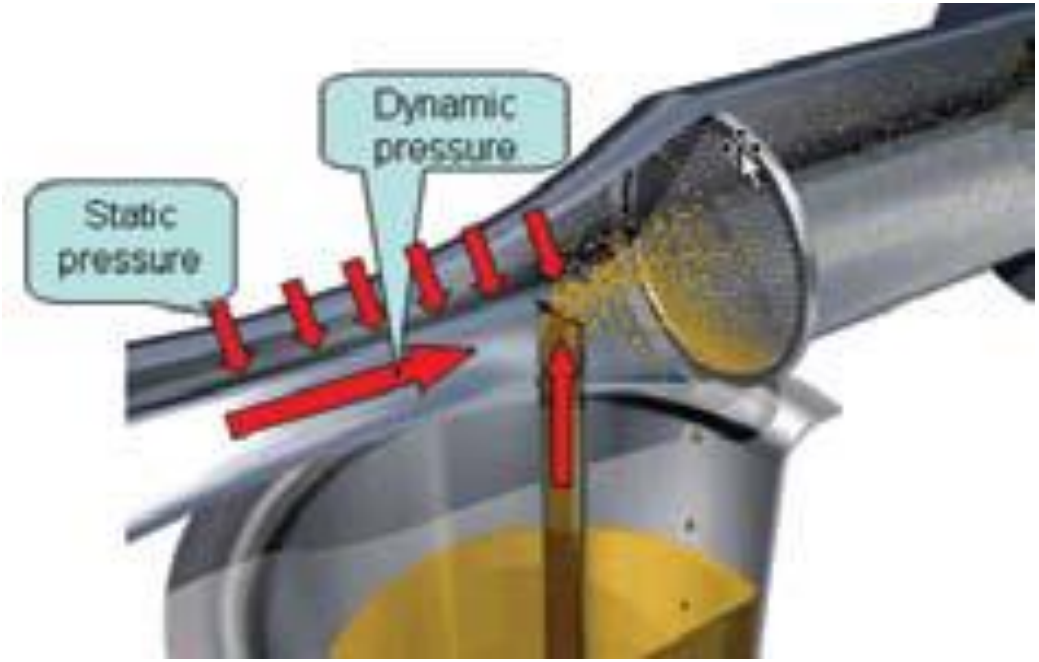
One oil mist generator can service all components within a radius of approximately 500 feet?

Mist generator must be properly sized, over sized generators are a problem (don't operator well at the low end of operating range)



VENTURI GENERATOR

- No moving parts
- Oil mist visibly resembles light smoke



GENERATOR CONSOLE

- *Five gallon reservoir* with pressure relief valve & oil level sight gauge
- *Minimum 10 PSI regulated air pressure*, normally instrument air is used since it is a reliable and dry source of air in most plants
- Header pressure maintained at 0.73 PSI
- *Ambient temperature swings have minimal impact on mist density after it leaves the generator provided the oil consumption and proper flow rate is maintained* by electric monitors controlling mist density

SUPPLY TANK

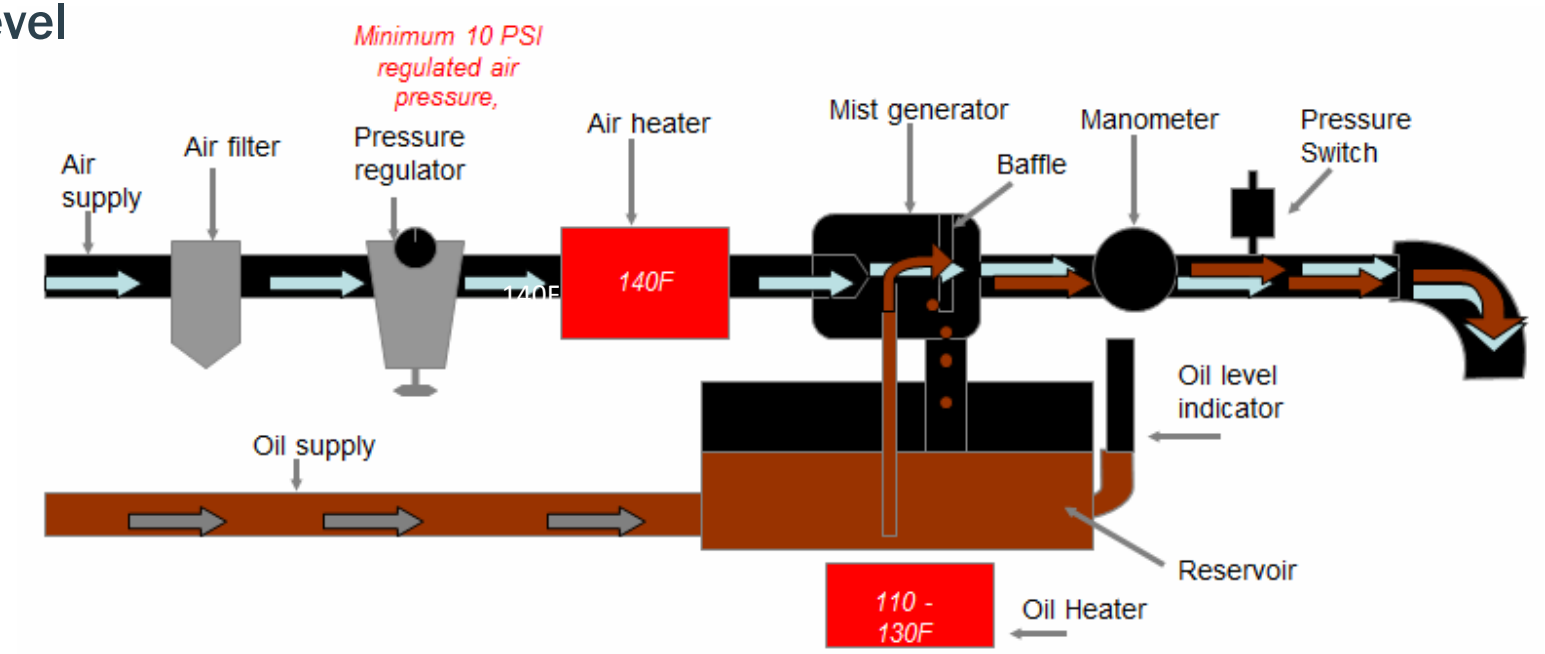
- Varies from manual fill, drums, skid tanks, to large supply tanks
- Oil supply should be kept dry – moisture can lead to suction screen and generator head plugging

GENERATOR

- Generator maybe very small
- No direct electrical power needed
- No moving parts

CONTROLS AND ALARMS

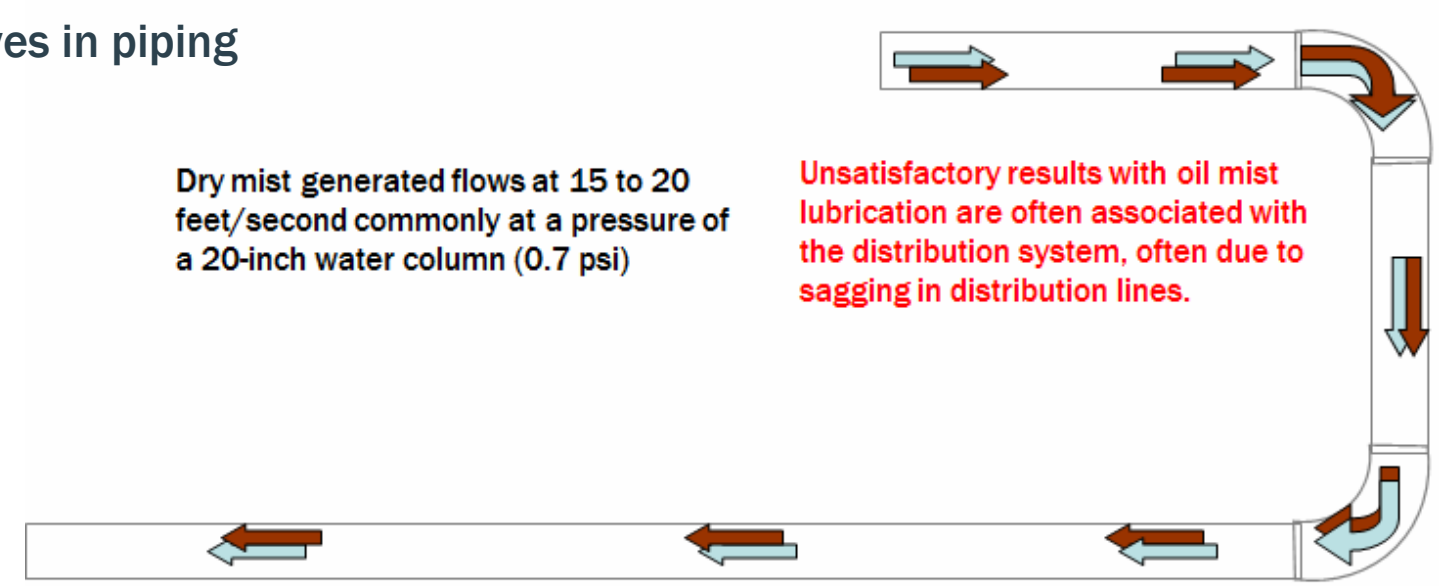
- Air pressure regulator
- Air and oil temperature
- Oil level



System performance is sensitive to temperature. To stabilize the oil/air ratio under widely varying ambient temperatures, heaters are often used to maintain the air and reservoir oil to temperatures between 110˚to 140˚

HEADER PIPE

- Transports mist
- Should slope back to generator or drains 1 inch per 20 foot
  - Allows for oil mist that coalesces to drain back to the mist generator for reuse
- Large scale systems are normally two inch galvanized carbon steel pipe
- No Traps or Sags
- No valves in piping

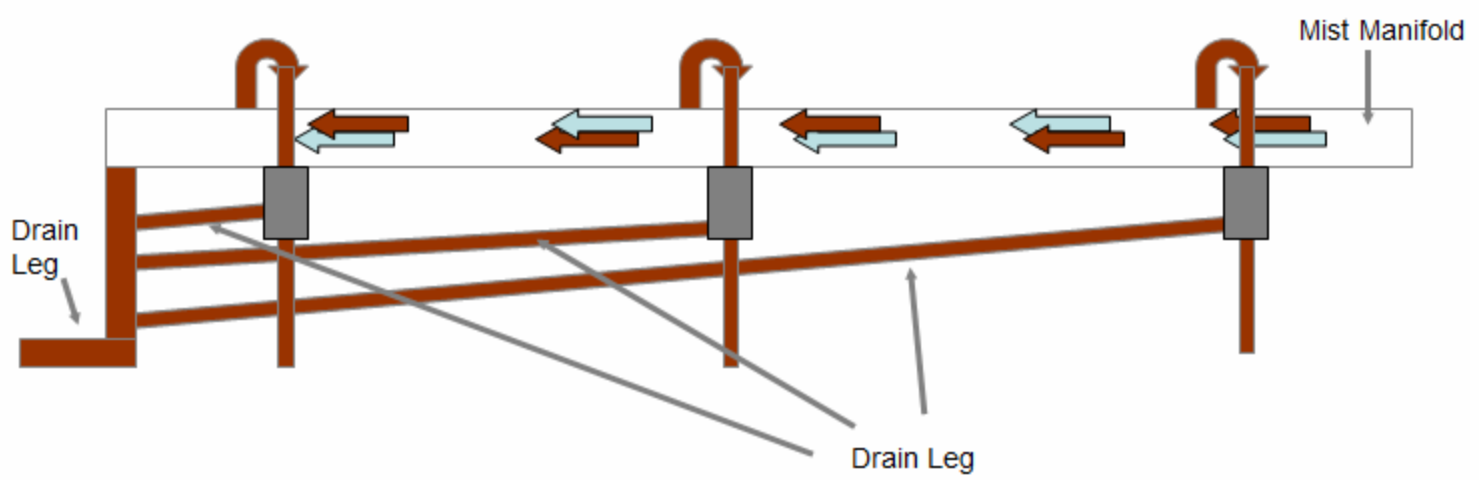


MIST SYSTEM FLOW RATES

- Laminar flow (below approximately 24 feet/second) must be maintained in feed lines, turbulent flow causes oil particles to impact the pipe wall and be removed from the air stream
- Excessively low flow velocities may lead to oil droplet fall out
- Oil particles must reach application within five minutes or gravity settling will occur (rarely an issue)
- Some level of oil will coalesce in the piping, therefore header piping is sloped to return coalesced oil to the generator

DRAIN LEGS
SHOULD BE AVOIDED

- Drain oil back to reservoir from middle or end of system
- Sometimes unavoidable due to loss of clearance in overhead pipe rack
- Correct slope should eliminate need for drain legs

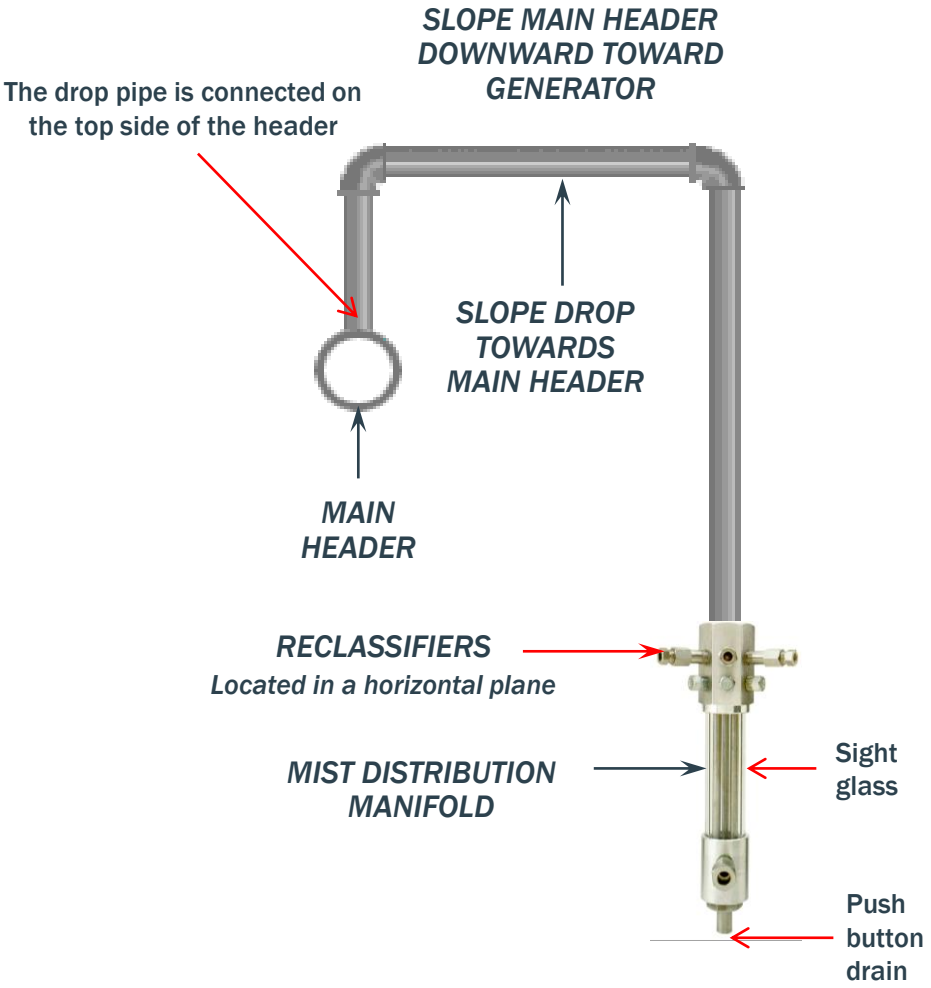


BRANCH HEADERS

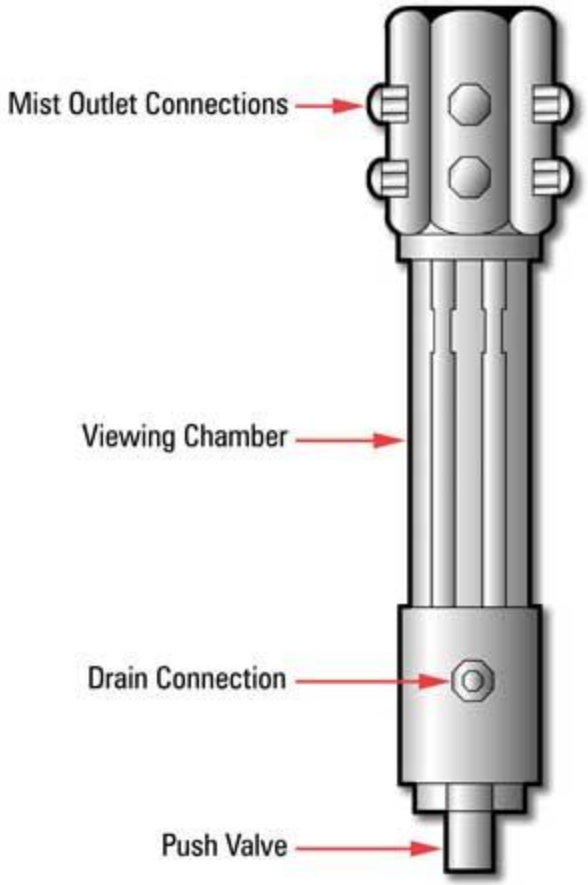
- May be needed to reach equipment located off of the main header pipe
- Branch headers come off the top of the main header
- Slope back to main header

OIL MIST DROP POINTS

- Established at individual equipment or group of equipment
- Comes off the top of main or branch header
- Terminates Mist Distribution Manifold
- Usually three quarter inch pipe



OIL MIST DISTRIBUTION MANIFOLD

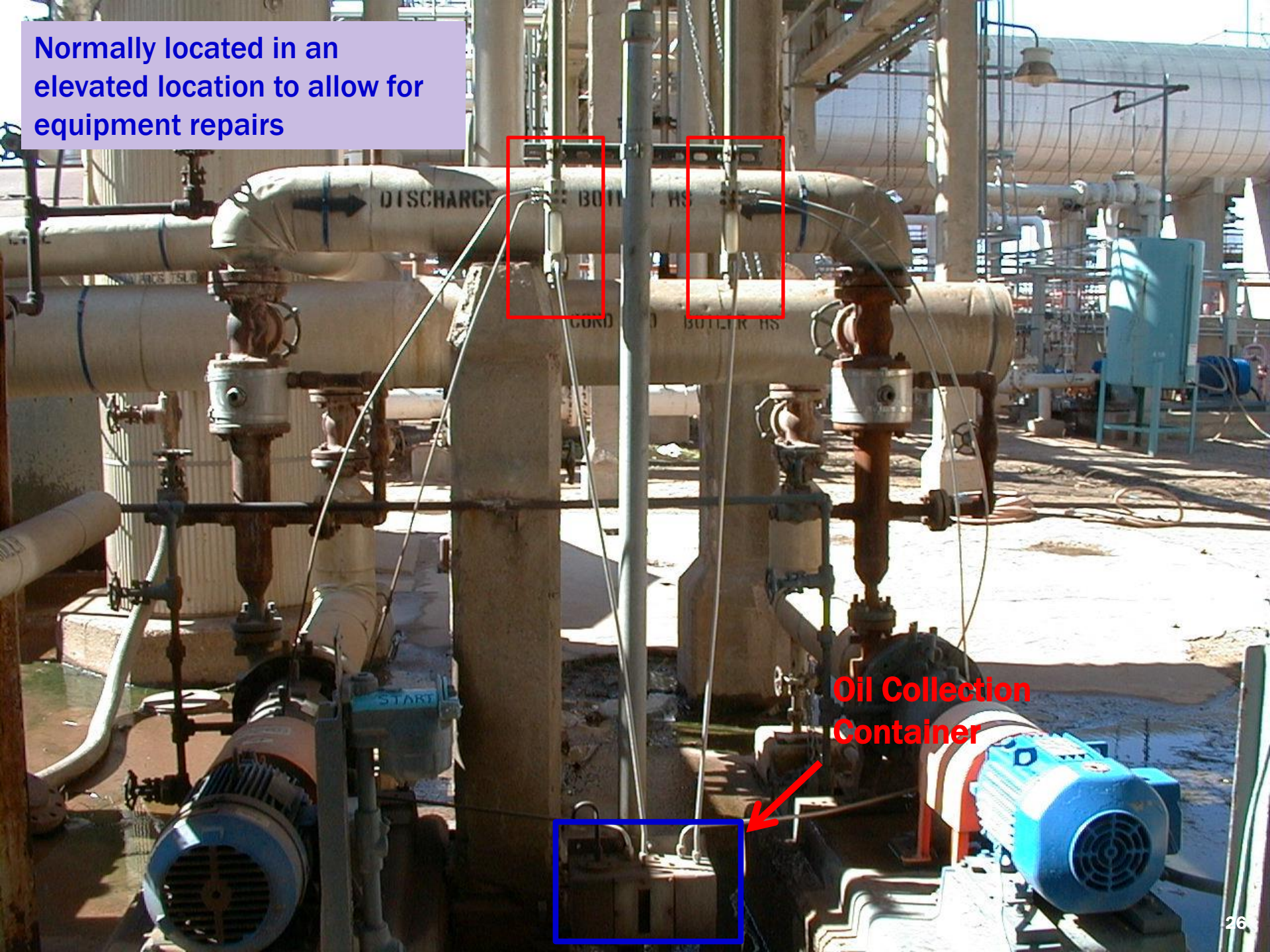


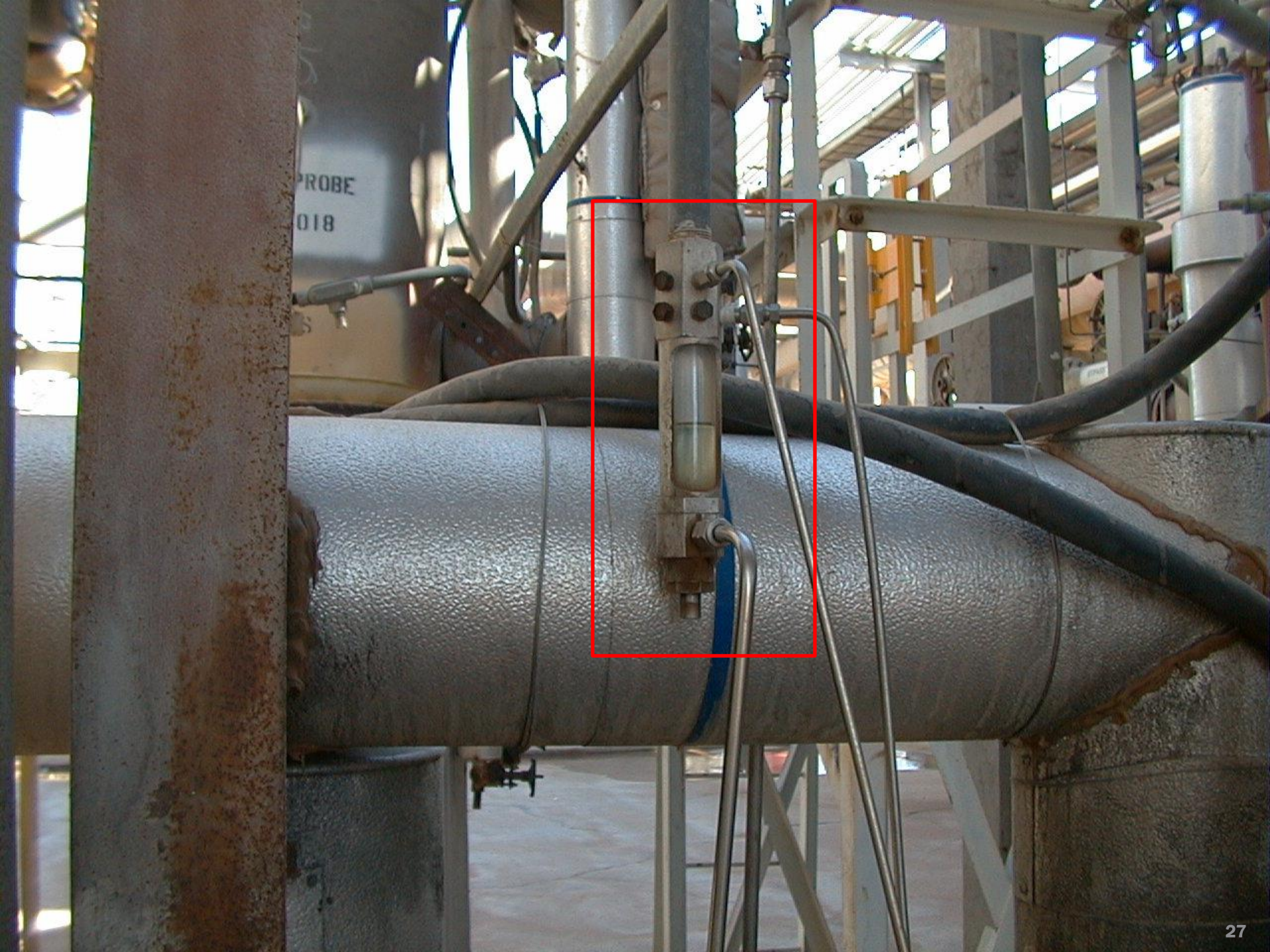
Manifolds are used to locate the reclassifiers and to collect the coalesced oil particles from the drop points.

The viewing chamber allows operators to see when oil needs to be drained.

Draining is accomplished with push valve, drain connection is connect to a return manifold to a collection container.

The amount of oil collected here should be minimal in a properly designed and operated system


Normally located in an elevated location to allow for equipment repairs
DISCHARGE
Oil Collection Container


PROBE
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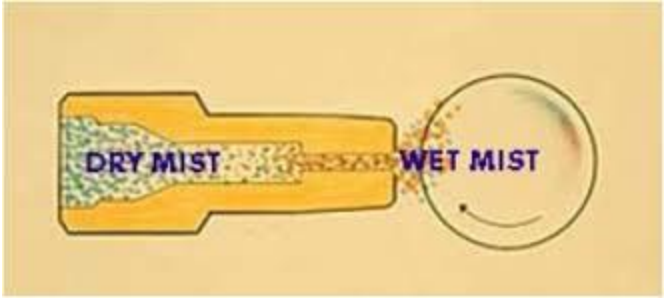
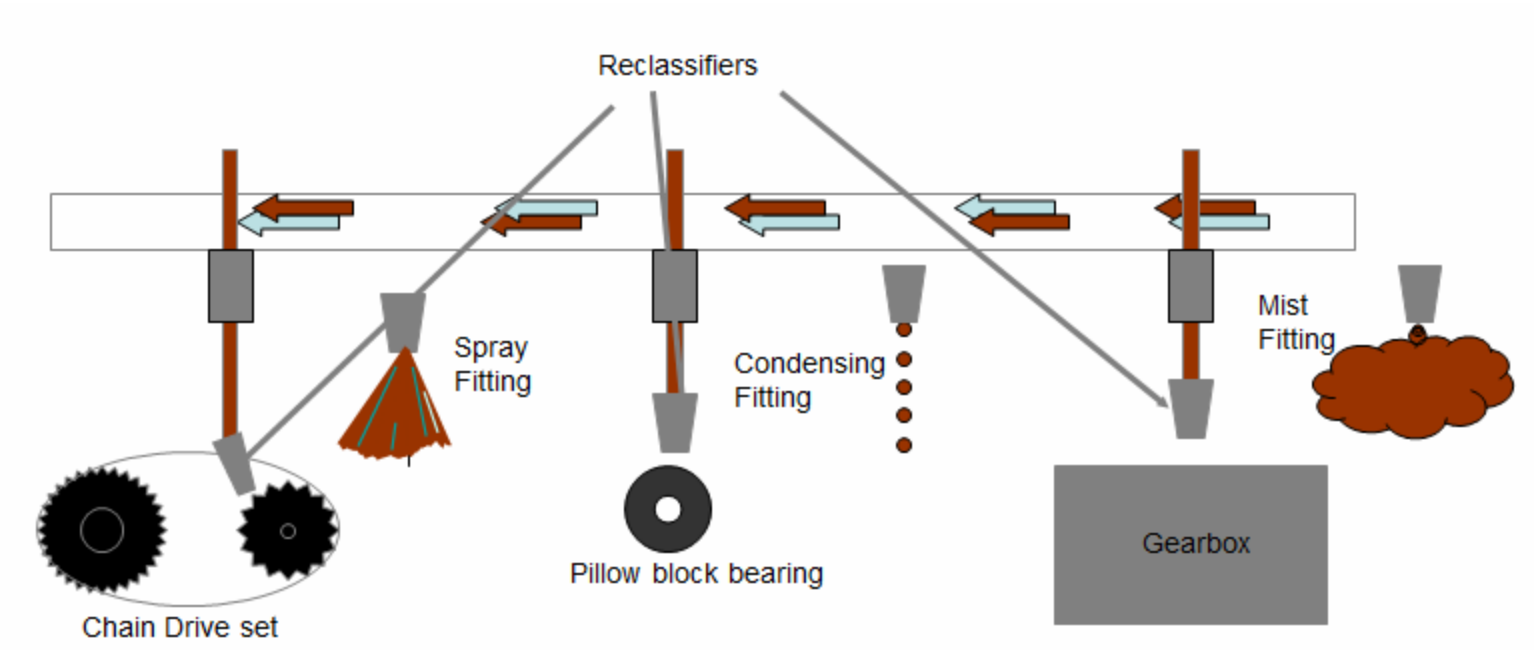
RECLASSIFIERS

- Metering Orifice Device controls flow of mist to each application point
- Creates turbulence (by increasing velocity) causing dry mist to coalesce and form wet mist
- Sizing Factors: RPM, shaft diameter, number of bearing rows, load
- One reclassifier for each application point
- Normally located in the manifold but can be fitted to the lubricated equipment
- Reclassifier must be located within 6 feet of application to prevent the larger particles from falling out of suspension



RECLASSIFIERS

- Three types: mist, condensing, and spray
- Increase mist particle size for proper lubrication



TWO TYPES OF OIL MIST

- ***Wet Mist*** - greater than three microns for lubrication
  - will fall out of suspension prior to reaching the application points
  - applied to the bearings for lubrication
  - Wet mist created in reclassifiers
  - Heavier particles are large enough to wet the surfaces
- ***Dry Mist*** - less than three microns for conveyance
  - Generated at the oil mist generator
  - Dry mist particles too small to allow wetting and therefore lubrication but easily transported throughout the piping header system.

Dry mist particles which bond with most solid contaminates or water are too heavy for transport and fall out of suspension, therefore only clean dry oil is provided at applications

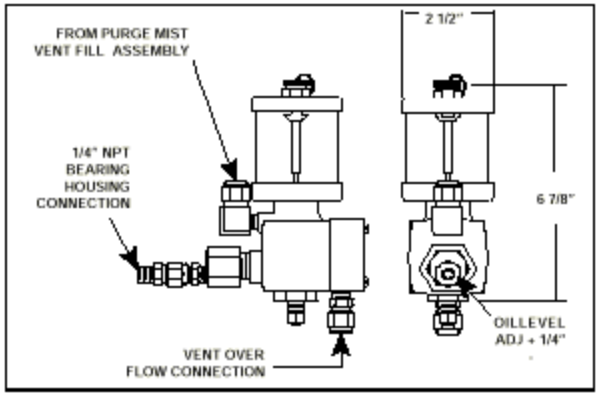
TWO TECHNIQUES OF APPLYING OIL MIST LUBRICATION

- *Pure Mist* - dry sump lubrication
  - No oil level is maintained in the bearing housing, lubrication is provided by mist only
  - Used with all types of rolling element bearings
  - Provides a slight positive pressure in the bearing housing that eliminates ingression of air borne contaminates
  - Preserves idle equipment
  - Placements of mist entries and vents are used to promote the movement of oil mist through certain assemblies
  - Sight glass or other bottle-type device is installed at the bottom of the bearing housing to capture condensed oil
  - No constant oil leveler is needed

TWO TECHNIQUES OF APPLYING OIL MIST LUBRICATION

- ***Purge Mist*** - wet sump lubrication
  - Purge mist used with sleeve bearings, gear boxes sometimes rolling bearings with high constant thrust loads
    - Small steam turbines, cooling tower gearboxes
  - *Oil level is maintained and the oil from the oil reservoir provides the lubrication.*
  - Oil mist continuously enters and flows through the space above the oil level.
  - Oil mist only acts to pressurized housing excluding contaminant ingression
  - Should extend oil drain interval of excluding contaminant ingression
  - Not sufficient to provide lubrication if the oil level is lost
  - Internal surfaces continuously coated, protecting against corrosion, (particularly important in stand-by equipment)

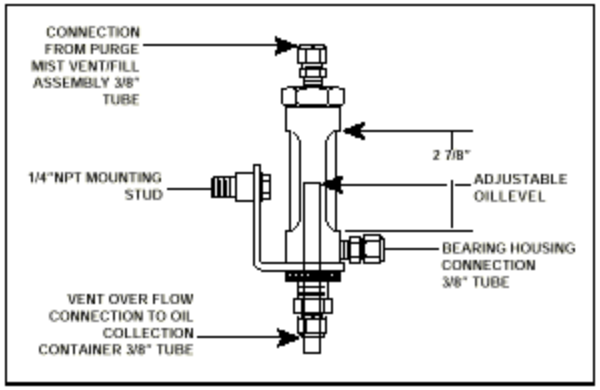
PURGE MIST
OIL LEVEL CONTROL DEVICES



CONSTANT LEVEL OILER ASSEMBLY P/N 77-700-202

Function/Description
- Monitors oil level inside bearing housing
- 5oz. capacity oil reservoir with fill cap
- Equipped with viewing chamber to set and check oil level in bearing housing
- Compatible with ***LubriMist®*** purge mist vent/fill assembly and connection to ***LubriMist®*** oil collection containers

Material
- Aluminum body
- High temperature glass sight tube
- SS tube fittings

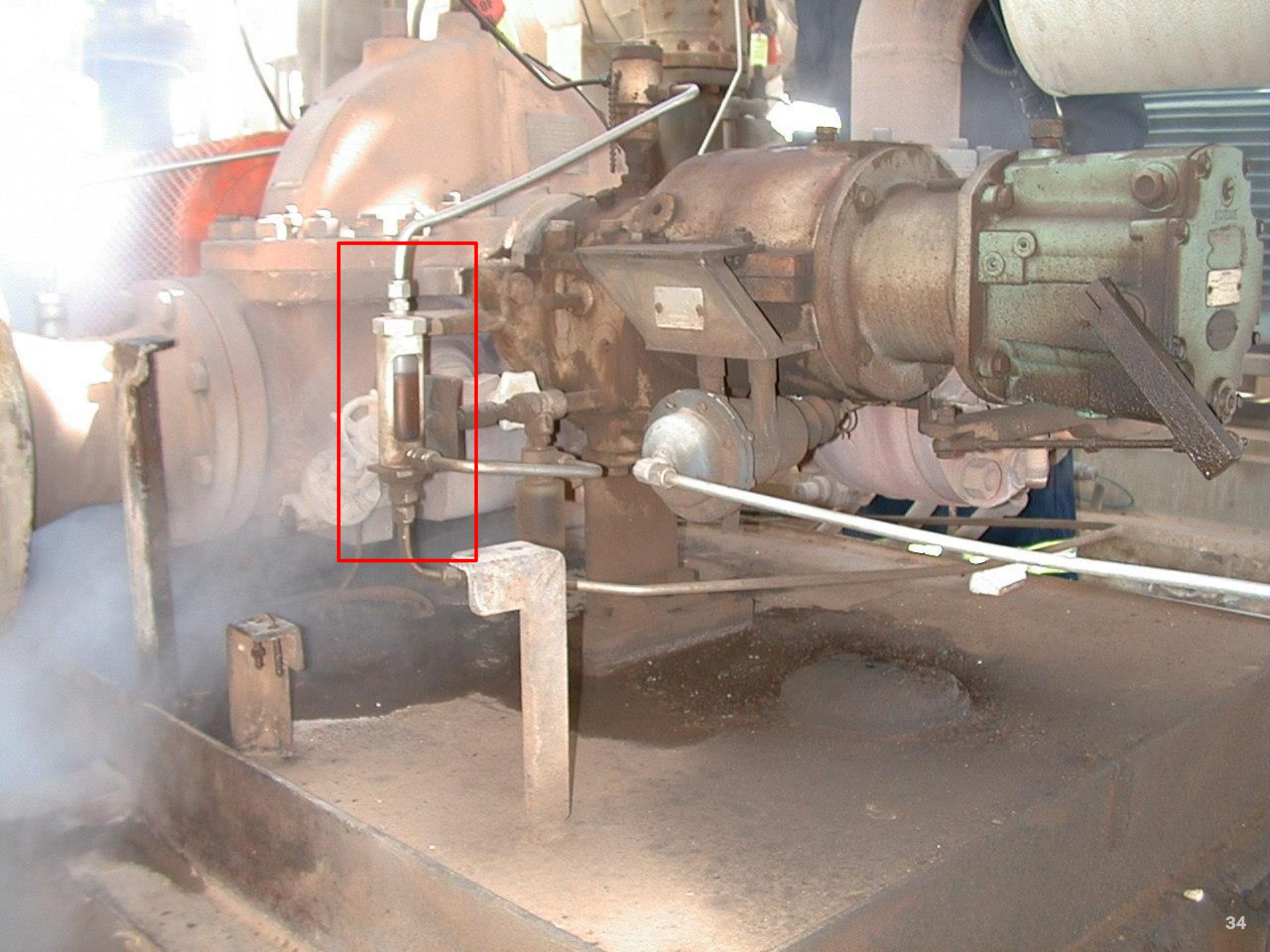


OIL LEVEL SIGHT ASSEMBLY P/N 77-700-217

Function/Description
- Monitors oil level inside bearing housing
- Adjustable level setting
- Designed for use with ***LubriMist®*** purge mist vent/fill assembly and connection to ***LubriMist®*** oil collection containers

Material
- Aluminum body
- High temperature glass sight tube
- SS tube fittings

Options
- T-304 SS body (P/N 77-600-878)



NEW EQUIPMENT OR RETROFIT INSTALLATIONS

- Mist systems can be specified for new pumps and some motors
- Retrofit installations on existing equipment is usually possible on most equipment
  - *Over hung and between bearing pumps are fairly easy to retrofit with pure mist and can be done without equipment shut down,*
  - To insure passage of mist through bearings, driver HP, RPM, bearing housing internal configuration, bearing type and the seals must be considered when selecting reclassifiers and location of oil mist inlet locations and vent/drain lines
  - When converting from oil sump to pure mist, take bearing temperature/vibration readings before, during and after draining the oil, temperature/vibration should drop, an increase indicates bearings near end of life
  - *Retrofit of motors requires more effort, must remove all grease, the internal porting to the junction box must be* thoroughly *sealed,* winding epoxy and lead wire insulation must be confirmed as oil compatible, *a case drain must be installed* on the coupling end of the motor

ONCE THROUGH AND CLOSED LOOP SYSTEMS

- Once through
  - Oil not collected, used once
  - Advantages - simple, least expensive
  - Disadvantages – oil disposal, stray mist
- Closed loop
  - Oil collected and reused
  - Advantages – no oil disposal, reduced stray mist and oil costs
  - Disadvantages – complexity, increased cost

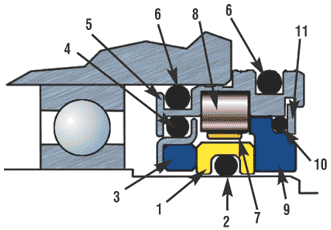
STEPS TO PREVENT AIR POLLUTION/STRAY MIST

- Install closed-loop oil mist systems
- Use of correct product: mist oils contain mist control additives
- Environmental concerns:
  - Non-toxic, not a Volatile Organic Compound (VOC)
  - One part oil to 200,000 equal parts of air

OSHA regulation : threshold limit value of 5mg/m3 for a 8 hour workday. Therefore, oil mist in concentrations found around oil mist lubricated machinery in typical open air should not present a health hazard.

CLOSED-LOOP OIL MIST SYSTEMS

- *Labyrinth seals are not capable of fully containing mist leakage* and oil accumulation on ground.
- The most *recent systems* apply *API-610-compliant, dual-point injection with a closed-loop design, recovering up to 99% of the lube oil. Closed oil mist systems require a near-perfect seal* just outboard of the bearing which encloses all the lubricants in the system eliminating stray mist to escape into the environment.



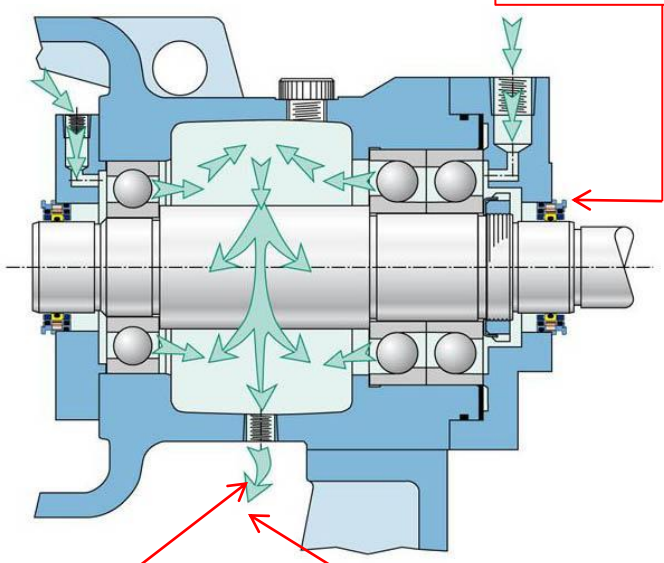
Item	Description	Material
1	Rotary Seal Face	Tungsten Carbide
2	Rotary Elastomer	Viton®/ Aflas®/ EPR/ Kalrez®
3	Stationary Seal Face	Ant.Car-S/S
4	Stationary Elastomer	Viton®/ EPR
5	Outer Body	Stainless Steel
6	Outer Body Elastomer	Viton®/ Aflas®/ EPR/ Kalrez®
7	Shroud	Phosphor Bronze
8	Magnet	Metal
9	Stationary Seal Face	Bronze filled Teflon
10	Staionary Elastomer	Viton®/ EPR
11	Circlip	Stainless Steel

Advanced, *cartridge-type dual-face, magnetically energized bearing isolator.* This isolator provides a quasi-hermetic seal for the bearing housing. (Source: AESSEAL, Inc., MagTecta II®)

With the use of advanced cartridge-mounted face-type magnetic bearing isolators, *the reuse of the collected oil* is now both feasible and economical. This makes it relatively easy to cost-justify premium priced, superior-quality synthetic lubricants, which appears to be the direction in which technology is heading.

CURRENT EDITION API-610 PUMP INJECTION APPLICATION

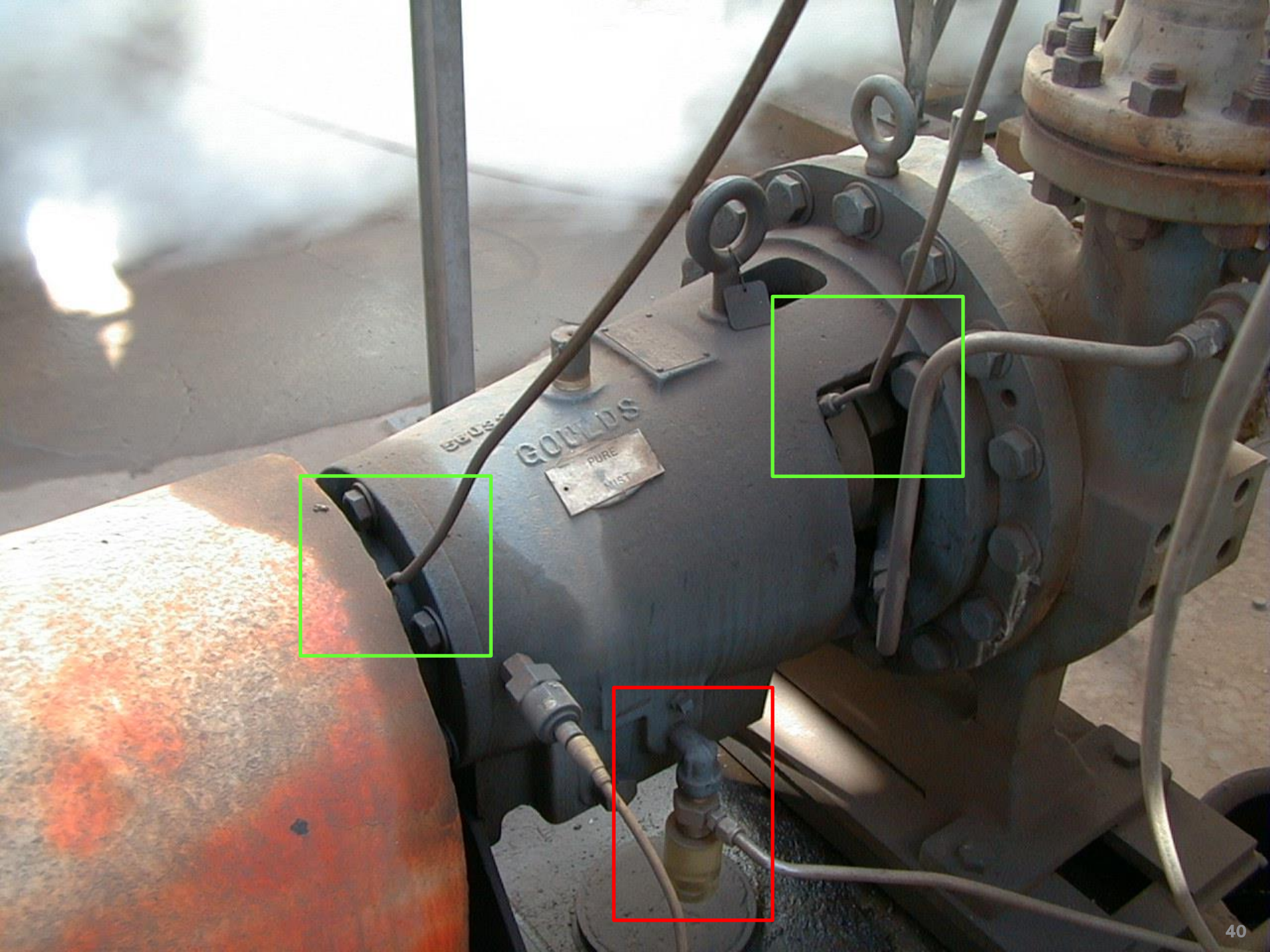
CLOSED OIL MIST SYSTEM



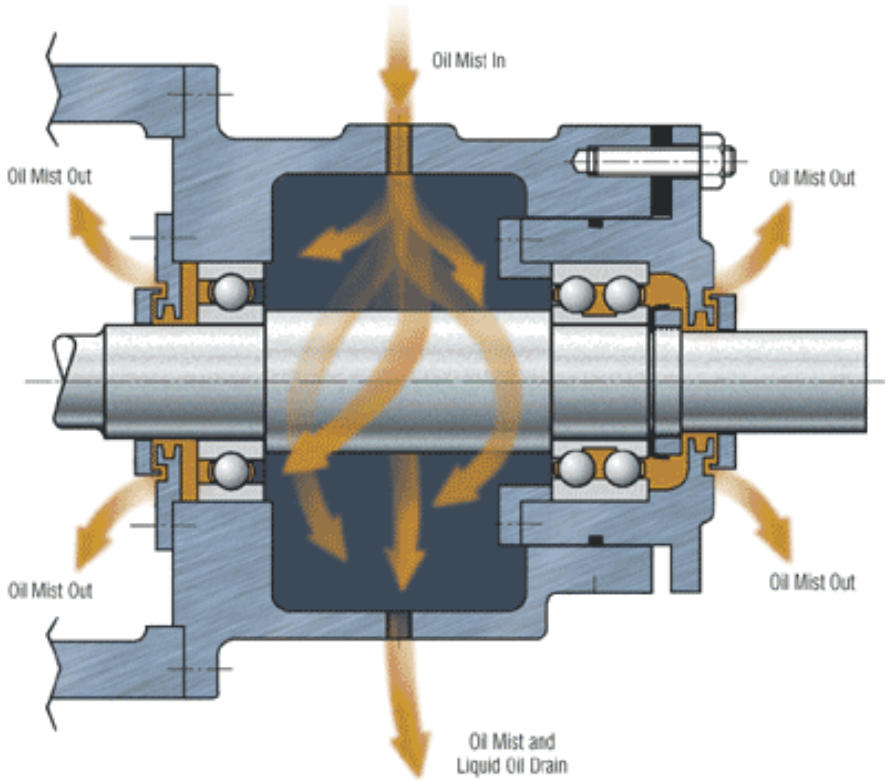
- *Oil passing through the bearings minimizes travel straight down the housing,* therefore converting from a center-injection to a dual-injection plan reduces oil consumption
- *Dual-injection oil mist is a superior lubrication method especially for multiple row bearings*, allows for reclassifiers to be sized for thrust and radial bearings
- *Current API 610 pump specifications require NPT (National Pipe Thread) connections outboard of the bearings.*

Oil mist and liquid oil drain, port size is critical if too small will restrict the flow creating back pressure in the housing restricting the flow through the bearing, should be 3 to 4 times larger than the diameter of the reclassifier

Machinery Lubrication May 2006

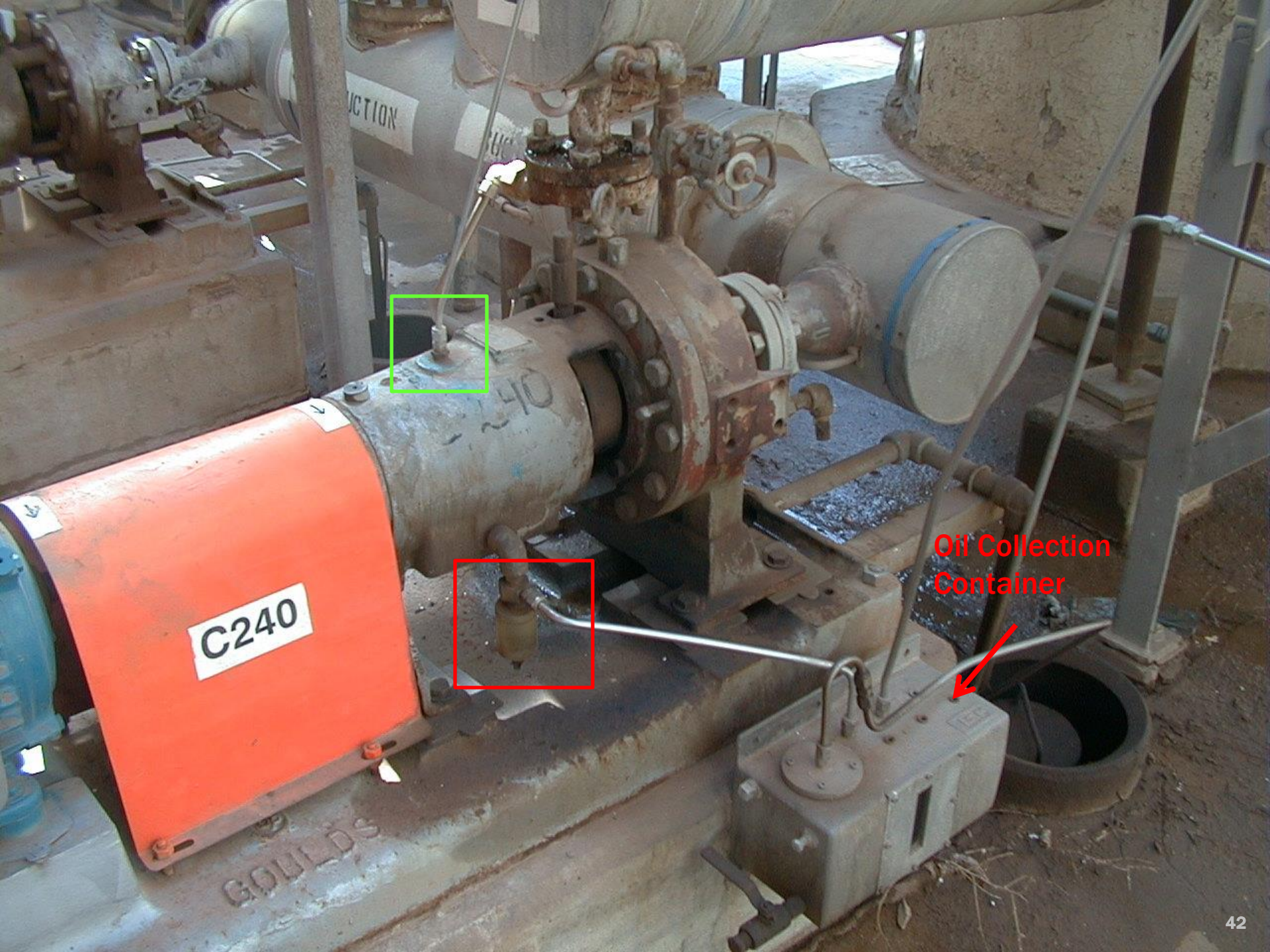

GOULDS
PURE
MIST

SINGLE INJECTION APPLICATION, OLD-STYLE (NON-API TYPE), OPEN OIL MIST SYSTEM



Sight glass or bottle-type device is installed at the bottom of the bearing housing to capture condensed oil

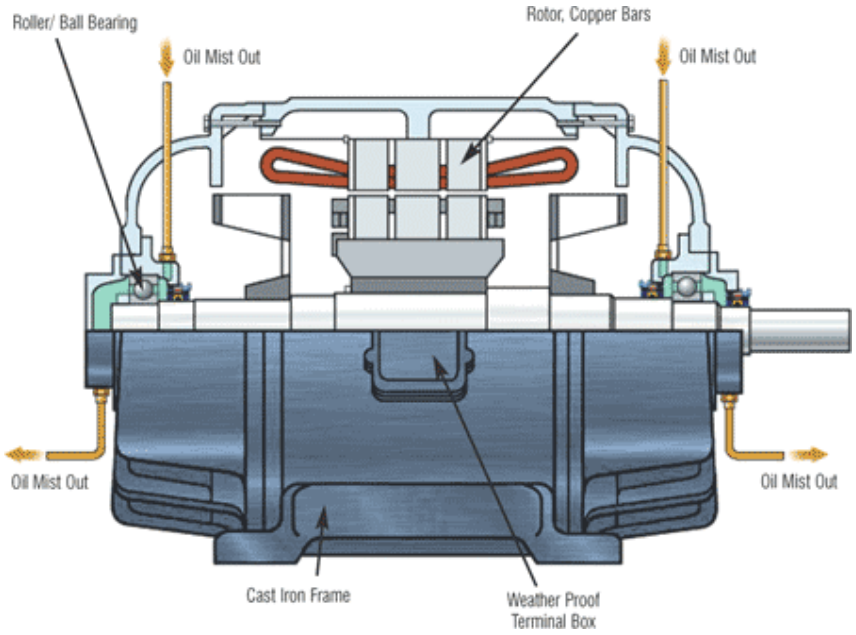
- *Old-style (non-API type) oil mist insertion at midpoint of bearing housing, venting taking place through the bearing housing seals and a hole near the bottom of the housing,* much of the oil mist escaped to the environment
- Dry mist (<3 microns) that do coalesce are vented away from the equipment housing and are referred to as stray mist.
- *Tight-sealing bearing protector seals to minimize stray mist leads to "dead-ending" with no mist flow past bearings*
- *Single point system in middle housing is acceptable when operating less than 3000 RPM and less than 200HP when lip or labyrinth seals are used, > 3000 RPM and > 200HP require two point mist injection*


C240
GOULDS
Oil Collection
Container

DRAIN SYSTEMS

- Can vary in complexity
- Oil mist creates no environmental concerns
- Oil liquid is more of an issue, volume is small and often system is connected to the oily water sewer when one exist or collected in a containers which are periodically drained

ELECTRIC MOTOR MIST LUBRICATION



API-compliant dual-point oil mist injection, at locations between the bearings and the isolators in an electric motor.

- Many refineries have extended MTBF for their 15 hp and larger size electric motors
- Most electric motors are configured for grease lubrication. If oil mist is injected into the motor bearings, must isolate the bearings from the windings to prevent oil buildup on the windings.
- Neither lip seals nor straight or rotating labyrinth isolators can seal out oil mist; only face seals are effective hermetic seals.

Source: AESSEAL Inc., UK and Knoxville, Tenn.

MAINTENANCE OF MIST SYSTEMS

- Daily maintenance schedule
  - check equipment twice daily
  - check mist quality
  - check for proper temperatures
- Routine generator console maintenance
  - performed at least every six months
  - should include
    - air and oil filter change
    - running backup mist generator
    - clean main reservoir/ generator head
    - checking and resetting controls and alarms

COST JUSTIFICATION FOR MIST SYSTEMS

- Extended mean time between repairs
  - Often is sufficient to justify investment
- Reduction in man hours required to change oil, maintain levels, re-greasing
- Reduction in seal failures
- Reduction in cooling water usage
  - Pure mist often eliminates the need for cooling water
- Reduction in oil consumption

NEGATIVES OF MIST LUBRICATION

- Too messy?
- Cost of installation and retro-fitting of existing equipment