Design Manual
For Machine Lubrication

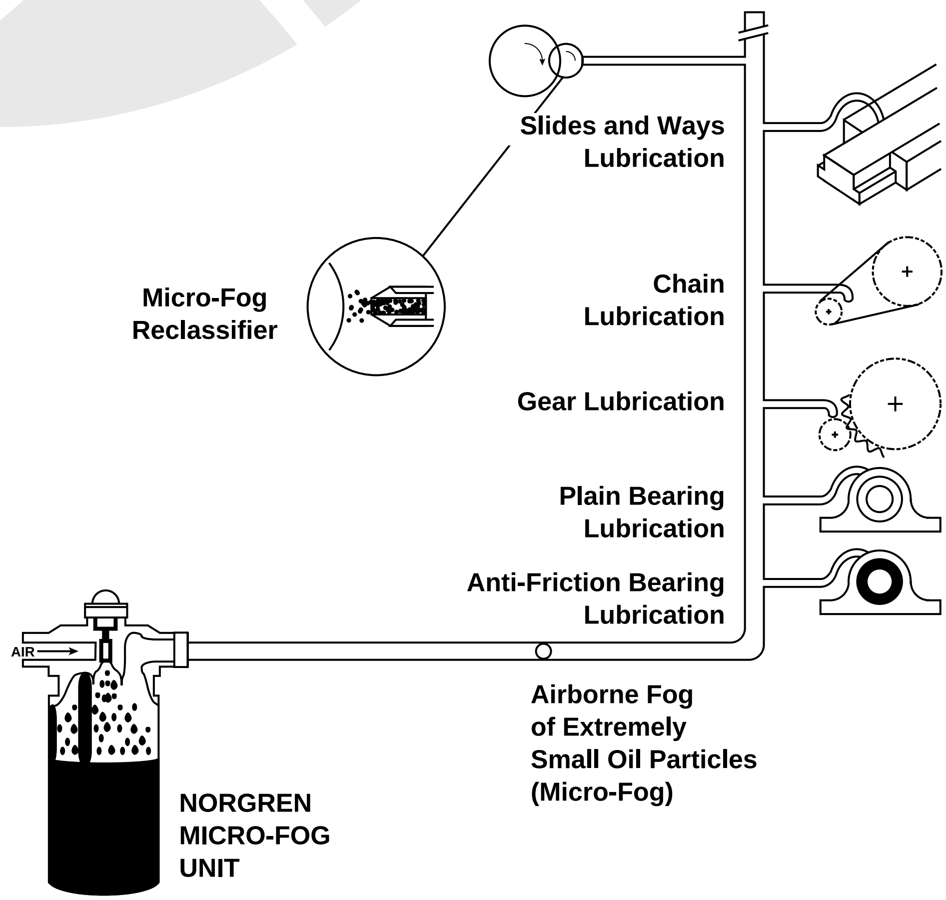


Table of Contents

Introduction

The information given in this manual is presented to enable the user to properly utilize Norgren products in the design of his machine lubrication system. No analysis of the effects of component failure or of loss or variation in lubricating oil delivery to bearings, gears, chains, ways, slides, etc., has been made by Norgren. The user of Norgren products or of the information presented herein is cautioned to make sure his system design includes safeguards to protect against personal injury and property damage in the event of failure of any component or combination of components or the loss of, or variation in, lubricating oil delivery. Any warranty of fitness of Norgren products identified herein for a particular purpose is disclaimed by Norgren

In lubrication applications, some oil mist may escape from the point of use into the surrounding atmosphere. Users are referred to OSHA Safety and Health Standards for limiting oil mist contamination and utilization of protecting equipment.

Centralized Lubrication

Micro-Fog lubrication makes possible centralized air-borne lubrication for all sizes of machines and equipment. Micro-Fog centralized lubrication permits the continuous lubrication of numerous machine elements while only having to maintain one central lubricator per system.

Where to Use

The Norgren Micro-Fog method has been tried and proven in many applications on all types of machines. It can be used to lubricate bearings of all types, gears, chains, slides, ways and other devices requiring a thin film of oil for lubrication.

Machine tool builders have designed it into their finest and costliest machines. Textile mills, rolling mills and rubber factories have applied it to existing machines with excellent results.

Benefits of Micro-Fog Machine Lubrication

Greater Design Flexibility

The use of Micro-Fog lubrication allows the machine designer greater freedom than any other lubrication method for two important reasons.

1. Because the lubrication source is centralized, it is not necessary to provide for ready access to the points requiring lubrication. This allows much greater design freedom and enables the designer to give more consideration to appearance and less to accessibility.
2. Centralized lubrication simplifies the installation of automatic controls. Controls can easily be installed to permit the start-up and shut-down of the lubrication system with the machine it is serving. Automatic oil-fill devices can also be utilized to insure adequate oil supply in the lubricator reservoir.

Proper Lubrication

With any method of lubrication, the only oil actually lubricating is the thin film that separates the bearing surfaces. Any additional lubricant is a waste and may even be harmful, causing overheating through fluid friction. Micro-Fog lubrication supplies just the amount of lubricant required with no waste or overflow. This makes housekeeping easier and avoids product contamination.

Every particle of oil is efficiently used. One fluid ounce of oil per hour will generally provide effective lubrication for 100 bearing-inches. Daily consumption of oil by a machine can often be reduced from quarts to fluid ounces compared to other systems.

Proper lubrication means longer bearing life, reduced down time, less maintenance and lower replacement costs. Lower bearing temperatures are maintained because the compressed air carrying the lubricant passes through the bearing housing, reduces bearing temperature, and reduces bearing contamination.

Because the oil feed is visible and because the lubrication system can be interlocked with machine operation or an alarm system, the maintenance of proper lubrication can be assured.

Cost Savings

In addition to the benefits of proper lubrication, the cost of hand lubrication is eliminated and equipment savings realized – no pumps, drainage or return lines, or elaborate filtering systems are required. Less lubricant is used since the lubricator delivers only the quantity of oil for lubrication purposes.

Principles of Operation

How the Micro-Fog Lubricator Works

Compressed air passing through the lubricator creates a pressure differential that causes oil to flow from the reservoir through the sight-feed dome into the venturi section. An oil fog is created at the venturi and is discharged into the upper portion of the oil reservoir. Only the finer particles of two microns (.000078 inch diameter), or less, remain airborne. Only a small percent of the oil passing through the sight-feed dome is converted into Micro-Fog and travels with the air to the lubrication points. The heavier particles of oil return to the oil supply.

Micro-Fog can be conveyed long distances through low pressure pipelines directly to the bearing surfaces. Recommended maximum distance is 300 feet.

At the bearing surfaces a nozzle-like fitting, called a re-classifier, causes the small oil particles to combine into larger particles. These impinge upon the bearing surfaces and covers them thoroughly and continuously with a protective film of clean oil. The turbulence created by rapidly moving machine elements also aids in the reclassification of oil.

Because no return piping is required as is the case with circulating lubrication systems, assemblies can be designed for easy installation and removal. Full advantage can be taken of the modern trend to building-block unitized machine construction which simplifies service, repair and maintenance, thus greatly reducing machine downtime.

Figure 1 illustrates the generation of Micro-Fog in a lubricator and also demonstrates the use of a manifold distribution system for carrying the fog to the various machine elements.

How Micro-Fog Lubrication Works

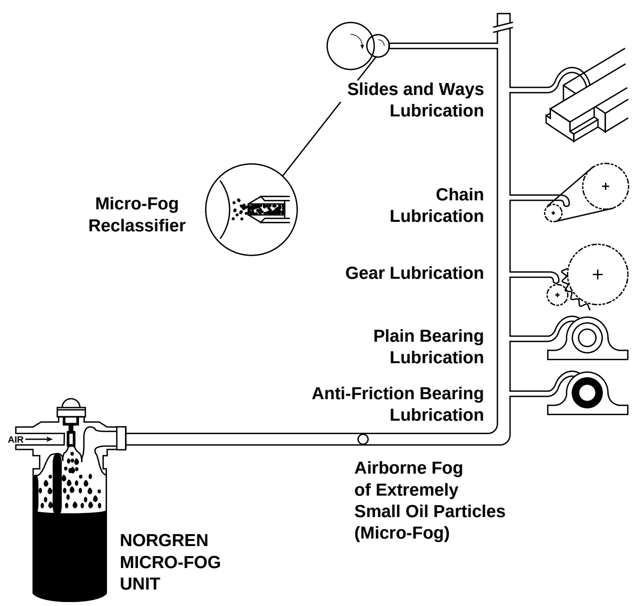


Figure 1

Basic Equipment Available for Micro-Fog Lubrication

Lubricator

The heart of the system is the lubricator. The lubricator is available with a wide selection of reservoir sizes. Proper sizing of the lubricator is important for efficient operation.

Filter-Regulator

To complement the lubricator, a filter (5 micron element) and pressure regulator must be used upstream of the lubricator. This will assure clean air delivered at the proper pressure.

Combination Units

A Norgren Micro-Fog Lubro-Control Unit is a combination of three Norgren units: an air line filter to remove the compressed air contaminants; a pressure regulator to accurately control pressure: and a Micro-Fog Lubricator.

Accessory Equipment

Accessory equipment to provide automatic control and to permit monitoring of the system is available for most units. Consult the Norgren catalog APC-104, Air Preparation Products or your local Norgren Distributor for detailed information.

Reclassifiers

Reclassifiers are nozzle-like fittings which convert the dry Micro-Fog into a wet usable oil. One must be used at each application point. Reclassifiers can be purchased as separate fittings, or made an integral part of the machine design.

Rating the Machine Lubrication Requirements

Bearing-Inch

The term Bearing-inch has long been in use as an arbitrary means of computing lubrication requirements for machine elements. The bearing-inch basically reduces all machine elements to a common denominator. After each machine element has been analyzed as to its bearing-inch requirement, the figures can be totaled to compute the actual bearing-inch requirements of the machine or machines to be lubricated. This rating is then used to select the proper Micro-Fog equipment. When selecting the lubricator make certain this bearing inch number falls within its specified range.

All dimensions are in inches when using the Bearing-inch System.

Lubrication Units

The Lubrication Unit is the metric equivalent of the Bearing-inch. All dimensions in this system are given in millimeters. When using the metric system, be certain that the formula for Lubrication Units is used. Metric dimensions cannot be used with the Bearing-inch formula. The resultant solution of either method when using correct units will yield equivalent numbers. Therefore,Lubrication Unit numbers and Bearing-Inch numbers can be used interchangeably when selecting a lubricator. In other words, a 30 Bearing-inch unit is also a 30 Lubrication Unit unit

For simplification, the term Bearing-inch will be used throughout this manual, but it should be kept in mind that it is numerically synonymous with Lubrication Unit

Figure 2 illustrates the Bearing-inch and Lubrication Unit concept.

How to Design for Micro-Fog Lubrication

Basic Design Procedure

There are five steps necessary in the design of a Micro-Fog Lubrication application. Each of these is covered in detail in this manual. The five steps are:

1. Determine the lubrication requirements of the machine by rating the machine elements.
2. Select the reclassifiers.
3. Determine the required lubrication capacity of the Micro-Fog lubricator by totaling the machine element reclassifier ratings.
4. Select the proper Micro-Fog Lubro-Control Products.*
5. Installation and adjustment.

These steps can be combined on a work sheet as shown on following page, see Figure 3. A more elaborate work sheet has been shown on page 17, Figure 39.

* Refer to catalog APC-104, page ALE-13-20 for selection of equipment.

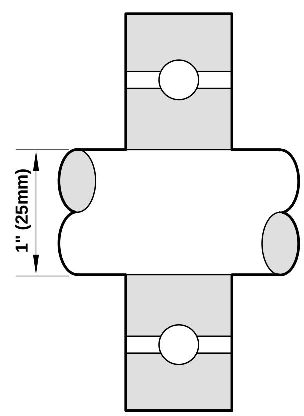


Figure 2
One B.I. or One L.U.

Rating the Machine Elements

Anti-Friction Type Bearings – Ball, Roller, and Needle Bearings

The bearing-inch requirement of anti-friction bearings is calculated by multiplying the shaft diameter by the number of rows and a load factor.

Equation No. 1

B.I. = D x R x LF

Where:

D = Shaft diameter in inches

R = Number of rows of balls, rollers, or needle bearings

LF = Load Factor governed by the type of bearing and degree of preload

LF = 1 for:
Ball, straight and tapered roller bearings without preload

LF = 2 for:
Spherical roller bearings without preload

LF = 2 for:
Ball bearings with initial preloading

LF = 3 for:
Spherical, straight and tapered roller bearings with preload

Assuming a load factor of "1", a single anti-friction bearing running on a one-inch shaft requires a one bearing-inch reclassifier. A four-inch shaft mounting a four-row anti-friction bearing would require sixteen bearing-inches of reclassifier rating (4 x 4 x 1 = 16).

Normally the speed of the bearing need not be considered for the purpose of these calculations.* The bearings in Figures 4 and 5 are of different types but in each case a one bearing-inch reclassifier would be required.

* NOTE: These calculations are good for DN numbers up to 250,000.

DN number = shaft diameter in mm x rpm

If the shaft is fractional in size, the next larger rating of reclassifier should be used.

Example:

Shaft diameter — 1.187 inches

Bearing — single-row, tapered, without preload.
Using Equation No. 1

B.I. = 1.187 x 1 x 1 = 1.187

Recommended: 2 bearing-inch rating reclassifier

Example:

Shaft diameter — 7.75 inches

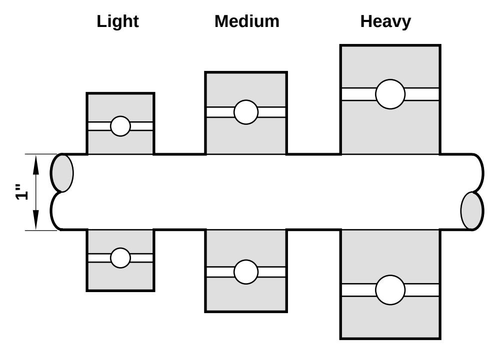
Bearing — double-row ball, without preload

B.I. = 7.75 x 2 x 1 = 15.5

Recommended: 20 bearing-inch rating reclassifier

Simplified Working Sheet					
Item No.	Item Identity	Item Dimensions	Bearing Inch Calculations	Reclassifier Rating	Reclassifier Part No.
1	Spindle	4" Long 3" Dia.	$\frac{4 \times 3}{4} = 3$	4	18-009-012
2	SKF	6"	6	8	18-009-014
3	Gears	2" x 4" 2" x 6"	$\frac{(4 + 6)\ 2}{4} = 5$	8	18-009-015
4	Hyatt	2" Shaft	2	2	18-009-010
5	Plain	6" Long 4" Dia.	$\frac{6 \times 4}{4} = 6$	8	18-009-015
6	—	—	—	8	18-009-015
Total 38					

Figure 3



All Three Are One Bearing Inch

Figure 4

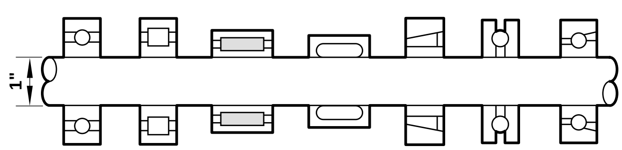


Figure 5

Tapered Roller Bearings

On tapered roller bearings (not pre-loaded) the reclassifier should be positioned to apply the lubricant on the small end of the rollers because of the natural pumping action of the rollers. The reclassifier should be located a minimum of 1/8 inch to a maximum of 1 inch from the bearing surfaces (see Figure 6).

Tapered Roller Bearing with Pre-Load

Tapered roller bearings with an initial pre-load require three times the lubrication of a non-preloaded bearing. This is accomplished by using two reclassifiers so that 1/3 of the lubricant is applied to the small end and 2/3 to the heel of the bearing (see Figure 7).

Example:

Shaft diameter – 3.375 inches

Bearings – pre loaded, single row, tapered roller

Actual bearing-inch – 3.375 x 1 x 3 = 10.125

Recommended: One 4 bearing inch rated reclassifier on small end and one 8 bearing-inch reclassifier on large end.

Heavily pre-loaded tapered roller bearings may require an oil sump in conjunction with delivery of lubricant through the reclassifier. The oil level should contact the lower rolls. The sump will provide lubrication during the starting revolutions.

Recirculating Ball Nuts

The bearing-inch rating of recirculating ball nuts is equivalent to the pitch diameter of the screw plus 10 percent for each row of balls additional to the first. The reclassifier should be directed at the approximate center of the loaded portion. No additional venting is necessary.

Equation No. 2

$$B.I. = d + .1\,(R-1)$$

Where:

d = Pitch diameter of screw in inches

R = Number of rows of balls

Plain Bearings

Bearing-inch rating of plain bearings are based on projected areas of the bearing surface. The bearing-inch rating is determined by multiplying the bearing length by the shaft diameter and dividing this product by eight.

Equation No. 3 (see Figure 8)

$$B.I. = \frac{D \times L \times LF}{8}$$

Where:

D = Shaft diameter in inches

L = Bearing length in inches

LF = Load factor

The static loading is determined by the mass load on each bearing in pounds divided by the projected area of the bearing in square inches.

Projected area = Shaft diameter x bearing length

Example: (Refer to Figure 9)

Shaft diameter = 2 inches

Bearing length = 2-3/4 inches

Static loading = 150 lbs/in^2

$$\text{Bearing inches} = \frac{2 \times 2.75 \times 2}{8} = 1.375$$

Recommended: 2 bearing inch rated reclassifier. Under normal bearing loading where static loading is not known, use a load factor of 2.

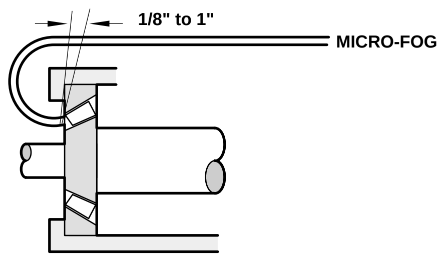


Figure 6

Preload Tapered Bearings (2)

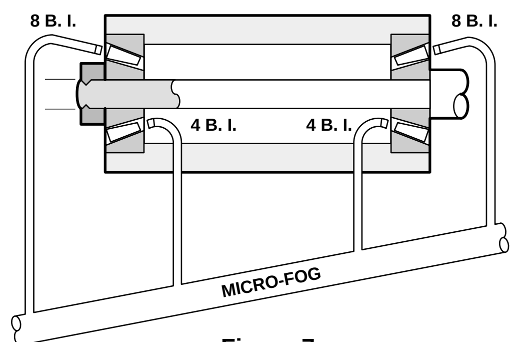


Figure 7

LF	Static Loading Projected Area lbs/in^2
1	Under 100
2	101 to 200
4	201 to 400
8	401 to 500

Figure 8

2 BEARING INCH RECLASSIFIER

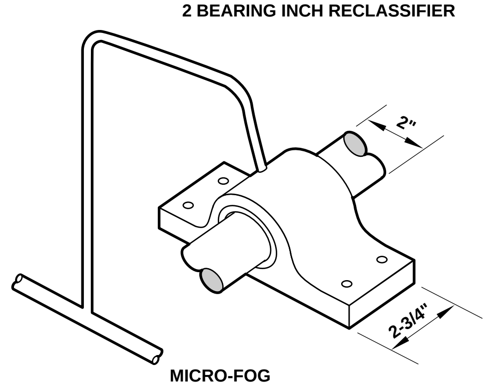


Figure 9

The reclassifier should be located to deliver oil to a longitudinal groove in the unloaded portion of the bearing. This grove should be approximately 90% of the length of the bearing cap. To make the groove the full length of the bearing cap would increase the end losses and defeat the distribution of oil along the length of the bearing (see Figure 10).

The groove location should be ahead of the load area as per Figure 11. This location is also satisfactory where the heavy load is at the top of the bearing on the working stroke and at the bottom on the return stroke.

The grove edges should be smoothly rounded to avoid scraping action (see Figure 11).

The optimum distance between the reclassifier and the shaft is 1/4-inch. The minimum is 1/8-inch and the maximum is 1-inch (see Figure 12).

Each six inches of bearing length or fraction thereof requires a reclassifier (see Figure 13).

Example:

Shaft diameter = 4 inches

Bearing length = 8 inches

LF = 2

Bearing-inches = $\frac{8 \times 4 \times 2}{8} = 8$

Required: 2 reclassifiers

Recommended: Two 4 bearing-inch rated reclassifiers fitted on the 1/4 points of the bearing length.

Grease-lubricated bearings are frequently found to have a figure “8” or “X” groove in the loaded portion of the bearing (see Figure 14).

These grooves will interrupt the formation of an oil film and should be eliminated before Micro-Fog lubrication is applied.

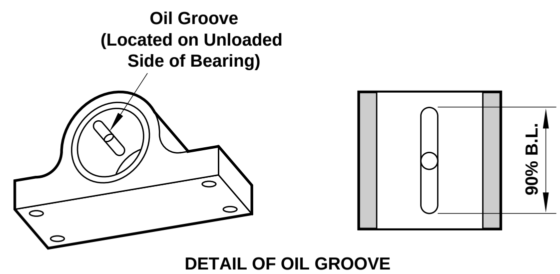


Figure 10

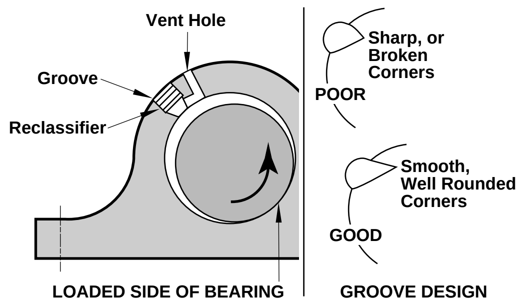


Figure 11

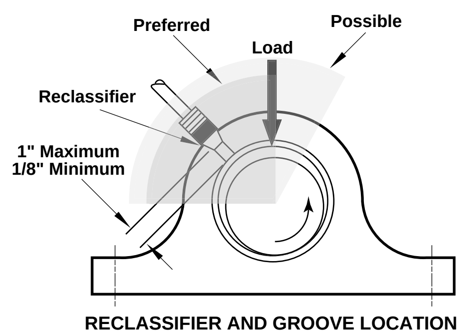


Figure 12

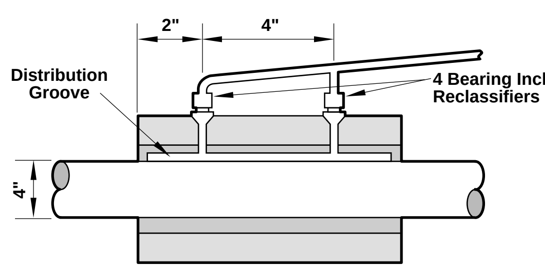


Figure 13

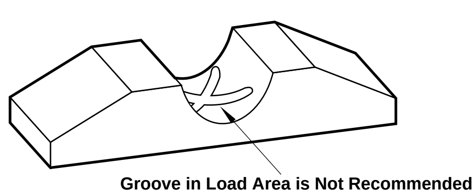


Figure 14

Oscillating Bearings

The bearing-inch calculation of an oscillating bearing is the same as a plain bearing. The number of reclassifiers required is dependent on shaft diameter and width. For shaft diameters of 1 inch or less, two reclassifiers are used diametrically opposed. For larger shafts, a minimum of two reclassifiers is required with the maximum number dependent on locating reclassifiers along the circumference no greater than 3 inches apart. Reclassifiers should be equally spaced (see Figure 15).

For horizontal bearings, each 6 inches of bearing length, or fraction thereof, requires a reclassifier.

For vertical bearings, the reclassifier should be set to deliver oil to a circumferential groove in the upper 1/3 of the bearing.

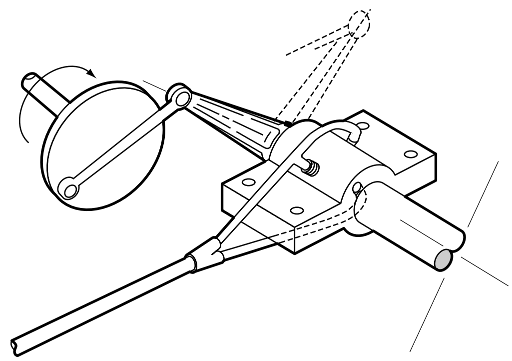


Figure 15

Venting of Bearings

The oil in Micro-Fog is carried to the point of application by means of an air stream. This air must pass through the bearing, thus carrying the oil directly to the bearing surfaces. Bearing seals obstruct the air flow and should be removed—at least on the side exposed to the Micro-Fog. The offside seals should be notched or removed (see Figure 16).

The minimum area of venting should be approximately twice the area of the reclassifier bore serving the bearing. Bearing caps will also require venting with appropriately located holes or grooves (see Figure 17.)

Care should be taken when lubricating double-row bearings from a central entry to see that vents on both sides are approximately equal in area. Labyrinth seals require no additional venting (see Figure 18).

Plain bearings must also be vented. Manufacturing tolerances are usually large enough to allow air to escape. If normal clearance is insufficient for venting, then additional venting must be provided.

A vent hole should be located on the same radial plane as the reclassifier entry hole and connected to it by a radial groove. This vent hole must be located with respect to shaft rotation as shown in Figure 11.

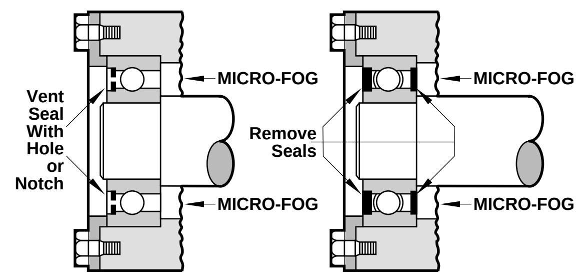


Figure 16

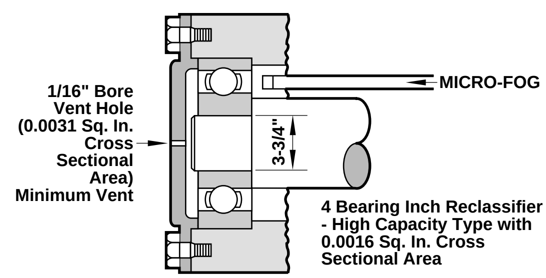


Figure 17

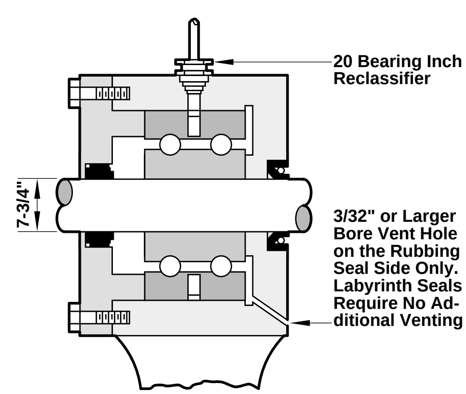


Figure 18

Gear Lubrication

Reclassifier ratings of gear pairs are determined by adding the pitch diameters, multiplying this sum by the face width, and dividing the product by four.

Equation No. 5

$$B\,I = \frac{F\,(P_1 + P_2)}{4}$$

Where:

F = Face width of gear in inches
P_1 = Pitch diameter of drive gear in inches
P_2 = Pitch diameter of driven gear in inches

Example: (Refer to Figure 19)

Drive gear = 4inch pitch diameter, 2-inch face
Driven gear = 7-3/4-inch pitch diameter, 2-inch face

$$\text{Bearing-inches} = \frac{2 \times (4 + 7.75)}{4} = 5.87$$

Recommended: 8 bearing-inch reclassifiers

Each two inches of gear face width, or fraction thereof, requires a reclassifier (see Figure 20). Gear pairs that are wider than two inches require more than one reclassifier. One reclassifier should be used for each two inches of gear width or fraction thereof.

Example:

Drive gear = 6-inch pitch diameter, 3-inch face width
Driven gear = 12-inch pitch diameter, 3-inch face width

Required: 2 reclassifiers (minimum)

$$\text{Bearing-inches} = \frac{(6 + 12) \times 3}{4} = 13.5$$

This must be divided between two reclassifiers; therefore, it is recommended that two 8 bearing-inch reclassifiers be located at the 1/4 points of the face width.

The above procedures are applicable on plain, spur, beveled, helical or herringbone gears operating at surface speeds up to 2000 feet per minute when using standard reclassifiers. From 2000 to 3000 feet per minute, pressure jet reclassifiers should be used. Information on pressure jet reclassifiers is given in the Reclassifier Table. For speeds above 3000 feet per minute, consult the factory.

Large-Ratio Gearing

If in a gear pair, the pitch diameters have a ratio greater than 2 to 1, use the following equation.

Equation No. 6*

$$B.I. = \frac{F\,(3P_1)}{4}$$

Where:

F = Face width of gear in inches
P_1 = Pitch diameter of smaller gear in inches
P_2 = Pitch diameter of larger gear in inches

*Use this equation where $\frac{P_2}{P_1}$ is equal or greater than 2.

Example: (Refer to Figure 21)

Drive gear = 2 inches face width,
13 inches pitch diameter
Driven gear = 2 inches face width,
36 inches pitch diameter

$$\frac{P_2}{P_1} = \frac{36}{13} = 2.77$$

$$\text{Therefore B.I} = \frac{2\,(2.77 \times 13)}{4} = 18$$

Recommended: 20 bearing-inch reclassifier

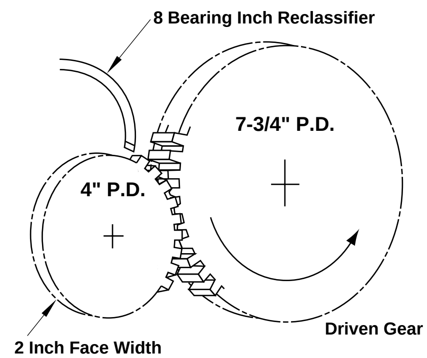


Figure 19

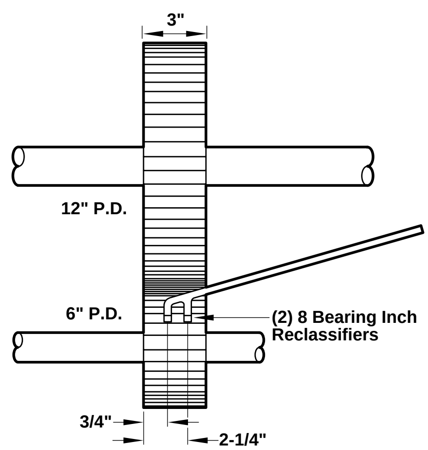


Figure 20

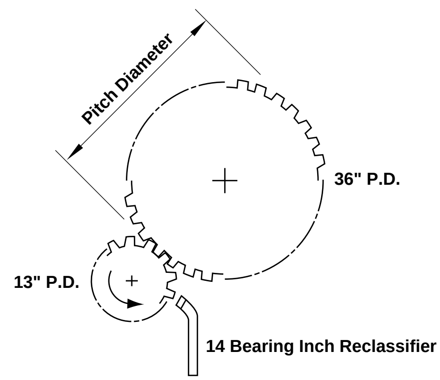


Figure 21

Gear Trains

Add together the pitch diameters of the gears and multiply this quantity by the gear face width divided by four. If the gear under consideration is greater than two times its mating gear, it should be considered to be twice the pitch diameter of this gear.

Equation No. 7

$$B.I. = \frac{F}{4}(P_1 + P_2 + P_3 + P_4 + \ldots)$$

If $P_n > 2P_{n \pm 1}$ consider $P_n = 2P_{n \pm 1}$

Where:

P_n = Gear under consideration

$P_{n \pm 1}$ Gear either before or after the gear under consideration

F = Face width of gear in inches

P = Pitch diameter of gear in inches

Reference Figures 22 and 23 for techniques in applying Micro-Fog to gear trains.

Reversing Gears

Reversing gears require twice as much lubrication (divided between 2 reclassifiers) as non-reversing gears, because both sides of the tooth must be lubricated (see Figure 22).

$$B.I. = \frac{2}{4}(3 \times 4) = 6 \text{ (Refer to Equation No. 6)}$$

Worm Gearing

Worm-drive reclassifier ratings are based on the projected areas of the worm and gear. The projected area of the worm is equal to its length multiplied by the pitch diameter. The projected area of the gear is found by multiplying its pitch diameter by its face width. The bearing inch rating is determined by adding the projected area of the worm to the projected area of the gear, and dividing this sum by four.

Equation No. 7

$$B.I. = \frac{(L_w \times P_1) + (P_2 \times F)}{4}$$

Where:

L_w = Length of worm gear in inches

P_1 = Pitch diameter of worm gear in inches

P_2 = Pitch diameter of spur gear in inches

F = Face width of gear in inches

Example: (Refer to Figure 25)

Worm length = 2 inches
Worm pitch diameter = 1.5 inches
Gear pitch diameter = 8 inches
Gear face width = 1 inch

$$\text{Bearing inches} = \frac{(2 \times 1.5) + (8 + 1)}{4} = \frac{3 + 8}{4} = 2.75$$

Recommended: 4 bearing inch reclassifier

Worm gears should have the reclassifiers directed toward the loaded side of the tooth of either the worm gear or the spur gear. Reversing worm gears require twice as much lubrication as non-reversing worm gears, since both sides of the tooth need to be lubricated. Reclassifiers should be located 1/8 inch minimum from the tooth face.

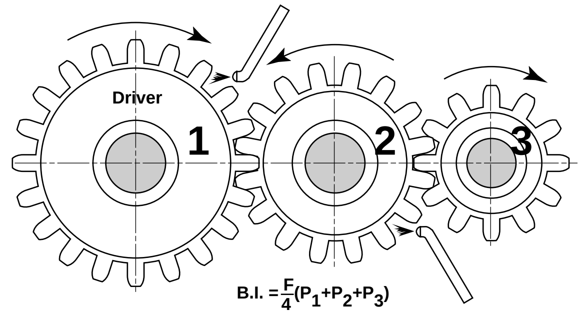


Figure 22

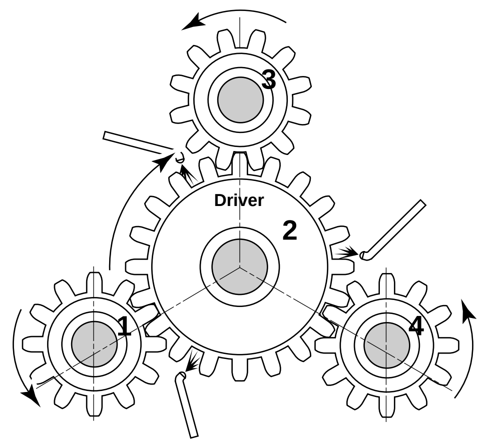


Figure 23

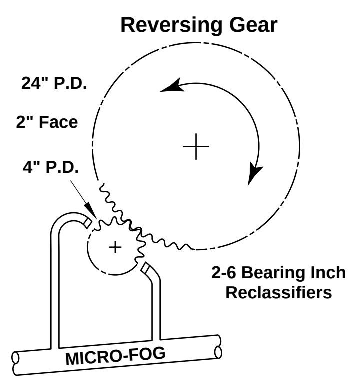


Figure 24

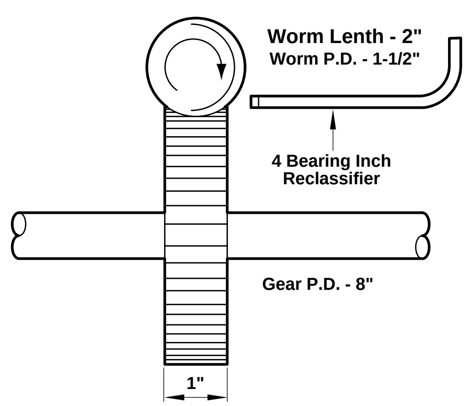


Figure 25

Rack and Pinion

In a rack and pinion the bearing-inch total is 1/2 the projected area of the pinion. If the pinion is reversing, that is loaded in both directions, a reclassifier should be applied to both sides of the gear.

Equation No. 8

$$B.I. = \frac{F \times P}{2}$$

Where:

F = Face width of pinion gear in inches
P = Pitch diameter of gear in inches

Reclassifier Location for Gears

On all gears the reclassifiers should be located at an optimum distance of 1/4-inch from the outside of the tooth, and not more than 1-inch or less than 1/8-inch away.

The preferred point of lubricant application is on the loaded side of the driving tooth, approximately 90° to 120° from the point of mesh (see Figure 26).

Cams

The bearing-inch rating for Cams is determined by multiplying the face width of the Cam by the maximum Cam diameter and dividing this product by 10 (see Figure 27).

Each two inches of Cam width, or fraction thereof, requires a reclassifier which should be located at an optimum distance of 1/4-inch from the Cam surface, and not more than 1 -inch or less than 1/8 inch away.

Equation No. 9

$$B.I. = \frac{F \times D_m}{10}$$

Where:

F = Face width of Cam in inches
D_m = Maximum diameter of Cam in inches

Slides and Ways

Normally, one (1) bearing-inch will service twenty (20) square inches of contact surface area.

Equation No. 10

$$B.I. = \frac{L \times W}{20}$$

Where:

L = Length of slide in inches
W = Width of contact in inches

Other considerations such as the physical size of the traveling member or the attitude of the member will also influence the total bearing-inch requirement.

Applications Techniques

The reclassifiers should discharge into grooves across the contact surface perpendicular to the direction of motion. The grooves should be similar to those described under plain bearings. Reclassifiers should enter the grooving so that there is sufficient air flowing for impingement and be positioned to give an impingement distance of from 1/8 inch minimum to 1-inch maximum.

When this slides and ways are nearly horizontal, the slides should have a reclassifier of one bearing-inch for every four inches of length, or fraction thereof, with the end reclassifier fitted within one inch of the leading and trailing edges. Every six inches of slide width (or contact width) will require a reclassifier. Sliding members under four inches in length require only one reclassifier.

Example No. 1

Slide length - 5 inches
Contact width - 5 inches

$$B.I. = \frac{5 \times 5}{20} = 1.25$$

Since the length exceeds four inches two reclassifiers are required. Since the width is less than six inches, no additional reclassifiers are required.

Recommended: 2 one bearing inch reclassifiers

Reclassifiers should be located on the center line, one inch from the leading and trailing edges (see Figure 28).

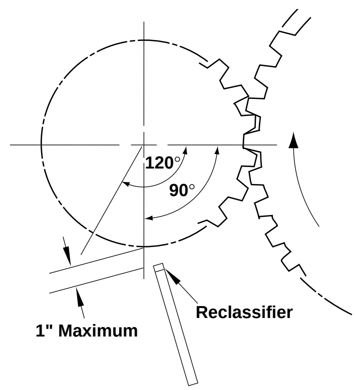


Figure 26

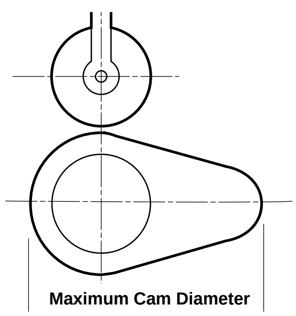


Figure 27

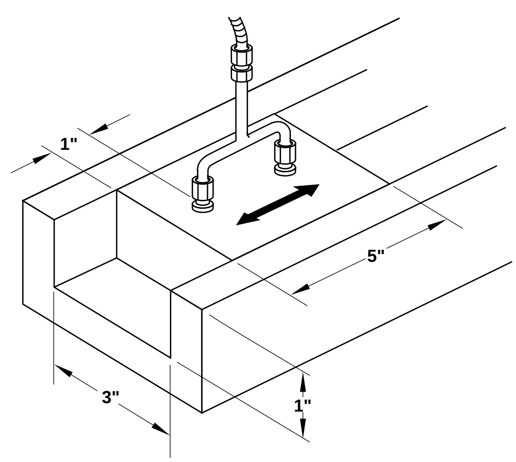


Figure 28

Example No. 2

Slide length - 10 inches

Contact width - 8 inches

Slide length exceeds four inches. 10/4 = 2-1/2 so three reclassifiers are required for distribution over the length. Width exceeds six inches. 8/6 = 1-1/3 so two rows of reclassifiers are required.

Recommended: 6 one-bearing-inch reclassifiers, spaced as shown in Figure 29.

Figure 30 illustrates one method of grooving the slide and for providing Micro-Fog access to the bearing surfaces. The same procedure for applying reclassifiers to horizontal surfaces can be applied to inclined or vertical slides.

Vertical Slides

Advantage can be taken of gravity by placing the reclassifiers near the top of the slide and allowing gravity plus grooving to distribute the oil. Every six inches of width, or part thereof, should have its reclassifier. These reclassifiers can be located at the top of the sliding portion and allow gravity to distribute the oil the length of the slide. Reclassifiers are sized by taking the contact area in square inches and dividing by 20.

Example:

Slide width = 3 inches

Slide length = 15 inches

$$\text{Bearing-inches} = \frac{3 \times 15}{20} = 2\text{-}1/4$$

Recommended: 1 four-bearing-inch reclassifier

Chains

The bearing-inch rating for simple drive chains comprised of a drive sprocket and driven sprocket can be calculated by using Equation 11 or 12.

Equation No. 11 for Roller Chains

$$B.I. = \frac{PDR\sqrt{\left(\frac{S}{100}\right)^3}}{8}$$

Where:

P = Chain pitch in inches (Figure 31B)
D = Diameter in either sprocket in inches (Figure 31A)
R = Chain rows for multiple strand roller chains
S = Speed in rpm of the sprocket used for “D” (If speed is less than 200 rpm, use 200 rpm in calculations)

Equation No. 12 for Silent Chains

$$B.I. = \frac{WD\sqrt{\left(\frac{S}{100}\right)^3}}{15}$$

Where:

W = Chain width in inches
D = Diameter of either sprocket in inches
S = Speed of the same sprocket in rpm (If the speed is less than 200 rpm, use 200 rpm in calculations)

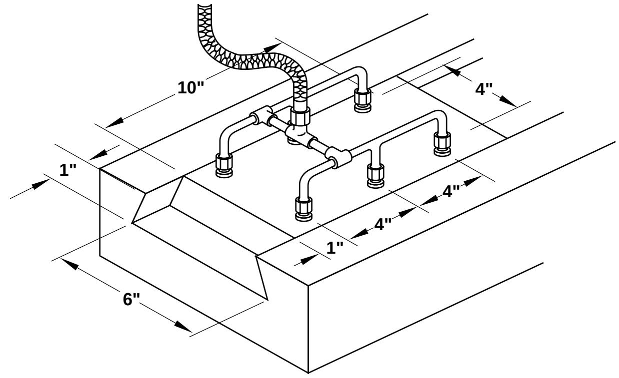


Figure 29

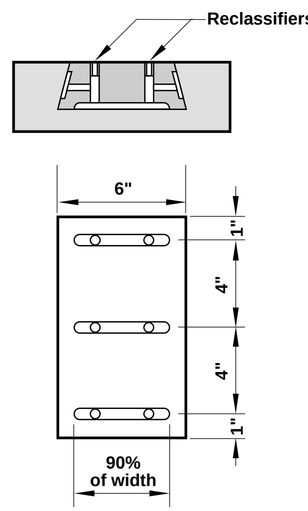


Figure 30

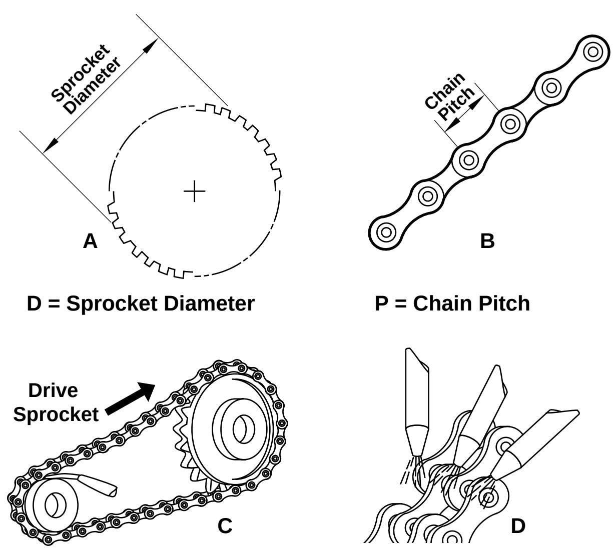


Figure 31

If the chain is completely enclosed, only 1/2 of the bearing inch rating as calculated need be used.

For each sprocket beyond two, the total reclassifier rating should be increased by 10%.

At surface speeds up to 2000 feet per minute, standard reclassifiers can be used. From 2000 to 3000 feet per minute, pressure-jet reclassifiers should be used. (See Reclassifier Table, Figure 36.) For speeds above 3000 feet per minute, consult the factory.

On single roller chains, the bearing-inch rating as determined from Equation 11 should be divided so that one reclassifier points at each row of side plates. Micro-Fog application to a double-row roller chain is illustrated in Figure 31D.

On double-row and wider chains the center rows of side plates should get twice as much lubrication as each outside row. For instance, a triple-row chain requiring 24 bearing inches should have 4 bearing-inches on each outside row. Thus, the reclassifiers across the chain width would read 4 - 8 - 8 - 4.

Silent chains should have equally rated reclassifiers every half-inch of width, starting 1/4inch in from the outside edges

On all chains, the reclassifiers should point slightly against the chain motion and should be within one inch of the chain. The preferred point of application is inside the chain as it leaves the drive sprocket, since here the chain is slack and the oil can penetrate (see Figure 32). By applying oil on the inside surface, centrifugal force around the next sprocket will tend to pass the oil through the chain.

Before running a new chain, it should be washed free of grease and then soaked in oil.

Selecting the Reclassifiers

General

Reclassifiers are nozzle-like fittings which reclassify the dry fog into a wet usable oil. They should be used at each application point. Reclassifiers also proportion the Micro-Fog to the various points of application in accordance with the bearing inch requirement.

Basic reclassifier ratings are: 1, 2, 4, and 8 bearing-inches. When calculating the requirements of machine elements, choose the next highest rated reclassifier whenever calculations give a result between any two available ratings.

Basic Reclassifier sizes are shown in Figure 36.

Figure 33 Illustrates the various configurations available.

When it is not possible to install fitting-type reclassifiers due to space limitations it is usually possible to drill appropriate sized nozzles into the housing or bearing spacers to permit fog impingement on the bearing surface. Refer to Figure 34. Consult the bore diameter and minimum length figures on Figure 36 (Reclassifier Table) for proper dimensions.

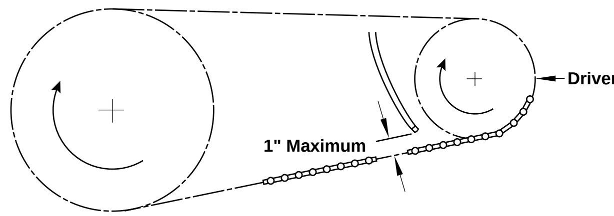


Figure 32

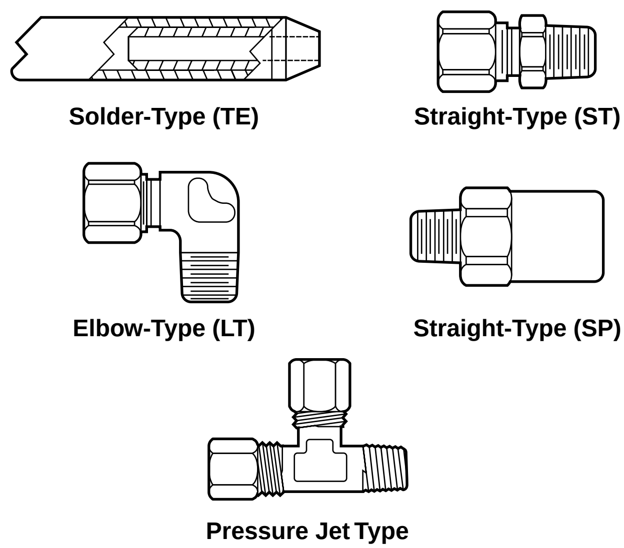


Figure 33

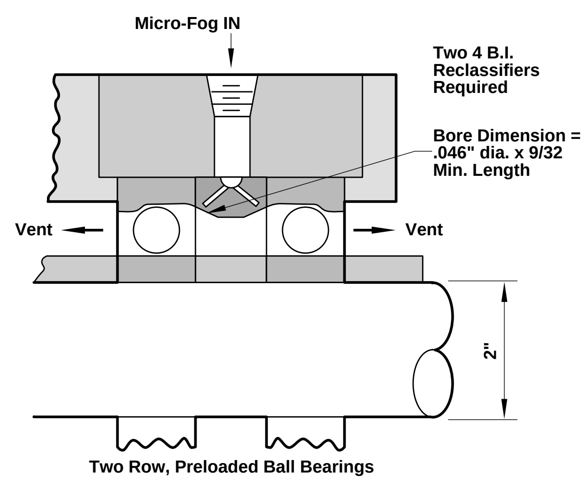


Figure 34

Reclassifier Selection

Reclassifiers are rated according to the amount of oil they will deliver. An eight-bearing inch reclassifier will deliver approximately four times as much oil as a two-bearing inch reclassifier (See Figure 36 – Reclassifier Table).

Lubro-control units with a bearing -inch capacity of 32 or less should be fitted with reclassifiers based on the ratings given in Figure 36 (Reclassifier Table).

For some gear and chain applications, pressure-jet reclassifier are required. These should be selected from the appropriate listing in Figure 36 (Reclassifier Table). Pressure-jet reclassifiers incorporate the standard type of reclassifier with an auxiliary source of air jetting along the reclassifier axis. The result is the delivery of lubricant with sufficient force to penetrate the boundary-air layer common to high speed parts. They require an auxiliary supply of filtered air at a pressure of 10 to 12 psi. They may be connected as shown in Figure 35.

When using pressure-jet reclassifiers, a connection can be made in the line between the filter and regulator to supply the required air. A Norgren pressure regulator and pressure gauge should be used in the auxiliary line to the reclassifier to supply the 10 to 12 psi pressure.

As will be noted in Figure 36 (Reclassifier Table), each size reclassifier has its characteristic bore and minimum length of bore. If it is preferred, the reclassifiers may be integrated into the machine element by locating orifices of these dimensions at the lubrication points (see Figure 34). It may be convenient to use a small-bore tubing as a reclassifier, particularly to inaccessible bearing locations The small-bore tubing should have an I.D. and length similar to the reclassifier bore. The use of such tubing frequently simplifies installation at some points.

SIZING THE SYSTEM

TOTAL BEARING-INCHES

After the bearing-inch requirement has been determined for each individual point of application, they should be totaled. This total bearing-inch quantity then serves as a basis for selecting the proper lubricator. To facilitate calculating bearing-inch requirements, a Work Sheet, Form NS-3, is available from your Norgren distributor or can be obtained from Norgren. This form is illustrated in Figure 40.

The figure for the calculated bearing inch requirement will generally be larger than the machine's actual bearing inch total since standard reclassifiers are available in increments of 1, 2, 4, and 8.

EXAMPLE PROBLEM

Figure 37 shows a machine tool which is to be converted to Micro-Fog lubrication. The analysis of the individual lubrication points is shown on Figure 39. The final plumbing configuration is illustrated in Figure 38.

Estimating the Required Lubricator Capacity

There are two factors which influence the selection of lubricator capacity:

1. The total bearing inch being served.
2. The frequency with which it is desirable to refill the lubricator reservoir.

For estimating purposes. the rate of oil usage is approximately .01 fluid ounce per hour per bearing inch for lubricants having a viscosity of less than 700 SSU at 100°F. In actual practice there is a considerable variance in this figure due to a multiplicity of variable operating conditions and the fogging ability of the oil selected for the application.

Rate of Oil Consumption =
.01 x total bearing inches = fluid oz./hr.

Example: 25 bearing-inches total rate of oil consumption =
.01 x 25 = .25 fl. oz./hr.

Tank Selection = Determine tank size most suited to your application by multiplying fluid ounces per hour by hours of operation desired between refill.

Example: 100 hours of operation desired

$$\frac{.25 \text{ fl ozs}}{\text{hrs.}} (100 \text{ hrs.}) = 25 \text{ fl. ozs}$$

Referring to Figure 41, a 2-quart tank or larger should be selected, based on a working capacity of 40 fluid ounces.

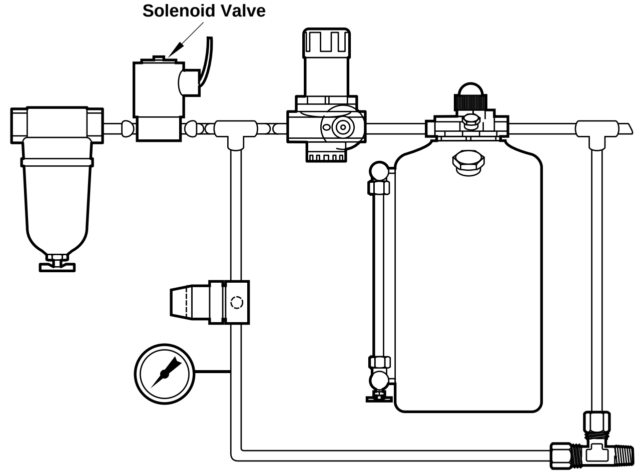


Figure 35

How to Design for Micro-Fog Lubrication

Reclassifier Table						
Reclassifier Bearing Inch Rating When Used With:		Reclassifiers		Bore Dimensions – Reclassifier		
10-015 Type Lubricators 8 to 32 B.I.		Type Connection	Number*	Diameter	Minimum Length (in.)	Area in Sq. Inches
		Solder (TE) Straight Tube (ST) Elbow Tube (LT) Straight Pipe (SP)				
0 to 1		TE ST LT SP SP	18-009-024 18-009-003 18-009-008 18-009-001 18-009-002	.046 (#56 Drill)	9/32	.00166
1 to 2		TE ST LT SP	18-009-034 18-009-010 18-009-011 18-009-016	.062 (1/16" Drill)	3/8	.00307
2 to 4		TE ST LT SP SP	18-009-029 18-009-012 18-009-013 18-009-005 18-009-006	.093 (#42 Drill)	9/16	.0069
4 to 8		ST LT SP	18-009-014 18-009-015 18-009-007	.129 (#30 Drill)	11/16	.0131
Pressure Jet Reclassifiers for High Speed Chains, Gears, Etc.				Equivalent Bore Diameter	Auxiliary Air Requirements cfm at 10 psi	
0 to 1		Pressure Jet Type	18-009-030	.046	0.28	
1 to 2			18-009-031	.062	0.28	
2 to 4			18-009-032	.093	0.28	

* Refer to Figure 51

Figure 36

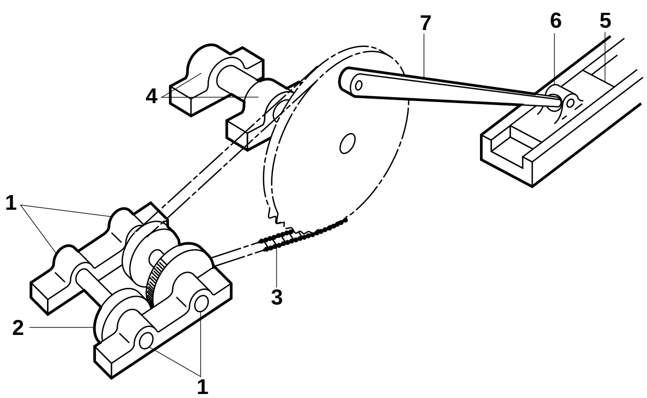


Figure 37

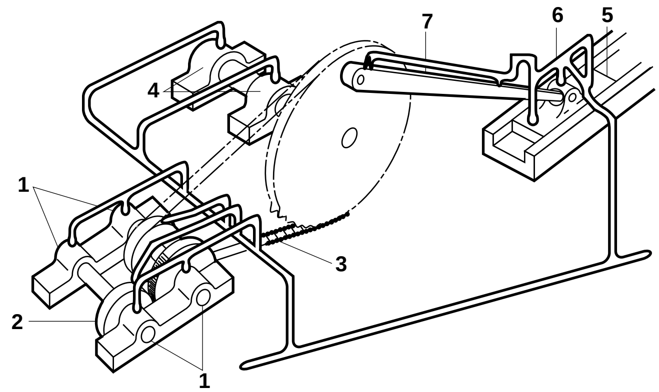


Figure 38

Working Sheet

For use with Norgren Application Design Manual NT-1

Firm ______________________________ Date ______________________________

Address ______________________________ Reference Dwg ______________________________

Machine ______________________________ Lubricant Used ______________________________

System Required ______________________________ Sketch Attached Yes __________ No __________

Ambient Temp __________________ ° F ________

Figure Ref. No.*	Identification of Lubrication Point	Quantity	Size (in.)†	Type & Manf.	Speed (RPM)	Calculations	Reclassifier		Bearing Inches	Reclassifier Type‡
							Rating x	Quantity =		
1	Ball Bearing (no preload)	4	2.187 Shaft D	SKF	2-1750 2-1160	(2.187 x 1) = 2.187 B.I.	4	4	16	Four 18-009-013
2	Gear pair	1	2" Face Width	SPUR	1750	$\frac{(6 + 9) \times 2}{4} = 7.5$ B.I.	8	1	8	One 18-009-014
3	Roller Chain	1	6" P.D. & 9" P.D. .75" Pitch Single Row 8" Sprocket Diam.		1160	$\frac{.75 \times 8 \times 1\sqrt{\left(\frac{1160}{100}\right)^3}}{8} = 29.6$	4	8	32	Eight 18-009-032
4	Plain Bearings Load=102 lbs./in.^{2}	2	4" Shaft D. 4" Length		350	$\frac{4 \times 4 \times 2}{8} = 4$	4	2	8	Two 18-009-005
5	Horizontal Slide	1	5" Length 3" Projected Width			$\frac{5 \times 3}{20} = 0.75$	1	2	2	Two 18-009-003
6	Plain Bearing Load as for #4	1	1.5" Shaft D. 1" Length			$\frac{1.5 \times 1 \times 2}{8} = 0.38$	1	1	1	One 18-009-003
7	Plain Bearing Load as for #4	1	2" Shaft 1.5" Length			$\frac{2 \times 1.5 \times 2}{8} = 0.75$	1	1	1	One 18-009-003
							§ Total Bearing Inches		68	

Figure 39

* Reference number should be used on sketch or drawing for clarification of points being lubricated.

† Dimensions Required:

§ Refer to Norgren Catalog for Machine Lubrication sheets for proper equipment selection; this is determined by total BI required.

‡ Refer to Figure 36 for proper reclassifier selection.

Additional blank copies of this work sheet available from your Norgren Representative.

Working Sheet Form NS-3
For use with Norgren Application Design Manual NT-1

Firm ____________________ Date ____________________

Address ____________________ Reference Dwg ____________________

Machine ____________________ Lubricant Used ____________________

System Required ____________________ Sketch Attached Yes __________ No __________

Ambient Temp __________ ° F __________

Figure Ref. No.*	Identification of Lubrication Point	Quantity	Size (in.)†	Type & Manf.	Speed (RPM)	Calculations	Reclassifier Rating x	Quantity =	Bearing Inches	Reclassifier Type‡

Figure 40

Total Bearing Inches

* Reference number should be used on sketch or drawing for clarification of points being lubricated.

† Dimensions Required:

Refer to Norgren Catalog for Machine Lubrication sheets for proper equipment selection; this is determined by total BI required.

‡ Refer to Figure 36 for proper reclassifier selection.

Additional blank copies of this work sheet available from your Norgren Representative.

Selecting the Lubro-Control Unit

General Requirements

There are three main criteria for selecting the proper Micro-Fog Lubro-Control unit:

1. Bearing-inch capacity
2. Reservoir size
3. Accessory equipment (Filter-Regulator)

The bearing-inch capacity requirements and the sizing of the reservoir were covered earlier in the section entitled “Sizing the System.”

Lubricators

Lubricators are rated from 8 to 32 bearing inches. These can best be identified by their 1/4-inch NPT port size and by the separate drip rate and air by-pass controls located adjacent to the sight dome. These lubricators use the “10-015” lubricator head in the following product numbers: 10-015,
10-065.

Norgren machine lubricators are normally identified by their maximum bearing-inch rating, i.e., 32 B.I.

When selecting reclassifiers make certain that these selections are based on the proper type lubricator.

Accessory Equipment

The use of accessory type equipment will depend upon the degree of sophistication the customer wishes to achieve. A simple on-off solenoid valve can be provided to permit the Lubro-Control unit to be cycled with the machine it is serving. Pressure switches can be provided to monitor line or manifold pressures. Liquid level switches are available to provide warning signals for low oil level or for indicating high and low oil levels. Pressure relief valves, pressure gauges, and other devices are also available for the control, safety or monitoring of the total lubrication system. A 5-micron filter and an air pressure regulator should precede each lubricator.

Nominal Reservoir Size	Reservoir Working Capacity*	
1/2 pint	5.00 fl. oz.	148.0 ml.
1 quart	19.00 fl. oz.	562.0 ml.
2 quart	40.00 fl. oz.	1.2 liter
2 gallon	114.00 fl. oz.	3.4 liter
5 gallon	315.00 fl. oz.	9.3 liter

Figure 41

* Working capacity indicates the range between the minimum and maximum oil levels of the reservoirs for proper lubricator operation. This is the amount of oil which can normally be consumed between refills. In the case of large tanks equipped with a sight glass this figure will vary considerably from total actual tank capacity. The working capacity figure should be used when determining the time interval desired between refills.

Systems Installation

Distribution Lines

Distribution lines, or manifold lines as they are frequently referred to, are used to convey the Micro-Fog from the lubricator to the point of application. Distribution lines should be sized according to the bearing-inch loading being served. Figure 42 lists the recommended distribution line sizes for systems up to 32 bearing-inches.

Distribution plumbing should not be smaller than the minimum size as listed in Figure 42. In general use smooth bore plumbing having a cross-section area approximately equal to six times the aggregate reclassifier area being serviced. All piping should be smooth and clean. Unnecessary bends, fittings, etc., should be avoided to eliminate turbulence in the transmission system. Do not use street ells in transmission system. The system must be flushed clean during installation to eliminate scale and dirt that could plug the small reclassifier bores.

The reclassifiers should be installed at a minimum distance of 1/8-inch and a maximum of 1-inch from the bearing surface to be lubricated.

In an extensive system, there may be some “wetting out” of the Micro-Fog in the plumbing due to plumbing wall friction and unavoidable turbulence. Over a long period of time this may collect in a low spot and block further Micro-Fog delivery to reclassifiers beyond that point. To avoid this, all plumbing should be pitched 1-1/2° either toward the reclassifier or toward the Lubro-Control unit. Avoid all down loops in transmission plumbing (see Figure 43). Flexible lines should be looped upward.

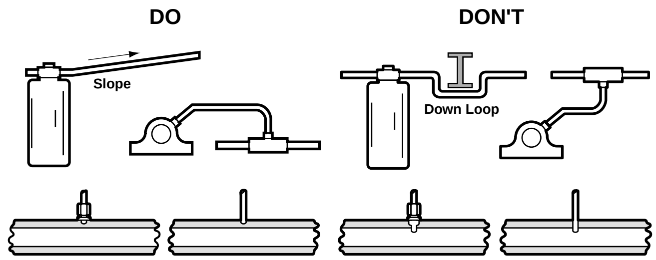
In any system where it is impractical to avoid all down loops a sump can be installed at a pre-planned low point to facilitate collection and drainage of accumulated oil.

Figure 44 illustrates the sizing of distribution lines.

NOTE: All lubricators should be preceded by an air pressure regulator. The Micro-Fog bearing lubricator operates on a balance of operating pressure and manifold pressure against the reclassifiers. The output of the lubricator with respect to oil/air ratio can be controlled by balancing operating pressure with by-pass air. CAUTION: DO NOT ADJUST THE PRESSURE REGULATOR BELOW THE NORMAL OPERATING RANGE SPECIFIED IN THE SPECIFICATION TABLE AND IN ACCORDANCE WITH THE BEARING-INCH RATING OF THE UNIT.

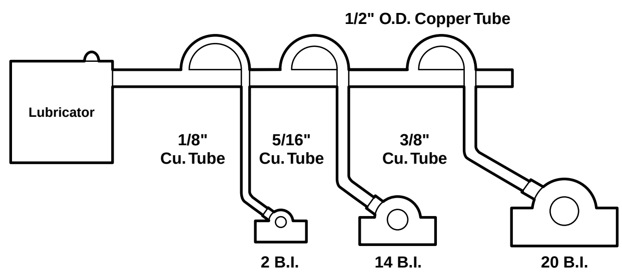
Distribution Pipe Size			
Nominal Pipe Sizes	Bearing Inches Served		Internal Area in Sq. Inches
Copper Tubing	10-015 Type Lubricators		
1/8" (.032 wall)	1		.0027
1/4" (.032 wall)	8		.0272
5/16" (.032 wall)	14		.0487
3/8" (.032 wall)	20		.0760
1/2" (.065 wall)	32		.1070
Iron Pipe (Sched. No. 40 or Equivalent)			
1/8"	16		.0570
1/4"	32		.1040

Figure 42



Method of Tapping Manifold

Figure 43



Total Bearing Inches 36 B.I.

Figure 44

SELECTION OF LUBRICANTS

GENERAL

Lubricants should be selected upon the basis of their performance with Micro Fog lubricators.

Some lubricants, when atomized, produce a large percent of very fine particles which do not reclassify at normal lubricator settings. These fine particles will appear as smoke (stray fog) escaping from the bearings. The stray fog, having already escaped from the bearing, will not lubricate. A slight amount of stray fog venting from a bearing is normal and is frequently used an an indicator that Micro-Fog is being delivered to the bearing.

Other lubricants display a large percent of very heavy particles when atomized which never enter the distribution lines or wet-out quickly in the manifold and never reach the reclassifiers. Obviously this would result in insufficient or no lubrication.

Many oil companies have recognized this problem and have developed special mist lubricants. Today a wide selection of mist lubricants is available. Many other commonly used oils have also proven effective for Micro-Fog lubrication Norgren distributor/representatives have lists of oils that have been evaluated for use in Norgren lubricators.

In general, compounding oils containing graphite, soap filler, or which are highly detergent are not recommended. Extreme pressure oils and certain suspensions of graphite and molybdenum disulphide may be used if recommended for the application by your lubrication engineer.

When selecting oils, select the lightest oil (lowest viscosity) that will give satisfactory lubrication. Standard Norgren Micro-Fog lubricator units will operate on oils up to 700 SSU at 100°F

Your oil company and bearing manufacturer can usually recommend the proper oil, and in most cases will know what oil is suitable for use in Micro-Fog lubricators. Some companies prefer to use heavier oils to retain lubricant at points requiring lubrication overnight or during extended machine shutdown.

Incoming and ambient air temperature can dramatically affect the viscosity of an oil. A temperature reduction of 20°F can result in a two-fold increase in the viscosity of many oils (see Figure 45).

The marketing data sheet (refer to Figure 46) summarizes the performance of the oil by listing the oil output at the reclassifier, which is an indication of the actual usable oil, and by categorizing the total lubricator output into percentage of output at the reclassifier, manifold losses and stray fog. The oils are then rated A, B, C, or D, depending upon their reclassified output. The distribution output percentages can be used to indicate potential problems such as excessive stray fog or manifold drop-out. For example, in a confined area the stray fog content should be as low as possible. In a large well-ventilated steel mill this would not impose a problem.

Some oils display a rather rapidly changing output when atomized due to the additives and blending of the particular oil. This characteristic is analyzed by the “stability factor” column which indicates the degree of change which may be expected. This is an arbitrary figure and should only be considered as a guideline when selecting oils.

The compatibility with polycarbonate column indicates whether or not the oil can be used with polycarbonate plastic materials. Most transparent plastic reservoirs and sight-feed domes are polycarbonate. If the oil is incompatible with polycarbonate it may be possible to use it in a system containing a metal reservoir and pyrex sight-feed dome.

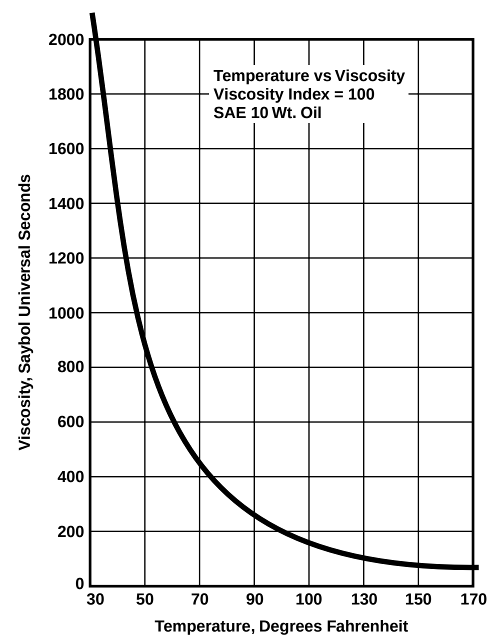


Figure 45

The Norgren Laboratory has tested the lubricants below only to determine their suitability for use in the 20 to 1000 Bearing Inch Micro-Fog Machine Lubricators. Testing in accordance with Norgren Standard Test Procedure No. 8a resulted in the values indicated. The ratings are based on the output of the high capacity (20 – 1000 B.I.) Lubricators. Low capacity (8 – 32 B.I.) Lubricators contain a drip control which permits output adjustments. Lubricants suitable for use with high capacity lubricators will most generally be satisfactory with low capacity units. Low capacity units can be identified by the 1/4" NPT threads in the lubricator head.

Note: Large capacity units are special order products.

Lubricant Identification	Date of Test	Viscosity SSU @ 100°F	Test Temp.°F		Reclassifier Output		Distribution of Output in Percent			Rating	Stability Factor	Compatible with Polycarbonate
			Oil	Air	Grams/Hr. /scfm	Fl. Oz./Hr. /100 B.I.	Reclassifier	Manifold	Stray Fog			
Sample "A"		300	72	72	16.44	1.57	55.1	37.6	7.3	A	+1	Yes
Sample "B"		115	72	73	16.46	1.59	54.9	42.3	2.8	A	+2	No
Sample "C"		2000	105	72	2.00	.195	26.9	71.0	2.1	D	+1	Yes
Sample "C"		2000	130	72	10.98	1.04	39.0	57.9	3.1	A	+3	Yes
Sample "D"		1000	73	74	2.32	.222	28.8	69.4	1.8	C	+2	Yes
Sample "D"		1000	103	73	16.69	1.59	44.6	51.0	4.4	C	+1	Yes

Lubricant Manufacturer	Rating	Indication of Output at Reclassifiers	Stability Factor	Indication of Output Change with Time	Page
Brand XYZ	A. B. C. D.	Very Good Output Satisfactory Output Limited Output Unsatisfactory	Stability Factors range from "1" thru "4" A "1" Factor indicates a stable oil with relatively constant output and a "4" Factor an oil which displays a very large output change with time. Plus and minus values indicate whether this change is an increasing or decreasing output		

Figure 46

Start-Up and Adjustment of Lubrication System

1. Make certain that all distribution lines have been properly cleaned, and that all reclassifier bores are open.
2. Make certain that all plumbing connections have been made.
3. Check out electrical equipment for proper operation.
4. Fill the reservoir with clean oil of proper viscosity.

   Reference section on ‘Selection of Lubricants.

   CAUTION: DO NOT OVERFILL. Oil level should always be visible in sight glass.
5. Turn on air supply to Lubro-Control unit.

   Note: If an automatic drain filter is used, a pressure of 5 to 8 psig must be reached before the drain valve closes.
6. When used, energize solenoid valve to supply air to regulator and lubricator.
7. Adjust air pressure regulator to supply proper pressure to lubricator.

   Reference: Catalog APC-104 specification table under Operating Pressure - psig.
8. Refine adjustment by monitoring manifold pressure. With air-pass closed, adjust regulator to achieve desired manifold pressure. Normal manifold pressure is between 8 inches to 15 inches water column pressure. Regulated pressure to lubricator should not fall below 6 psig and should not normally exceed 40 psig. If proper manifold pressure cannot be achieved on larger systems at 40 psig, open air by-pass. Manifold system pressure should be operated at an absolute minimum of 8 inches water column.
9. For verification that unit is producing Micro-Fog, the following checks should be made.
   a. There should be evidence immediately upon adjusting the air pressure that oil is being pumped and visible at the sight dome on the lubricator.
   b. Check the manifold pressure gauge for proper manifold pressure.
   c. Disconnect one of the feed lines from the manifold system at a point downstream of the lubricator and visually observe the presence of Micro-Fog.
10. When excessive lubricant is being delivered, reduce regulator pressure and open air by-pass to maintain manifold pressure. Do not decrease regulated pressure below 6 psig.
11. For unique applications where high manifold pressures are required, such as for additional cooling or additional pressure for keeping out contaminants, it may be necessary to add an air by-pass kit. (See accessories on page 19.)
12. Raising the manifold pressure above 8 inches of water column pressure increases the velocity through the reclassifier, This makes more particles “wet out” as usable oil and reduces stray fog.
13. Raising the manifold pressure above the recommended 15 inches water column pressure may cause an excessive wetting-out of oil in the distribution lines due to the increased velocity.
14. On all units only a fraction of the oil passing through the sight-feed dome is converted to Micro-Fog.

    Reference section on “Selection of Lubricants.

Initial Adjustment and Start-Up

The system MUST be designed and installed per the Norgren "Micro-Fog Machine Lubrication Application Design Manual" NT-1.

1. Fill the reservoir with clean oil of the proper viscosity. Select oil on the basis of recommendations by the lubricant supplier or equipment manufacturer Any lubricant used should be factory tested to insure that the lubricant can be successfully atomized and reclassified in quantities sufficient to provide lubrication Norgren catalog, NT-3, ***Lubricant Evaluation Data for Micro-Fog Lubrication Systems,*** provides test information on previously tested lubricants.

   CAUTION:

   Do not overfill The oil level must always be visible in the sight glass on the lubricator reservoir to assure proper operation of the lubricator.

   An airline filter with a 5-micron element shall be installed immediately ahead of the lubricator and regulator.

2. Install an inches of water column gauge in the downstream manifold system at the most remote point from the lubricator

   NOTE:

   If an inches of water column gauge is not available, set up a water container as described on back page.

3. Close (turn fully clockwise) the oil flow adjusting screw and by-pass air adjustment (see Figure 47).

4. ***Initial Air Pressure Adjustment.*** Apply air pressure to the lubricator (turn regulator adjustment clockwise) to obtain the applied pressure (psig) specified in Figure 51 for the bearing inch requirement of the lubricator.

5. ***Final Air Pressure Adjustment.*** The critical setting with bearing lubrication is manifold pressure. Readjust air pressure to the lubricator to obtain 15 inches of water column pressure in the downstream manifold system (the most remote point from the lubricator where the inches of water column gauge was installed).

   NOTE:

   The applied pressures specified in Figure 51 should provide the required 15 inches of water column pressure. These pressure settings, however, are only approximate. It may be necessary to slightly increase or decrease applied pressure to obtain 15 inches of water column pressure. If wide deviations from the specified pressure settings are required to obtain 15 inches of water column pressure, examine the system for plugged passageways and reclassifiers, open ports and missing reclassifiers.

6. On model equipped with a by-pass air adjustment (Figure 47), manifold pressure in excess of 15 inches water column may be obtained by turning the by-pass adjustment counterclockwise Manifold pressure in excess of 15 inches water column may be desired for the following reasons.

   - To achieve high velocity through the reclassifiers to assist in oil reclassification when stray fog is a problem.
   - To obtain a more positive pressure in the bearing housings to exclude contaminants in a severely contaminated atmosphere.
   - To provide more air for additional cooling of the bearings

   The by-pass air adjustment allows a portion of the air to pass thru the lubricator into the manifold without passing thru the fog-generator. Monitor the bearings being lubricated for a few days. Decrease oil flow if oil delivery is excessive (oil dripping off bearings indicates excessive oil delivery). In addition, too much oil as well as not enough oil may cause the bearings to run hot. Oil flow may be adjusted to obtain the coolest bearing operating temperature.

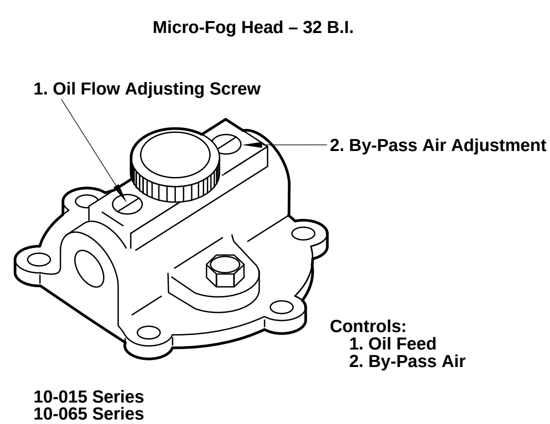


Figure 47

Trouble Shooting List

Use for determining possible cause and remedy of a malfunction in a Machine Lubrication System.

Malfunction	Possible Cause	Remedy
Unable to reduce manifold pressure	Too much air by-pass	Reduce air by-pass
	Operating pressure to lubricator too great.	Reduce regulator pressure. CAUTION: Do not reduce below recommended pressure
	Restriction in distribution system.	Make certain that any valves used in the distribution line are wide open.
	Plugged reclassifiers.	Remove and clean orifices.
	System undersized for lubricator being used.	Use lubricator with lower B.I. rating, or if possible add lubrication points.
	Undersized reclassifier.	Check for correct bore diameters. Replace if necessary
	Flow restriction through bearing.	Check for proper venting from bearing.
Unable to increase manifold pressure.	Air by-pass required	Open air by-pass on lubricator head. If additional air by-pass is required, it may be necessary to add an air by-pass kit.
	Operating pressure too low.	Increase pressure to lubricator. Do not exceed recommended pressures.
	Broken line in distribution system.	Repair.
	System oversized for lubricator being used.	Use lubricator with higher B.I. rating.
	Oversized reclassifiers.	Replace with proper size.
Unable to produce oil flow through sight feed dome.	Pressure to lubricate too low.	Maintain pressure within recommended range.
	Defective fog generator	Replace.
	Dirt in Lubricator	Disassemble and Clean Lubricator

Malfunction	Possible Cause	Remedy
Unable to detect fog at reclassifiers.	Manifold pressure too low.	Manifold pressure should be within recommended range at all points in the distribution system.
	Oil being used with poor fogging qualities.	Use oil with good reclassifier output rating.
	Lubricator not operating	Check for proper operating conditions. Correct conditions as required.
Excessive stray fog.	Low manifold pressure.	Increase manifold pressure.
	Oil with high stray fog content being used.	Use oil with lower percent of stray fog. Consult Manual NT-3
Excessive lubricant being delivered.	Operating pressure to lubricator too high.	Reduce pressure to lubricator. Do not reduce below minimum recommended pressure. Open air by-pass to maintain pressure.
	Reclassifiers oversized.	Use smaller reclassifiers.
Insufficient lubrication.	Operating pressure to lubricator too low.	Increase operating pressure.
	Manifold pressure too low.	Increase manifold pressure.
	Reclassifiers under-sized	Use larger, or additional, reclassifiers.

Figure 48

Glossary of Terms

Absolute Viscosity

Kinematic viscosity corrected to overcome the variations caused by differences in specific gravity.

Aerosol

A fine suspension of liquid particles in an air stream.

Bar

An S.I. metric unit for pressure. One bar is approximately equal to 14.5 psi.

Bearing-Inch

A method of rating machine elements based on empirical formula. These ratings are used to compute lubrication requirements. All dimensions used in the bearing-inch formulas are in inches

Bearing Lubrication

See "Machine Lubrication"

Centipoise

Unit of absolute viscosity. 100 centipoise = 1 poise. Centipoise = centistokes x specific gravity.

CentiStoke

Unit of kinematic viscosity. 100 centistoke = 1 stoke.

Compatible with Polycarbonate

Many aerosol lubricators use polycarbonate reservoirs and sight-feed domes. Polycarbonate is susceptible to chemical attack by certain oil additives or blends. Standard tests can be performed to check for compatibility.

Diffusion Plug

A device used on lubricators to diffuse the oil/air mixture, or aerosol, emanating from the fog generator. This prevents excessive turbulence of oil in the reservoir.

Distribution Line

A conduit used to transport Micro-Fog to the various points of application.

Fog Generator

A device capable of atomizing a liquid into a fine aerosol. It is generally located in the throat area of a lubricator. Frequently referred to as a "venturi plug."

Inches Water Column (H_2O)

One inch of water column exerts pressure of 0.036 psi.

Kinematic Viscosity

The property measured when a fixed amount of oil flows through a capillary tube under the force of gravity.

Lubrication Unit

A unit of measurement which is numerically equivalent to the "bearing-inch." The lubrication unit is used to rate machine elements. All dimensions used in the lubrication unit formulas are in the metric system.

Lubro-Control Unit

A filter, regulator, and lubricator coupled together. May also contain additional components such as solenoid valves and pressure switches.

Machine Element

Any device such as a bearing, gear, or slide which requires lubrication.

Machine Lubrication

This term and bearing lubrication are frequently used interchangeably. Basically it refers to the lubrication of machine elements of all types.

Manifold

The distribution lines for transporting Micro-Fog.

Manifold Drop-Out

Oil particles too large to be conveyed long distances. Oil particles will wet-out in manifold and draIn back into lubricator if manifold line is properly sloped.

Manifold Pressure

The pressure in the manifold, distribution line, or lubricator reservoir. This pressure is generally measured in inches water column or centimeters of water column.

Micro-Fog

A Norgren trade name referring to a fine oil mist or aerosol, generally two micron and under in particle size.

Micron

A millionth of a meter or 0.000039 inch.

Oil Feed Sight Dome

The transparent hemispherical dome located on the lubricator head giving visual evidence of oil delivery to the fog generator.

Oil Fog

A heterogeneous dispersion of oil mist, having particle sizes ranging from those of Micro-Fog size to small droplets.

Oil Level Sight Glass

A transparent tube attached to the side of the reservoir to indicate oil level.

Operating Pressure

The pressure applied to the lubricator head. Generally measured in psig or bar.

Pitch Diameter

Diameter of an imaginary circle concentric with axis of a toothed sprocket or gear, having a lineal speed equal to the speed of the chain or the pitch circle of its mating gear.

Preloaded Bearing

Bearings in which the radial clearance is taken up in assembly by an axial load on the bearing.

Pressure Drop

The loss of pressure between any two points in a system or component.

PSIA

Pounds per square inch absolute. psia = psig + 14.7 at sea level.

PSIG

Pounds per square inch gauge.

Rating of Mistability

A general rating denoting the level of performance of an oil in a Micro-Fog lubricator. Oils are rated from “A” through “D”. “A” oils are those with very good reclassifier output and “D” oils those with unsatisfactory output.

Reclassifier

A special fitting or restriction used to convert Micro-Fog into a wet mist. This device is used at the point of application of lubricant to a machine element.

Reclassifier Output

The rate of usable oil being delivered by the reclassifier.

Reservoir

The container or tank which holds the lubricant being Micro-Fogged.

SCFM

Standard cubic feet per minute.

Specific Gravity

The ratio of the specific weight of a substance (such as oil) to the specific weight of a standard substance (such as water).

SSU (OR SUS) Viscosity

Sabolt Universal Seconds. The time in seconds for 60 milliliters of oil to flow through a standard orifice at a given temperature.

Stability Factor

An arbitrary number giving an indication of the expected change of oil output over a given period of time. Stability factor numbers range from “1” through “4.” A “1” factor indicates a stable oil with relatively little change in output. A “4 ‘ factor indicates a significant output change with time. Plus or minus values indicate whether this change is in an increasing or decreasing output.

Standard Air

Air at a temperature of 68°F, a pressure of 14.70 psia and a relative humidity of 36%.

Stray Fog

Oil particles too small to be reclassified. Will appear as smoke escaping from machine elements being mist lubricated.

Total Usable Capacity of Lubricator

The usable volume of oil between the indicated maximum fill level and the minimum oil level at which oil will flow up the siphon tube, compensated for such items as switches, pumps, cups, etc., which are immersed in this volume.

Venturi Plug

See “Fog Generator” The name is descriptive of the principle used for Micro-Fog generation.

Viscosity

A measure of the internal resistance of the oil to flow.

Viscosity Index

A number indicating the rate of change in viscosity of an oil within a given temperature range.

Working Capacity of Lubricator

The total usable volume of oil between the indicated maximum fill level and the minimum recommended operating oil level, compensated for such items as switches, pumps, cups, etc., which are immersed in this volume.

Equations for Calculating Bearing-Inch

I. Anti-Friction Bearings

$$B.I. = D \times R \times LF$$

Where:

D = Shaft diameter in inches
R = Number of rows of balls, rollers, or needle bearings
LF = Load factor governed by the type of bearing and degree of preload

Ball, straight and tapered roller bearings without preload: LF = 1

Spherical roller bearings without preload: LF = 2

Spherical, straight and tapered roller bearings with preload: LF = 3

II. Plain Bearings (Journal Bearings)

$$B.I. = \frac{D \times L \times LF}{8}$$

Where:

D = Shaft in diameter inches
L = Bearing length in inches
LF = Load factor

Static Loading lbs./in.^{2}	Load Factor LF
Under 100	1
101 to 200	2
201 to 400	4
401 to 500	8

III. Oscillating Bearing (Plain Type Bearing)

B.I. rating same as for plain bearing

IV. Gears

$$B.I. = \frac{F (P_1 + P_2)}{4}$$

Where:

F = Face width of gear in inches
P_1 = Pitch diameter of drive gear in inches
P_2 = Pitch diameter of driven gear in inches

V. Large-Ratio Gearing*

$$B.I. = F \frac{(3P_1)}{4}$$

Where:

F = Face width of gear in inches
P_1 = Pitch diameter of smaller gear in inches
P_2 = Pitch diameter of larger gear in inches

*Use this equation where $\frac{P_2}{P_1}$ is equal to or greater than 2.

VI. Worm Gears

$$B.I. = \frac{(L_w \times P_1) + (P_2 \times F)}{4}$$

Where:

L_w = Length of worm gear in inches
P_1 = Pitch diameter of worm gear in inches
P_2 = Pitch diameter of spur gear in inches
F = Face width of gear in inches

VII. Reversing Gears

Reversing gears require twice as much lubrication as non-reversing gears.

VIII. Gear Trains

$$B.I. = \frac{F (P_1 + P_2 + P_n + P_{n+1} +)}{4}$$

Where:

F = Face width of gear in inches
P = Pitch diameter of gears in inches

If $P_n > 2P_{n\pm1}$, consider $P_n = 2P_{n\pm1}$

IX. Rack and Pinion

$$B.I. = \frac{F \times P}{2}$$

Where:

F = Face width of pinion gear in inches
P = Pitch diameter of gear in inches

X. Slides and Ways

$$B.I. = \frac{L \times W}{20}$$

Where:

L = Length of slide in inches
W = Width of contact in inches

XI. Roller Chains

$$B.I. = \frac{PDR\sqrt{\left(\frac{S}{100}\right)^3}}{8}$$

Where:

P = Chain pitch in inches
D = Diameter of either sprocket in inches
R = Chain rows for multiple strand roller chains
S = Speed in rpm of the sprocket used for "D"

(If speed is less than 200 rpm, use 200 rpm in calculations)

XII. Silent Chains

$$B.I. = \frac{WD\sqrt{\left(\frac{S}{100}\right)^3}}{15}$$

Where:

W = Chain width in inches
D = Diameter of either sprocket in inches
S = Speed of the same sprocket in rpm
(If speed is less than 200 rpm, use 200 rpm in calculations)

XIII. Conveyor Chains

$$B.I. = \frac{W (3D + L)}{10}$$

Where:

W = Face width of chain in inches
D = Pitch diameter of sprocket in inches
L = Length of chain in feet

XIV. Cams

$$B.I. = \frac{F \times D_m}{10}$$

Where:

F = Face width of cam in inches
D_m = Maximum diameter of cam in inches

Equations for Calculating Lubrication Units

NOTE: Numerically the "lubrication unit" and the "bearing inch" are equivalent. The lubrication unit is based on the metric system with the basic dimensions given in millimeters.

I. Anti-Friction Bearings

$$L.U. = \frac{D \times R \times LF}{25}$$

Where:
- D = Shaft diameter in millimeters
- R = Number of rows of balls, rollers, or needle bearings
- LF = Load Factor governed by type of bearing and degree of preload

Ball, straight and tapered roller bearings without preload: LF = 1

Spherical roller bearings without preload: LF = 2

Spherical straight and tapered roller bearings with preload: LF = 3

II. Plain Bearings (Journal Bearings)

$$L.U. = \frac{D \times L \times LF}{5000}$$

Where:
- D = Shaft diameter in millimeters
- L = Bearing length in millimeters
- LF = Load Factor

Static Loading	Load Factor
Kg/mm^2	LF
Under 0.07	1
0.07 to 0.15	2
0.15 to 0.30	4
0.30 to 0.35	8

III. Oscillating Bearings (Plain Type Bearings)

L.U. rating same as for plain bearing

IV. Gears

$$L.U. = \frac{F (P_1 + P_2)}{2500}$$

Where:
- F = Face width of gear in millimeters
- P_1 = Pitch diameter of drive gear in millimeters
- P_2 = Pitch diameter of driven gear in millimeters

V. Worm Gears

$$L.U. = \frac{(L_w \times P_1) + (P_2 \times F)}{2500}$$

Where:
- L_w = Length of worm gear in millimeters
- P_1 = Pitch diameter of worm gear in millimeters
- P_2 = Pitch diameter of spur gear in millimeters
- F = Face width of gear in millimeters

VI. Large Ratio Gearing*

$$L.U. = \frac{F (3P_1)}{2500}$$

Where:
- F = Face width of gear in millimeters
- P_1 = Pitch diameter of smaller gear in millimeters
- P_2 = Pitch diameter of larger gear in millimeters

*Use this equation where $\frac{P_2}{P_1}$ is greater than 2.

VII. Reversing Gear

Reversing gears require twice as much lubrication as non-reversing gears.

VIII. Gear Trains

$$L.U. = \frac{F (P_1 + P_2 + P_n + P_{n+1} +)}{2500}$$

Where:
- F = Face width of gear in millimeters
- P = Pitch diameter of gear in millimeters

If $P_n > 2P_{n+1}$ Consider $P_n = 2P_{n+1}$

IX. Rack and Pinion

$$L.U. = \frac{F \times P}{1250}$$

Where:
- F = Face width of pinion gear in millimeters
- P = Pitch diameter of gear in millimeters

X. Slides and Ways

$$L.U. = \frac{L \times W}{12{,}500}$$

Where:
- L = Length of slide in millimeters
- W = Width of contact in millimeters

XI. Roller Chains

$$L.U. = \frac{PDR\sqrt{\left(\frac{S}{100}\right)^3}}{5000}$$

Where:
- P = Chain pitch in millimeters
- D = Diameter of either sprocket in millimeters
- R = Chain rows for multiple strand roller chains
- S = Speed in rpm of sprocket used for "D

(If speed is less than 200 rpm, use 200 rpm in calculations)

XII. Silent Chains

$$L.U. = \frac{WD\sqrt{\left(\frac{S}{100}\right)^3}}{9375}$$

Where:
- W = Chain width in millimeters
- D = Diameter of either sprocket in millimeters
- S = Speed of the same sprocket in rpm

(It speed is less than 200 rpm, use 200 rpm in calculations)

XIII. Conveyor Chains

$$L.U. = \frac{W (D + 25L)}{2000}$$

Where:
- W = Chain width in millimeters
- D = Diameter of sprocket in millimeters
- L = Length of chain in meters

XIV. Cams

$$L.U. = \frac{F \times D_m}{6250}$$

Where:
- F = Face width of cam in millimeters
- D_m = Maximum diameter of cam in millimeters

Weight of a Fluid with a Given Specific Gravity to a Unit of Volume.

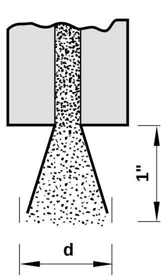
Specific Gravity	Grams / fl. oz.
.80	23.65
.85	25.15
.90	26.60
.95	28.10
1.00 (Water)	29.57
1.05	31.07
1.10	32.58
1.15	34.04
1.20	35.55
1.25	37.00
1.30	38.45

Figure 49

Useful Dimensional Data

Diameter	Diameter Decimal Equiv.	Circle Area	Internal Area Sq. In. Hose	Std. Pipe	.032 Wall Copper Tubing
1/32	(0.0312)	.00077			
1/16	(0.0625)	.00307			
3/32	(0.0938)	.00690			
1/8	(0.1250)	.01227	.01227	.057	.0029
5/32	(0.1562)	.01917			
3/16	(0.1875)	.02761			.0120
7/32	(0.2188)	.03758			
1/4	(0.2500)	.04909	.04900	.104	.0271
9/32	(0.2812)	.06213			
5/16	(0.3125)	.07670			.0485
11/32	(0.3438)	.09281			
3/8	(0.3750)	.11040	.11000	.191	.0760
13/32	(0.4062)	.12960			
7/16	(0.4375)	.15030			.1095
15/32	(0.4688)	.17260			
1/2	(0.5000)	.19630	.19600	.304	.1490
17/32	(0.5312)	.22170			
9/16	(0.5625)	.24850			
19/32	(0.5938)	.27690			
5/8	(0.6250)	.30680			.2470
21/32	(0.6562)	.33820			
11/16	(0.6875)	.37120			
23/32	(0.7188)	.40570			
3/4	(0.7500)	.44180	.44200	.553	.3700
13/16	(0.8125)	.51850			
7/8	(0.8750)	.60130			
15/16	(0.9375)	.69030			
1	(1.0000)	.78540	.78500	.864	
1-1/4	(1.2500)	1.22720	1.22700	1.495	
1-1/2	(1.5000)	1.76700		2.036	
2	(2.0000)	3.14160		3.355	
2-1/2	(2.5000)	4.90880		4.788	

Figure 50



Typical Spray Pattern for Standard Norgren Reclassifier

d	=	1/8"	to	1/4"	for	1 B.I.
d	=	1/4"	to	1/2"	for	2 B.I.
d	=	3/8"	to	3/4"	for	4 B.I.
d	=	1/2"	to	1"	for	8 B.I.

Performance Data on Reclassifiers

Manifold Pressure Inches H_2O	Bearing Inches	Inlet Pressure psig (bar)	Air Flow scfm (dm^3/s)
8	16	8 (0.6)	1.6 (0.76)
	24	17 (1.2)	2.4 (1.13)
	32	26 (1.8)	3.1 (1.46)
10	16	10 (0.7)	1.8 (0.85)
	24	20 (1.4)	2.7 (1.27)
	32	31 (2.2)	3.6 (1.70)
12	16	12 (0.8)	2.0 (0.94)
	24	23 (1.7)	3.0 (1.42)
	32	35 (2.4)	4.0 (1.89)
15	8	6 (0.4)	1.1 (0.52)
	16	15 (1.0)	2.2 (1.04)
	24	26 (1.8)	3.3 (1.56)
	32	40 (2.8)	4.5 (2.12)

Figure 51

Reclassifiers

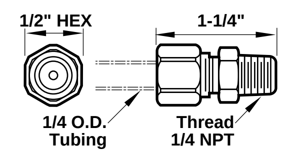
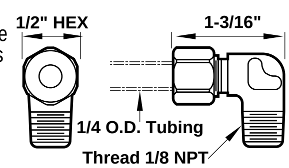
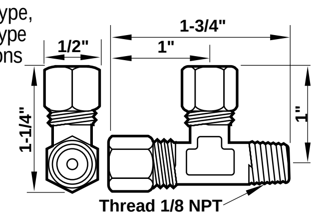
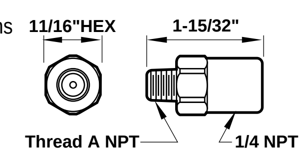
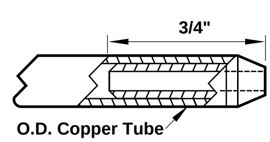
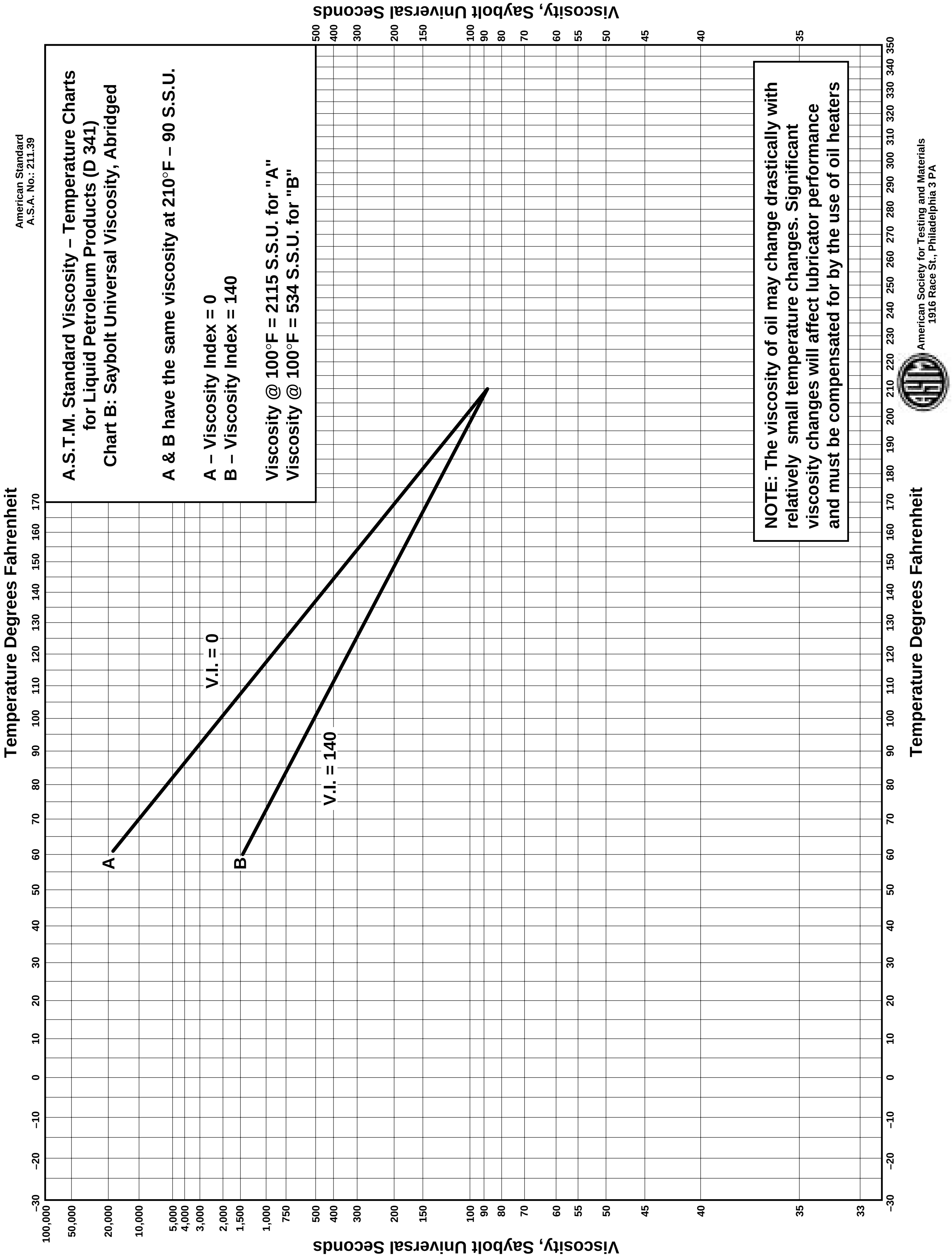
Description	Order Model Number	Bearing Inch Rating
Straight-type, Compression-type Tube Connections 	18-009-003 18-009-010 18-009-012 18-009-014	0–1 1–2 2–4 4–8
Elbow-type, Compression-type Tube Connections 	18-009-008 18-009-011 18-009-013 18-009-015	0–1 1–2 2–4 4–8
Pressure Jet Type, Compression-type Tube Connections 	18-009-030 18-009-031 18-009-032	0–1 1–2 2–4
Straight-type Pipe Connections  18-009-002 and 18-009-006 are 1/4" All others 1/8"	18-009-001 18-009-002 18-009-005 18-009-006 18-009-007 18-009-016	0–1 0–1 2–4 2–4 4–8 1–2
Solder-type 	18-009-024 18-009-029 18-009-034	0–1 2–4 1–2

Figure 52



American Standard
A.S.A. No.: 211.39
A.S.T.M. Standard Viscosity – Temperature Charts
for Liquid Petroleum Products (D 341)
Chart B: Saybolt Universal Viscosity, Abridged
A & B have the same viscosity at 210°F – 90 S.S.U.
A – Viscosity Index = 0
B – Viscosity Index = 140
Viscosity @ 100°F = 2115 S.S.U. for "A"
Viscosity @ 100°F = 534 S.S.U. for "B"
V.I. = 0
V.I. = 140
A
B
NOTE: The viscosity of oil may change drastically with relatively small temperature changes. Significant viscosity changes will affect lubricator performance and must be compensated for by the use of oil heaters
Temperature Degrees Fahrenheit
Viscosity, Saybolt Universal Seconds
American Society for Testing and Materials
1916 Race St., Philadelphia 3 PA

Figure 53

Checking Manifold Pressure with a Water Container

If an inches of water pressure gauge is not available, the manifold pressure can be checked by lowering a tube from the downstream manifold system into a container of water at least fifteen (15) inchs deep. Bubbles will cease to rise from the end of the tube at a depth corresponding to the inches of water column pressure (see Figure 54).

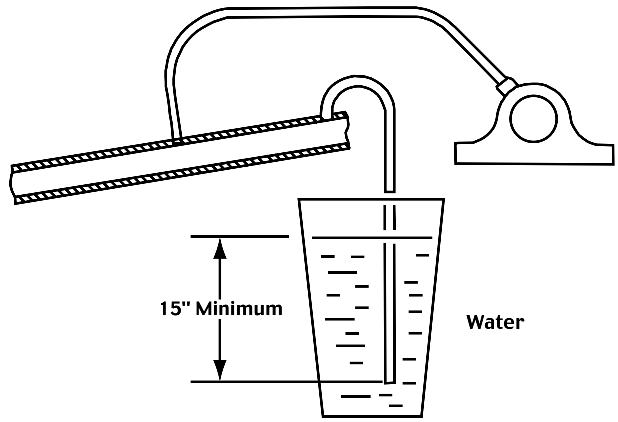


Figure 54. Checking manifold pressure with a water container.

Table 1. Lubricator Operating data

Model	Bearing Inch Requirement	Applied Pressure (psig)†	Air Consumption (scfm)
10-015	8	6††	1.1
10-065 (1/4" outlet)	16	15	2.2

† Approximate setting to obtain manifold pressure of 15" water column.
†† Manifold pressure will exceed 15" water column at 6 psig applied pressure. This condition is normal. do not reduce manifold pressure by reducing applied pressure to a value less than 6 psig.

MINIMUM OPERATING PRESSURE IS 6 PSIG.