

# Grease Lubrication of MOV Components

MOV Users' Group Meeting  
Desert Springs, CA, January 14-16, 2019

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## Why is this important?

First, for early failures many equipment and particularly bearing failures are **easily** preventable!

Preventing them requires better information about how to lubricate, what to use, how often and how to monitor them.

Unfortunately, for a variety of reasons new technologies are slow to be accepted, training is inadequate and corporate practices tend to focus on penny control and immediate benefits. It is also becoming very difficult to get good intel.

## How Are We Doing? Rolling Element Bearings



**Note:**  
**Only 3%**  
**reach**  
**their**  
**design**  
**life!**

According to SKF (bearing manufacturer)  
**contaminants cause 50% of bearing failures.**

## Do We Design Correctly? Ball Bearing Fatigue Lives - Now

**New life theory** (ISO 281:2007) takes into account the viscosity ratio of actual vs. required, type of bearing, type of loading and cleanliness of the oil.

$$L_{naa} = a_1 a_{ISO} (C/P)^3$$

$L_{naa}$  = adjusted rating life in millions of revolutions

$a_1$  = life adjustment for reliability (i.e. 10% failure)

**$a_{ISO}$  = life adjustment factor based on new life theory**

C = Basic load rating

P = Equivalent dynamic bearing load

**Rolling Element Bearings Lives - Now**

**Life Modification Factor  $a_{ISO}$**

**Among other things considers the influence of:**

- **Fatigue limit of the bearing material by the fatigue load limit  $C$ .**
- **Grade of contaminations by the factor  $e_c$ .**
- **Lubrication conditions by the viscosity ratio  $K$ .**

**Note:** ISO 281:2007 does not cover the influence of wear, corrosion and electrical erosion on bearing life.

**Note:** Using lube as supplied can reduce life by 50%!

Ref: [www.cwbearing.com](http://www.cwbearing.com)

**What to use?**

- Right consistency
- Right additives
- Right amount/level
- Right cleanliness
- Right procedures
- Right monitoring

**ISO-VISCOSITY SYSTEM  
FOR INDUSTRIAL FLUID LUBRICANTS [ASTM D 2422-97 (2007)]**

ISO Viscosity Grade	Mid Point cSt @ 40°C	Kinematic Viscosity @40°C Limits			
		Minimum		Maximum	
		cSt	SUS	cSt	SUS
2	2.2	1.98	32.0	2.42	34.0
3	3.2	2.88	35.5	3.52	37.5
5	4.6	4.14	39.5	5.06	42.5
7	6.8	6.12	46.0	7.48	50.5
10	10	9.00	55.5	11.0	62.5
15	15	13.5	71.5	16.5	83.5
22	22	19.8	97.0	24.2	116
32	32	28.8	136	35.2	165
46	46	41.4	193	50.6	235
68	68	61.2	284	74.8	347
100	100	90.0	417	110	510
150	150	135	625	165	764
220	220	198	917	242	1121
320	320	288	1334	352	1631
460	460	414	1918	506	2344
680	680	612	2835	748	3465
1000	1000	900	4169	1100	5095
1500	1500	1350	6253	1650	7643
2200	2200	1980	9171	2420	11209
3200	3200	2880	13340	3520	16305

Note:  
Grades increase by ~50%

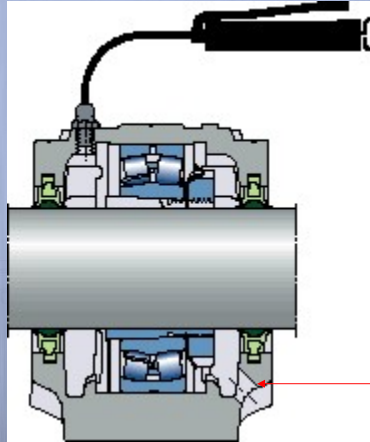
Ref: 2013 PC Lube Handbook

### Grease Stiffness Grades

NLGI Grade	Penetration
000	445-475
00	400-430
0	355-385
1	310-340
2	265-295
3	220-250
4	175-205
5	130-160
6	85-115

Note: The grade has nothing to do with quality.

## Greasing Bearings



*Note: There are many different configurations. How to grease and how the grease gets purged must be understood.*

Volumetric Grease Relief Port

## 'Normal' Temperature Rise



*Note: Lubricators need to communicate with operators. Do not raise temperature limits or use less than required grease amounts.*

Ref: Harris, A.F., 'The Lubrication of Rolling Bearings', p. 118, Shell Int'l Petroleum Co. Ltd., 1972

## How Do You confirm “When”, or measure grease or equipment condition?



Now getting a grease sample is just as easy as an oil sample. Just screw in place of the drain, or use a handle that allows you to extract from the “live zone”



**MRG Grease Thief**

## Grease Quantities – as a ‘guesstimate’

For replenishment from the side of a bearing;

$$G_p = 0.005 D B$$

For through the bearing outer or inner ring;

$$G_p = 0.002 D B$$

$G_p$  = grease quantity, g

$D$  = bearing outside diameter, mm

$B$  = bearing width (thrust bearings use height  $H$ ), mm

*Note: Also check the manual and take into account any lessons learned.*

Ref: SKF 2007

## Regreasing Amount Example

6316 ball bearing; ID 80, OD 170 mm Width 39 mm

It should get about  $0.005 \times 170 \text{ mm} \times 39 \text{ mm}$   
= 33 g (1.2oz) of new grease.

With the 70MPa (10,000psi) high pressure grease guns often used, this can require **43 strokes**.

*Note: Verify delivery rate of the grease gun being used. Pump into a paper cup or onto a paper towel. Density of grease is about the same as water. In this case 33 g ~ 33 ml or 1/8 cup*

## Can you afford not to do it? Make it easier to do it right



Provides for pressure-specific shut-off (for example, 20 psi). At the given shut-off pressure, the grease flow will stop.

**\$0.35 each**



Coloured grease fitting caps

**\$0.20 each**

Can you afford not to do it?  
**Make it easier to do it right**



Example of ultrasonic set-up on a grease gun. Add grease until reading starts to drop.

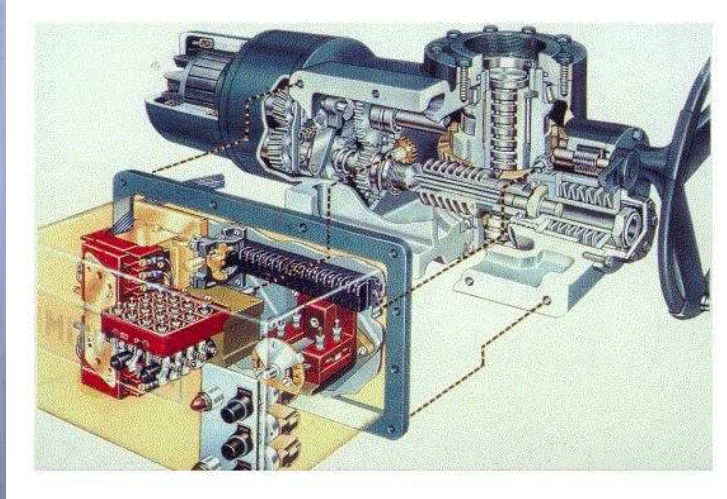
Ref: <http://www.uesystems.com/products/grease-caddies>

Can you afford not to do it?  
**Make it easier to do it right**



<https://www.sdtultrasound.com/products-solutions/products/sdt-lubexpert>

## SMB Internals



## SMB Grease Volumes and Weights

Actuator Size	Approximate Volume		Approximate Weight	
	Gal	L	lb	kg
SMB /SB/SBD-000	0.5	1.9	3.5	1.6
SMB /SB/SBD-00	1.0	3.8	8.5	3.8
SMB /SB/SBD-0	1.5	5.7	12	5.4
SMB /SB/SBD-1	2.1	7.9	17	7.7
SMB /SB/SBD-2	3.0	11.4	24	10.9
SMB /SB/SBD-3	6.0	22.7	50	22.7
SMB /SB/SBD-4	9.4	35.6	75	34.0
SMB-4T	8.7	32.9	70	31.8
SMB-5T	10.0	37.8	80	36.4
SMB-5	11.2	42.4	90	40.9

*Note: This is valid for MOV Long Life Grade 0. The weights are more than for Nebula EP used until 2002.*

Ref: Limitorque FCD LMAIM1401-00 (Replaces 140-11000) 2004

## How Often ?

The following lubrication inspection schedule is recommended until operating experience indicates otherwise.

- Main Gear Case Inspect lubrication every 18 months or 500 cycles whichever occurs first.
- Geared Limit Switch Inspect lubrication every 36 months or 1000 cycles whichever occurs first.
- Drive Sleeve Top Bearing Lubricate every 6 months through housing cover pressure fitting.

Ref: Limitorque FCD LMAIM1401-00 (Replaces 140-11000) 2004

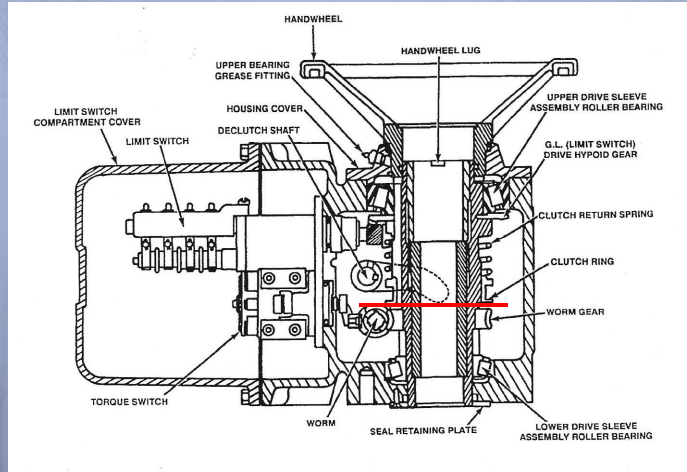
## SMB How Much?

SMB and SB actuators are built to operate on the immersion principle.

**CAUTION:** Ensure there is enough lubricant so that the Worm and the Worm Gear are totally immersed in grease regardless of the position. Use the “fill” and “drain” plugs provided on the actuator housing to verify this.

Ref: Limitorque FCD LMAIM1401-00 (Replaces 140-11000) 2004

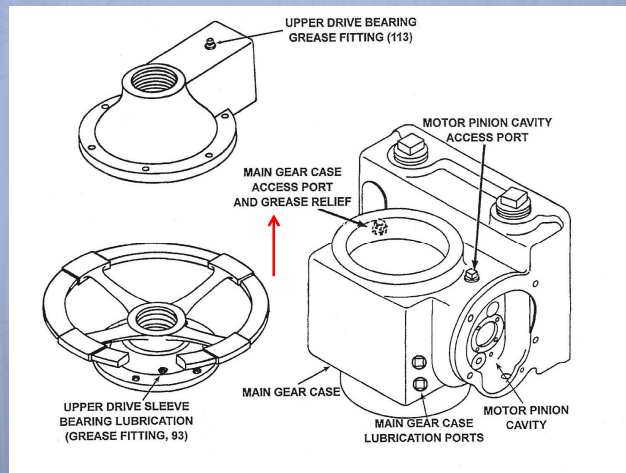
## SMB How Much?



*But there is more to greasing! Follow reassembly instruction. For example, bearings should be hand packed.*

Ref: Technical Repair Guidelines for Limatorque Model SMB-00 Valve Actuators, EPRI NP6631 R1s, June 1995

## SMB Where?



Ref: Technical Repair Guidelines for Limatorque Model SMB-00 Valve Actuators, EPRI NP6631 R1s, June 1995

**Some nice colors but how did they perform?**



## **OEM Requirements**

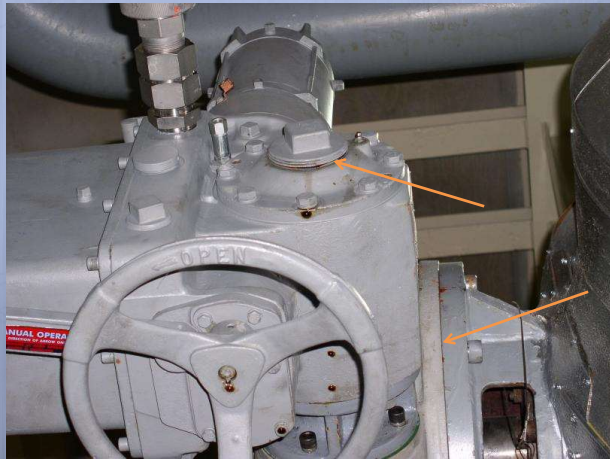
Requires the following lubricant qualities as a minimum.

The lubricant must:

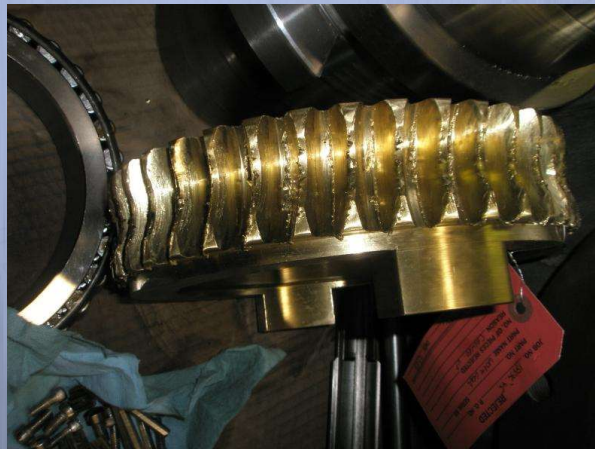
- Contain an “EP” additive.
- Be suitable for the temperature range intended.
- Be water and heat-resistant and non-separating.
- Not create more than 8% swell in Buna N or Viton.
- Not contain any grit, abrasive, or fillers.
- Comply with Slump-prefer NLGI grades 00 to 1.
- Not be corrosive to steel gears, ball or roller bearings, or yellow metals (bronze, brass, or copper alloys).
- Have a dropping point above 316°F (158°C) for temperature ranges of -20°F (-29°C) to 150°F (66°C).

Ref: Limatorque FCD LMAIM1401-00 (Replaces 140-11000) 2004

### Where not to Grease



### Where are the Savings?



## Stem Nut Wear



David Przyjemski, Susquehanna, INSPECTION & MONITORING OF MOV STEM NUT THREAD WEAR, January 2008, Orlando, Florida

- Inadequate lube of MOVs stems led to failures, NRC INFORMATION NOTICE 2010-03: FAILURES OF MOTOR-OPERATED VALVES DUE TO DEGRADED STEM LUBRICANT
- Five MOV stem lubrication events
- Commanche Peak 2011 failure due to lack of lubrication from valve stem inaccessibility



David Przyjemski, Susquehanna, INSPECTION & MONITORING OF MOV STEM NUT THREAD WEAR, January 2008, Orlando, Florida

### Timken 'Okay' Loads

	kgf	lb
<b>MOV Long Life Grade 0</b>	<b>24.9</b>	<b>55</b>
<b>Grade 1</b>	<b>27.2</b>	<b>60</b>
<b>Grade 2</b>	<b>27.2</b>	<b>60</b>
<b>MOV Extra Grade 0</b>	<b>22.7</b>	<b>50</b>
<b>Grade 1</b>	<b>25</b>	<b>55</b>
<b>NEBULA EP0</b>	<b>21</b>	<b>45</b>
<b>EP1</b>	<b>21</b>	<b>45</b>
<b>Mobilgrease 28</b>	<b>5.4</b>	<b>12</b>

An EP grease is generally 15 lbs minimum!

### Stem Thief

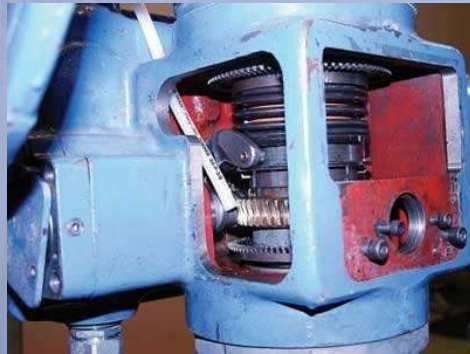


- Stem protector removed and pipe-to-straight thread adapter installed
- Relubricator is solid aluminum body with O-ring to mate to top of stem nut
- Zerk fitting works with high pressure grease gun to pump grease through nut, displacing old grease and applying a new layer to threads.

## StemThief - Palo Verde

- August 2014: 1 SMB-00 Stem Thief was initially purchased for evaluation and testing. December 2014: 2 additional SMB-00s. February 2015: 3 SMB-3s.
- 18 short stroke SMB00's within the HPCI system, (89-10 valves). If COF trend +/- Stem Thief is used instead of pulling stem nuts.
- StemThief allows testing and restoration in a 2 hour LCO window. Not possible to pull stem nut in that time.
- 12 to 15 BOPs with short stroking globe valves with no accessibility to the stem/stem nut interface. StemThief eliminates need to pull stem nuts and MG.
- Plans in place to increase the scope of valves tested with the StemThief.
- StemThief saves time and improves efficiency, safety
- At PVGS we had experienced As Found to As Left COF changes from 0.15 to 0.10 by using the Stem Thief. PVGS MOV typical CF is 0.10.
- Grease analysis performed in-house.

## Grease Sampling



Ref: Easy Testing for Grease Thickness, Bob Bolt, Bolt and Associates Chesley Brown, Texas Utilities Mike Pugh, EPRI, Machinery Lubrication 5/2003

- Old method – does not prevent non-active grease from being sampled
- EPRI Research – “Effective Grease Practices Guide”
- New method—using Grease Thief and T-handle produces representative sample

## StemThief - Stem relubrication and Grease Sampling from stem and gearbox



### MOV Main Gearbox Grease Sampling

ASTM Standard D7718 outlines methods for accurate sampling. MOV sampling kit designed to meet that guidance, that allows a blind sample to be taken from the worm-gear area by contacting the surface with a plastic stinger probe, which starts the coring process directly adjacent to the gear teeth.

For known-depth sampling, the T-handle is used to core a fixed-depth sample from within the gearbox. Other samples can be taken with the Pillow Block kit.

## Grease Condition Monitoring

Screening test for grease analysis that includes ferrous debris level in ppm, grease colorimetry, and FTIR analysis, all per ASTM D7918.

There is also a Basic Analysis test slate that adds Die Extrusion (consistency/flow properties), Moisture (ppm), RULER for anti-oxidants and RDE spectroscopy for 21 elements.

An Advanced Analysis test slate adds Analytical Ferrography and Rheometry for advanced flow properties.

Grease Mini-Lab for onsite testing, ferrous debris (ppm), colorimetry (CIE scale), and moisture (ppm) with no chemicals required.

## Limit Switch Gearbox Grease Failure – Grease or Maintenance Required?



## Limit Switch Gearboxes – How Much?

- Verify all internal parts are dry and the solvent is gone before reassembly and greasing.
- Install the bottom gear frame cover bowed outward with a lubricated gasket and the four (wider head diameter) fasteners (Figure 17-20).
- Add approved grease to the gear frame leaving a small air space.

9. Verify the grease level is above the top of the smaller gears and that the gear frame is not completely filled. Add or remove grease as necessary.

10. Coat the mating surfaces of the gasket (51 ) with a thin film of gear frame grease, if not previously lubricated.

*Ref: Technical Repair Guidelines for Limitorque Model SMB-00 Valve Actuators, EPRI NP6631 R1s, June 1995*

## Limit Switch Gearboxes – Really How Much?

The MOV Long Life is doing really well for us, we haven't had any issues with it.

**FYI, we fill the limit switch gearboxes ~80% full.**

*Ref: 2018 from a user at a very large US nuclear station*

## Lessons Learned

1. Most bearings **fail early**.
2. Many failures are because of **improper** lubrication.
3. Many failures can be **easily** prevented.
4. Do not **overfill** the limit switch gearboxes.
5. Use the **right** grease, applied the **right** way and **verify performance**.

## MUG Presentations

- 2019 Grease Lubrication of MOV Components
- 2017 What You Need to Know about Oil & Greases and Compatibility Testing
- 2015 Understanding Low Temperature MOV Greases
- 2014 MOV Stem Nut Wear Testing – An Update
- 2013 Stem and Stem Nut Relubrication (Wurzbach)
- 2013 MOV Long Life Grease a Decade Later- Approvals and Lessons Learnt
- 2010 Semifluid Grease for Oil Filled MOV's
- 2009 MOV Long Life – Reducing Oil Seepage
- 2008 Commercial Grade Dedication and In-service MOV Long Life Grease Testing
- 2007 MOV Stem Grease Wear Testing
- 2006 MOV Long Life Condition Monitoring Update
- 2005 MOV Long Life Condition Monitoring
- 2004 MOV Long Life Limitswitch Applications
- 2003 All-In-One, An Update on MOV Long Life