2014 MOV Users' Group Meeting

MOV Stem Grease Wear Testing - Update

Ken Brown*, Eco Fluid Center Ltd.
Ted Austin, Canoil Canada Ltd.
Wayne Mackwood, Chemtura Co.
Solongo Wilson, Chemtura Co.

*Toll Free 888 442-5008
www.MOVLongLife.com

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Background

At the 2006 MUG Meeting a presentation showed severe wear on a stem nut that had been attributed to the use of an anti-seize paste.

While the use of such products had been not generally been recommended because of poor antiwear characteristics, a 1996 survey by EPRI had shown that these were one of the most common products being used on stem/stem nuts. They are reportedly **still** in use at some stations.

EPRI Stem Nut Grease Survey

Grease	Users %
Calcium Complex (i.e. Nebula EP)	26
Nickel Antiseize Compound (i.e. N-5000)	24
EP Lithium Soap (i.e. Mobilux)	16
Clay Synthetic Hydrocarbon (i.e. Mobilgrease 28)	14
Other Types	20

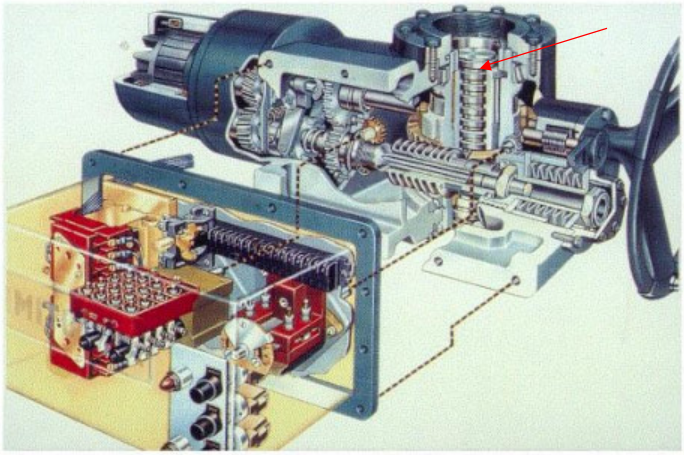
- Ref: EPRI Lube Note #1 Dec 1996

Our 2007 MUG on wear testing in the standard tests showed the poor performance of some pastes and greases.

This was bad enough but MOV contact surfaces tend to be bronze and stainless steel. This is different than the steel on steel pairs used in many power station applications **AND** used in most grease wear tests.

There was a need a more representative test in case the results could be different. This has now been done.

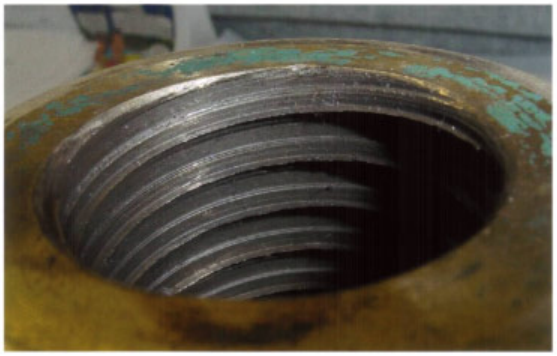
Limitorque SMB



Stem Nut Wear

Stem Nut Wear, Antiseize

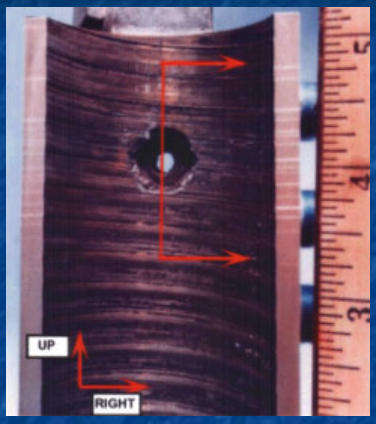
- RHR Minimum Flow Valve (SB-00, 1.25" Diameter)



Significance

- Proper lubrication of the stem/stem nut is important to achieve consistent torques and to lubricate the working surfaces.
- While the requirements for a good gearbox lubricant are given, those for the stems are less clearly defined.
- One concern is that a worn stem nut could fail badly if the teeth strip.

Worst Case?

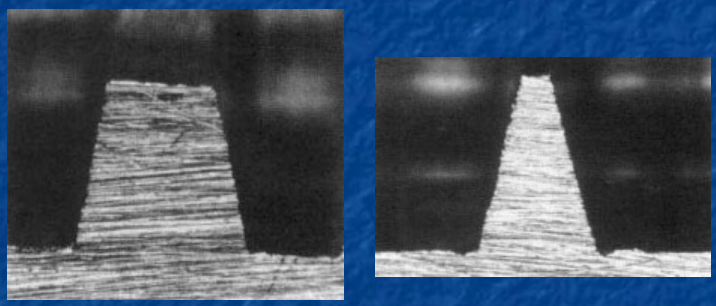


Alaska Airlines Flight 261
Stripped ACME Thread Stabilizer Nut
Aluminum Bronze – MG28 & Aeroshell 33 Greases

Nuke Plants re NRC Instruction Notices

- IN 2006-29: 'Potential Common Cause Failure of Motor-operated Valves as a Result of Stem Nut Wear' re Susquehanna
- IN 2010-03: 'Failures of Motor-Operated Valves Due to Degraded Lubricants' re Peach Bottom, Vogtle and Callaway.

EPRI



Bronze stem nut from a SMB 000 after 6 years of service using different lubricants.

Lube Note #3 May 1990

Stem Nut Applications

- In many ways lubrication of the stem is **more** severe than the gearbox because the lubricant can be directly exposed to heat (ambient, radiant and/or conduction), water, and radiation.
- It can also be subjected airborne contaminants and volatility of the grease constituents can play a role because the lubricant is not in a sealed compartment.
- But it is not EQ'd.

'EQ' Testing

PRODUCT	LONG LIFE Grade 1	EXXON NEBULA EP1	MOBIL MOBILUX EP1
THICKENER CONDITIONS	Calcium Sulphonate	Calcium Complex	Lithium 12 Hydroxystearate
Initial Worked Penetration	321	317	324
25°C (77°F)	327 (+1.9%)	287 (-9.5%)	350 (+16%)
25°C (77°F) and 50% water	311 (-3.1%)	309 (-2.5%)	347 (+7.1%)
One hour preheat at 77°C (170°F)	324 (+0.9%)	322 (+4.8%)	347 (+7.1%)
One hour preheat at 77°C (170°F) and 50% water.	313 (-2.5%)	407 (+28.4%)	399 (+23.2%)
SUMMARY	Very slight changes	Considerable softening with heat and water	Considerable softening with heat and water

Application Demands

- It is also important that the grease not harden in service because this can affect the operating torque.
- Plus it should have good resistance to oil separation. This is because too much oil loss will mean a stiffer grease. Also oil seepage in contact with hot stems in packing/seals can harden and/or form an adherent deposit. This might cause seal damage when the stem turns.

NLGI Grease Grades

- The firmer the grease, the less the cone penetrates the sample and the smaller the number. The cone will sink more in softer grease. Penetrations ranges are given numbers from 000 to 6.
- The larger the number, the stiffer the grease. It is also possible to have products that are part way between grades like a 1½ but these are not official designations.

Grease Consistency

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

Test Grease/Paste Characteristics

	NLGI Grade	Penetration 60 Strokes	Base Oil Viscosity	
			40˚C	100˚C
MOV Long Life Grade 0	0	370	95	10.8
Grade 1	1	325	95	10.8
Grade 2	2	280	95	10.8
MOV Extra Grade 0	0	375	23.4	4.7
Grade 1	1	325	23.4	4.7
Nebula EP0	0	370	96.3	8.3
EP1	1	325	96.3	8.3
Mobilgrease 28	1½	295	29.3	5.6
Mobilux EP 2	2	280	160	?
Lubriplate 630AA	1	310-340	135	?
N-5000	~0-1	300-390**	?	?
N-7000	~0-1	325-375**	?	?

Grease/Paste Components

Name	Description
MOV Long Life	Calcium sulfonate complex (also CCS) hydrotreated paraffinic oil
MOV Extra	Calcium sulfonate complex (also CCS) mineral oil
MOV Syn	Calcium sulfonate complex (also CCS) PAO oil
Nebula EP	Calcium complex, hydrotreated naphthenic oil
Mobilgrease 28	Clay thickener and synthetic hydrocarbon (PAO) oil
Mobilux EP	Lithium hydroxystearate thickener, highly refined oil, zinc dithiophosphate, **pre 2007** chlorinated paraffins
Lubriplate 630AA	Lithium thickener, hydrotreated naphthenic oil, zinc oxide, antimony dithiocarbonate
N-5000	White oil (30-60%), nickel (10-30%) & graphite (10-30%)
N-7000	White oil (30-60%), calcium oxide (10-30%) and graphite (10-30%)

Metals In New Greases/Pastes

	MOV EX1	MOV LL1	NEB 1	MG28	N-5000	N-7000
Aluminum	28	17	38	8240	3380	141
Copper	<1	<1	1	<1	3	4
Iron	25	19	52	1651	133	100
Tin	13	<1	<1	4	17	2
Chromium	<1	<1	1	<1	3	3
Lead	11	1	<1	26	193	4
Cadmium	<1	<1	<1	<1	<1	<1
Nickel	7	1	<1	<1	129422	117
Titanium	5	2	<1	31	10	6
Zinc	<1	<1	7	3	349	17
Phosphorous	<1	218	758	333	<1	20
Molybdenum	3	3	1	5	6	2
Calcium	56496	59159	55989	3887	1838	98965
Barium	31	24	56	1	8	10
Magnesium	96	57	217	831	11	351
Boron	2746	2414	<1	6	19	17
Sodium	65	28	101	2817	50	99
Silicon	58	30	372	18788	55	353

Total metals analysis by ICP scan with Ashing and Acid digestion (ppm)

Metals In New Greases/Pastes

	MOV LL1	Mobilux EP2	Lubriplate 630AA
Aluminum	17	0	39
Copper	<1	91	19
Iron	19	26	43
Tin	<1	3	8
Chromium	<1	0	0
Lead	1	4	5
Cadmium	<1	0	0
Nickel	1	0	0
Titanium	2	3	0
Zinc	<1	4682	40019
Phosphorous	218	2703	28
Molybdenum	3	6	16
Calcium	59159	143	112
Barium	24	0	0
Magnesium	57	4	4
Boron	2414	24	8
Sodium	28	234	148
Silicon	30	22	2
Lithium	-	1198	1754
Antimony	-	0	3240

Wear Testing

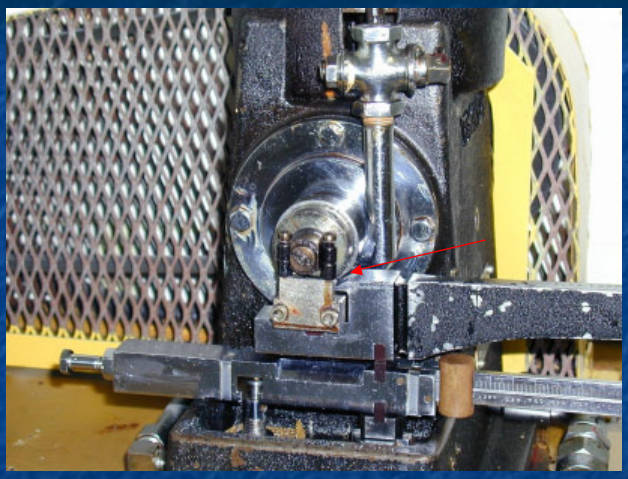
ASTM D2509-03 Standard Test Method For Measurement Of Load-carrying Capacity Of Lubricating Grease (Timken Method)

This test method covers the determination of the load-carrying capacity of lubricating greases by means of the Timken extreme pressure tester.

- Generally a grease is considered extreme pressure (EP) if the Ok Load (no scuffing) is ≥15 lb.

Higher is better.

ASTM D2509 Timken Wear Tester



Close-up Of Timken Ring On Block

Previous Timken OK Load Results

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

Data Sheet Values

Higher is better.

ASTM D2266-01 Standard Test Method For Wear Preventive Characteristics Of Lubricating Grease (Four-Ball Method)

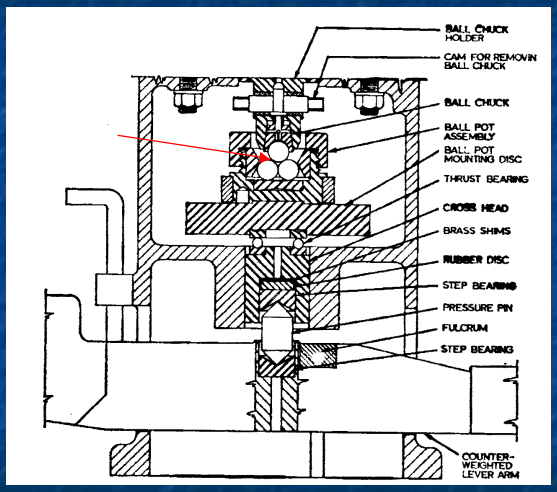
This test method covers the determination of the wear preventive characteristics of greases in sliding steel-on-steel applications.

Wear is reported as the diameter of the wear scar.

Smaller is better.

ASTM D2266 Four-Ball Wear Tester

ASTM D 2266 Four-Ball EP Test



Previous ASTM D2266 Four-Ball Wear Results

	Data Sheets	Test Data
	mm	mm
MOV LL Grade 0	0.49	0.49
Grade 1	0.49	0.47
Grade 2	0.49	0.40
MOV Extra Grade 0	0.48	-
Grade 1	0.38	0.42
Nebula EP0	0.67	-
EP1	0.67	0.47
Mobilgrease 28	0.5	0.52
N-5000	-	0.75
N-7000	-	0.69

New 4-Ball Wear Testing - Brass and Stainless Steel Balls

- The standard test uses ½" 52100 steel balls.
- These were changed to balls made of 2600 brass and 302 stainless steel.

Brass: Grade 200, C26000 per ASTM B134 (cartridge brass), 75-87 HRB, 57,000 psi yield strength.

Stainless Steel: Grade 100, S30200 per ASTM A493, 25-39 HRC, 75,000 yield strength.

New Four-Ball Wear Testing - Brass and Stainless Steel Balls

Grease	Wear Scar (mm)
Loctite N-5000	2.63
Loctite N-7000	2.40
Mobilgrease 28	1.73
Mobilux EP2	1.55
Lubriplate 630AA	1.43
MOV Long Life Grade 1	1.05

15 kg, 1200 rpm, 75°C (162°F), 60 minutes

Smaller is better.

New Four-Ball Wear Testing – Brass and Stainless Steel Balls

Grease	Wear Scar (mm)
MOV Long Life 2	1.17
MOV Long Life 1	1.05
MOV Long Life 0	0.88
MOV Syn 1	0.79
MOV Extra 1	0.79

At the worst still better than all the rest.

15 kg, 1200 rpm, 75°C (162°F), 60 minutes

Smaller is better.

Wear Protecting Characteristics

This can be achieved in different ways including;

- Base oil viscosity
- High base oil viscosity index
- Additives, and/or
- Better thickener system.

Some greases have many of the formulation components but generally only with calcium complex and calcium sulphonate greases does the thickener help. To be most effective the grease has to get to right place, stay in place and not change.

Antiwear, Antiscuff, EP?

- It used to be that an extreme pressure (EP) grease was all that was required but this term is not clear.

Generally an EP grease is one with a Timken Okay Load ≥15lb or in the 4-ball EP test anything over a 200kg weld point.

In which case over half of the grease/pastes being used might be borderline.

Measuring Stem Nut Wear

- During diagnostic testing one of the events on the stem thrust trace is where the force applied to the stem changes direction (zero plateau). This event can be used to estimate thread wear when a baseline test is available on a new nut.

- Ref: Chuck Reames – LinkedIn Power Plant Operations & Maintenance - Motor Operated Valve Stem Nut Failure Thread – Dec 2013

Measuring Stem Nut Wear cont'd

- As the thread wear increases, so does the plateau time. The zero plateau transition time is used to calculate the stem nut wear.
- Variables required to calculate wear are motor speed, overall actuator gear ratio, stem pitch and lead. Other variables that mask thread wear are loose stem nut locknut and stem rotation. A baseline test is needed.

- Ref: Chuck Reames – LinkedIn Power Plant Operations & Maintenance - Motor Operated Valve Stem Nut Failure Thread – Dec 2013

Directly Measuring Stem Nut Wear

SNAP – Stem Nut Analysis Protractor

Conclusions

1. If greases or pastes with solids OR a product showing higher wear rates are being used OR were used, it might be appropriate to assess the stem nut wear.

Conclusions

2. If you were using Mobilux EP you might want to check for any adverse consequences of the reformulation.

Conclusions

3. If using a lithium or lithium complex thickened grease and if EQ conditions are important verify that the performance will not be significantly degraded by heat and water.

Conclusions

4. A test using copper alloy and stainless steel materials has been developed. This showed that calcium sulfonate thickened MOV Long Life, MOV Extra and MOV Syn greases had less wear.

Thank you