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Understanding Low Temperature MOV Greases

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Background

For stations with the steam turbines and/or auxiliary equipment located outside and/or for fossil stations with coal or fuel oil handling actuators, low temperatures can be important. Plus MOV's are used in many other industrial applications that can see low temperatures.

What is considered 'low' is based on large part on the characteristics of the grease being used, not just the actuator.

Not Just Low Temperatures

Aged greases that have hardened are expected to also show some of the same consequences as greases that are stiffer because of low temperature. For aged limits some use NLGI Grade 3 maximum.

Stiff aged greases can be worst because of a loss of oil. Cooled greases can warm-up but you cannot get the oil back with aged greases.

Greases

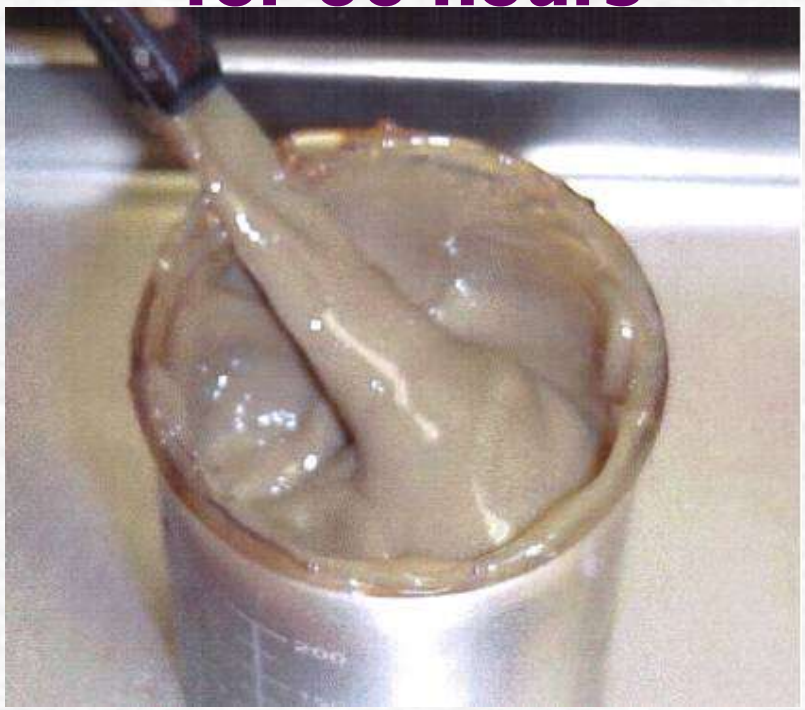
Greases are a mixture of the thickener, the base oil and the additives.

The affect of low temperatures is dependent on all three aspects of the formulation. The result of low temperature is a stiffer grease but it is not the same as age hardening or thermal hardening. These two are not reversible but with temperature as it rises the grease will soften again.

After oven aging at 177°C (350°C) for 66 hours

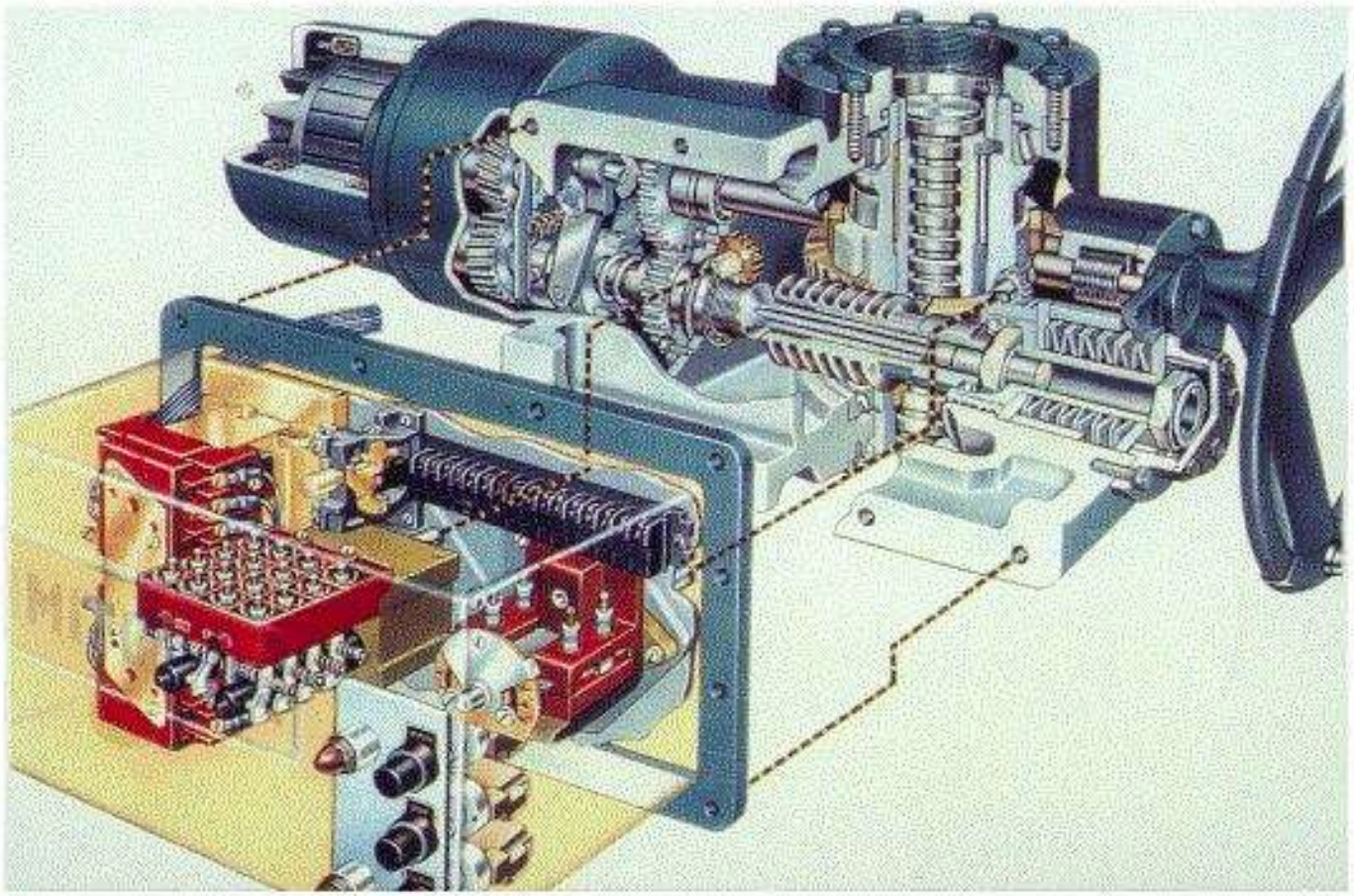
Previous commonly used calcium complex grease was solidified.

After oven aging at 177°C (350°C) for 66 hours

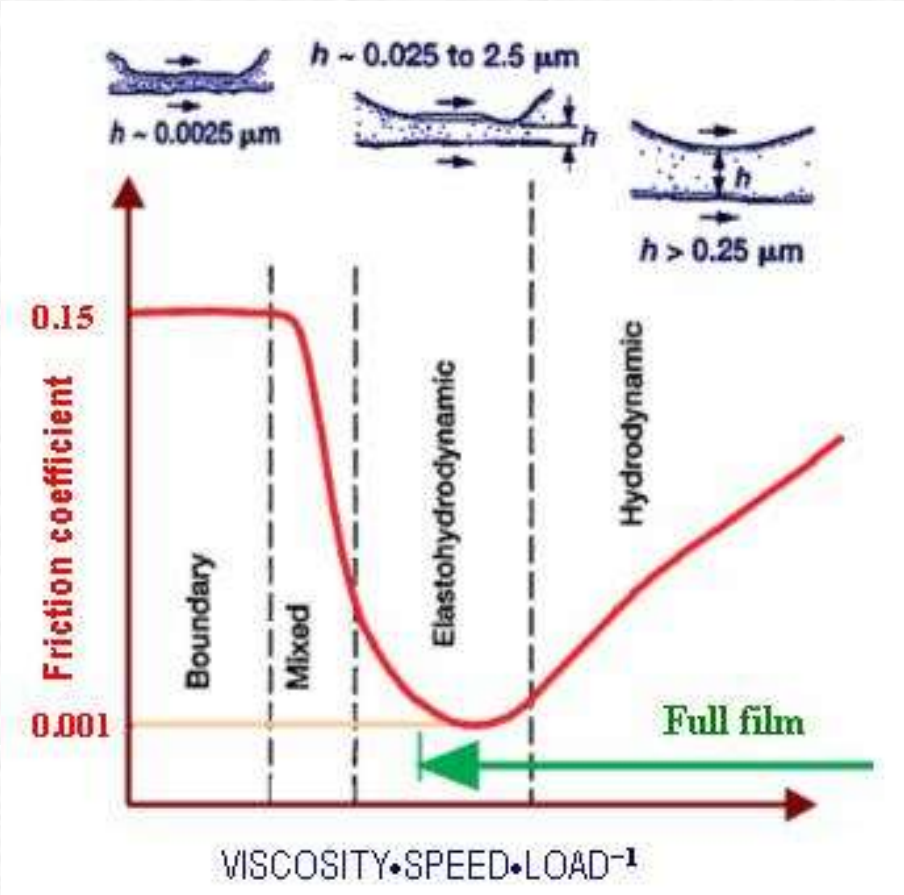


MOV Long Life Grade 0 - Still grease-like.

Limitorque SMB



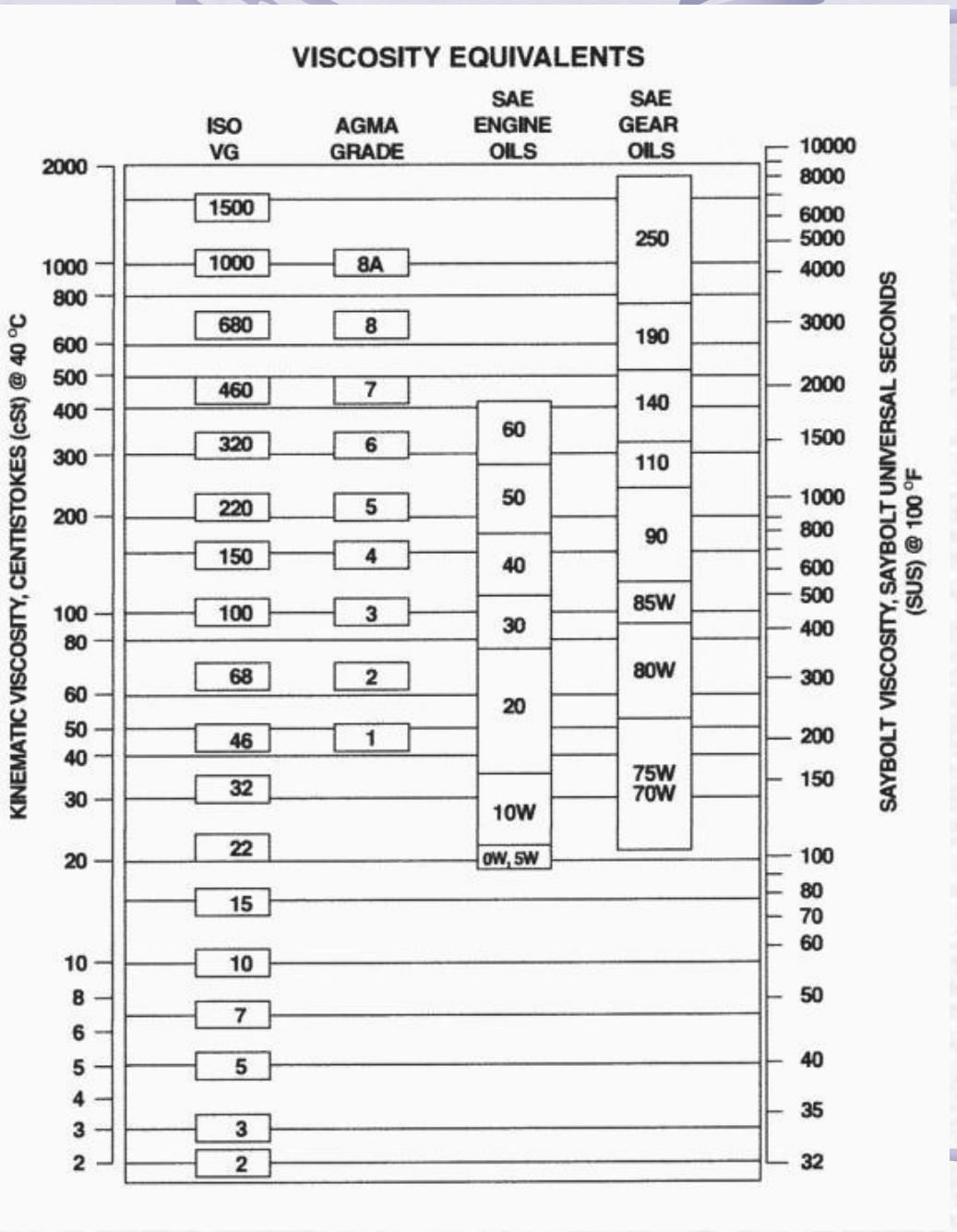
Moving Surfaces - Stribeck Curve



Wear **No Wear**

Viscosities of Common Fluids

	Centipoise	Centistokes
Water	1.0	1.002
SAE 10 oil	70	80
Olive oil	100	110
SAE 30 oil	300	350
Glycerin	500	400
SAE 50 oil	800	910
Honey	2,000	1,430


VISCOSITY EQUIVALENTS
ISO VG
AGMA GRADE
SAE ENGINE OILS
SAE GEAR OILS
KINEMATIC VISCOSITY, CENTISTOKES (cSt) @ 40 °C
SAYBOLT VISCOSITY, SAYBOLT UNIVERSAL SECONDS (SUS) @ 100 °F
2000
1000
800
600
500
400
300
200
100
80
60
50
40
30
20
10
8
6
5
4
3
2
1500
1000
680
460
320
220
150
100
68
46
32
22
15
10
7
5
3
2
8A
8
7
6
5
4
3
2
1
60
50
40
30
20
10W
0W, 5W
250
190
140
110
90
85W
80W
75W
70W
10000
8000
6000
5000
4000
3000
2000
1500
1000
800
600
500
400
300
200
150
100
80
70
60
50
40
35
32

Application	Low-temp Viscosity Limit (cSt)
Heavy-duty turbine drive	175
Ring oiling (motors and line shafts)	1,000
Hydraulic pumps	1,300
Industrial electric motors	2,000
Small gear pumps	2,000
Automobile engines	3,000
Jet aircraft engines	13,000
Industrial gearboxes	50,000

Table 1. Approximate Low-temperature Viscosity Limits

- Ref. Konsari, M. and Booser, R., 'Low Temperature and Viscosity Limits', Machinery Lubrication 3/2007

SAE J306 Automotive Gear Lubricant Viscosity Classifications

SAE Viscosity Grade	Maximum Temperature for Viscosity of 150,000 cP, °C	Kinematic Viscosity at 100°C, cSt Minimum
70W	-55	4.1
75W	-40	4.1
80W	-26	7.0
85W	-12	11.0

Grease Formulations

First the thickener systems can be fibrous, gel-like, soaps, micelles and types of suspensions.

The base oil can be different types, have different processing, have different viscosities and have different viscosity indexes. The latter is an indication of the changes with temperature.

Then there can be additives that can affect temperature response such as polymers to improve water washout resistance.

The Concerns

Too viscous a lubricant can result in some or all of the following;

- Very high starting torque.
- Bearing skidding damage.
- Locking of spring pack.
- Local overheating.
- Local lubricant starvation.
- Wear debris scoring.
- Seal damage.

Greases - Thickeners

Ref: Ward, W., ‘Understanding Calcium Sulfonate Thickeners’, Machinery Lubrication, Jul 2006

NLGI Grease Grades

- The consistency is determined by the thickener, additives and both the amount and type of base fluid. This is quantified by the National Lubricating Grease Institute (NLGI) classification system.

- This is very simple and is based on the depth that a cone penetrates into a lightly worked (60 strokes) sample.

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.

Base Oil Content

MOV Long Life Family	
NLGI Grade	% Oil
9000	90
0	80
1	75
2	70

OEM Requirements

Reference: Limitorque SMB Series / SB Series Instruction and Maintenance, 40-11000 July 2003

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°) to 150°F (66°C).

Oil Low Temp Tests

- **D97 Standard Test Method for Pour Point of Petroleum Products**
- **D2500 Standard Test Method for Cloud Point of Petroleum Products**
- **D2983 Test Method for Low-Temperature Viscosity of Lubricants Measured by Brookfield Viscometer**
- **FTM 3456** Channelling characteristics of lubricants
- **D3829 Test Method for Predicting the Borderline Pumping Temperature of Engine Oil**
- **D4684 Test Method for Determination of Yield Stress and Apparent Viscosity of Engine Oils at Low Temperature**
- **D5133 Test Method for Low Temperature, Low Shear Rate, Viscosity/Temperature Dependence of Lubricating Oils Using a Temperature-Scanning Technique**
- **D6821 Standard Test Method for Low Temperature Viscosity of Drive Line Lubricants in a Constant Shear Stress Viscometer**
- **D6896 Test Method for Determination of Yield Stress and Apparent Viscosity of Used Engine Oils at Low Temperature**

Grease Low Temp Tests

- ASTM D217 Standard Test Methods for Cone Penetration of Lubricating Grease
- ASTM D1092 Standard Test Method for Measuring Apparent Viscosity of Lubricating Greases*
- FTM 3456 Channelling characteristics of lubricants
- ASTM D1478 Standard Test Method for Low-Temperature Torque of Ball Bearing Grease*
- ASTM D4693 Standard Test Method for Low-Temperature Torque of Grease-Lubricated Wheel Bearing
- Lincoln Ventmeter- Pressurize a 25' long coil to 1800 psi, open a venting valve and read the pressure after 30 seconds
- U.S. Steel Method LT37 Mobility of Grease – Measure the flow of grease through a capillary under 150 psi inlet pressure.*

* Will present this data.

So what works? Wait for Problems or Grease Mobility Test

Re: Koehler – Bases on a US Steel Mobility LT37 Method. Flow is measured in grams per second by pumping the sample through a standardized pressure viscometer at controlled temperature and 150 psi (1.04 MPa) pressure.

Grease Mobility

Product	Viscosity	Mobility (g/minute)				
	cSt	0 F	-10 F	-20 F	-30 F	-40 F
	40°C	-17.8°C	-23.3°C	-28.9°C	-34.4°C	-40°C
MOV Extra 00	24.3	262	127	46	15.2	
MOV Extra 0	24.3	287	139	69	16.5	1.2
MOV Extra 2	24.3	49	18	10	2.3	
MOV Long Life 00	95	52	22	10	1.8	
MOV Long Life 0	**95**	**40**	**19**	**9**	**2.2**	
MOV Long Life 1	95	11	5			
MOV Long Life 2	95	13	6	2.2		
Nebula EP0	**96.3**	**21**	**6**	**2.4**	**1.3**	
Nebula EP1	96.3	3.6	1.4	0.6	0.2	
Mobilith SHC 007	460	27				
MOV Syn 2	50	86.4				
MOV Syn Plus 1	223			39.2*		18.6*

Mobility Key Factors

For good performance at <20°F (-29°C) requires some or all of the following;

- A 00 or lower (softer) NLGI Grade.
- A lower viscosity base oil.
- A higher viscosity index base oil.
- The right additives with antiwear (EP).

ASTM D1478 Low Temperature Torque Test

Re: Koehler – The low temperature torque test measures the extent to which a grease sample retards rotation of a 6204 ball bearing assembly at the test temperature.

Low Temperature Torque

Grease	Grade	Temp	Start	1 Hour
		°F	g-cm	
MOV Long Life	00	-20	2607	319
MOV Long Life	**1**	**-20**	**2500**	**1500**
MOV Extra	00	-20	442	130
MOV Extra	0	-20	533	130
Nebula EP	**0**	**-20**	**2483**	**559**
Lithium	0	-20	1209	358
Syn	00	-20	481	280

Low Temperature Torque

Grease	Grade	Temp	Start	1 Hour
		°F	g-cm	
MOV Long Life	00	-40	13572	2347
MOV Extra	**00**	**-40**	**728**	**280**
MOV Extra	**0**	**-40**	**2425**	**351**
MOV Extra	1	-40	5356	299
MOV Extra	2	-40	8710	858
MOV Syn	00	-40	1062	206
Nebula EP	0	-40	26891	5057
Nebula EP	**00**	**-40**	**878**	**358**
Lithium	0	-40	18337	5857
Syn	00	-40	3380	858

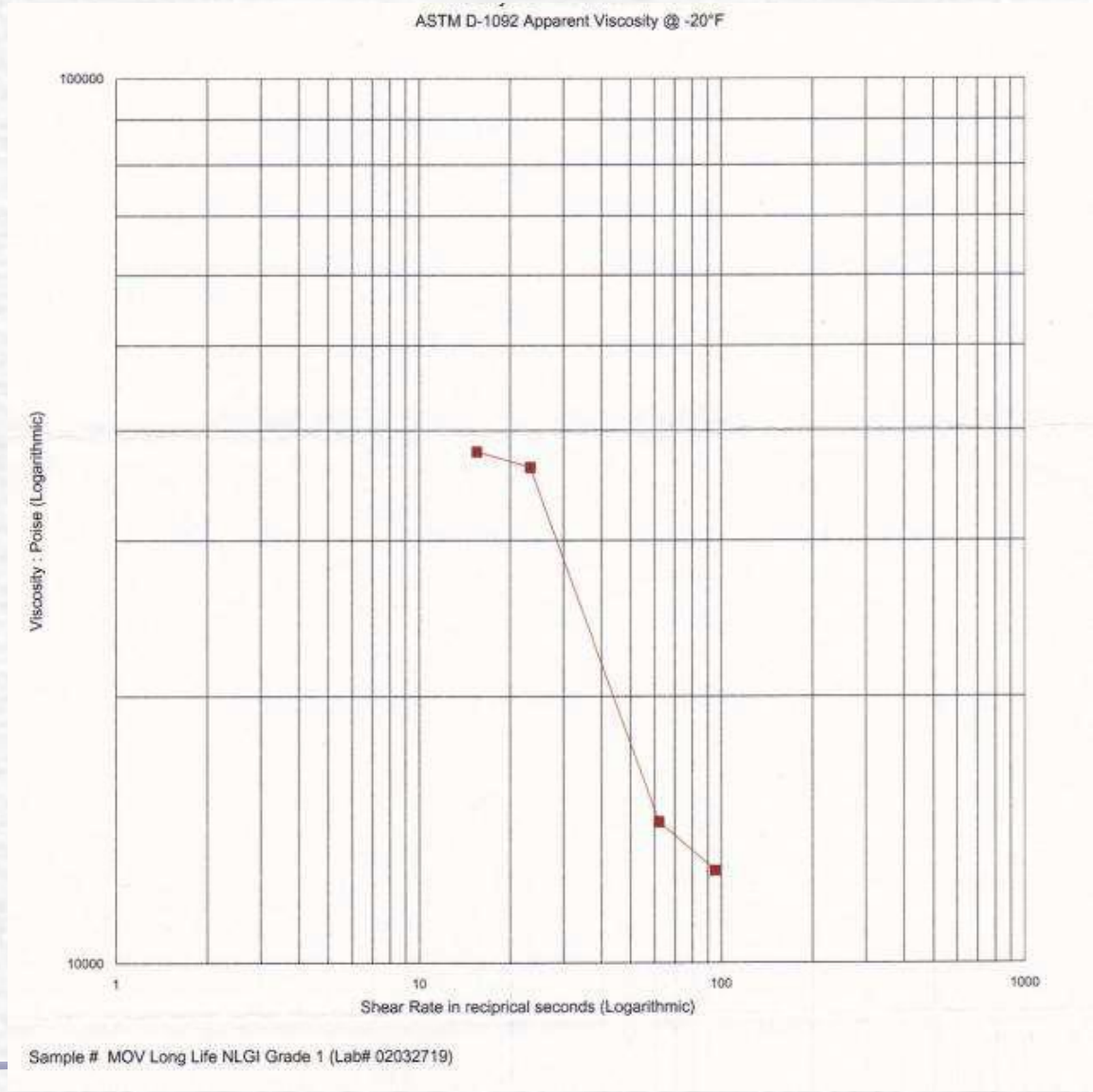
Low Temperature Torque Factors

For good performance at <20°F (-29°C) requires some or all of the following;

- A 0 or lower (softer) NLGI Grade.
- A lower viscosity base oil.
- A higher viscosity index base oil.
- The right additives with antiwear (EP).

ASTM D1092 Low Temperature Pressure Viscometer

Ref: Koehler - Apparent viscosity is used to evaluate pumpability and handling characteristics of greases. The sample is forced through a capillary by means of a gear pump-driven hydraulic system and the resulting pressure in the system is measured. Apparent viscosity is then calculated from the flow rate and pressure.


ASTM D-1092 Apparent Viscosity @ -20°F
100000
10000
Viscosity : Poise (Logarithmic)
1
10
100
1000
Shear Rate in reciprical seconds (Logarithmic)
Sample # MOV Long Life NLGI Grade 1 (Lab# 02032719)

Other Factors

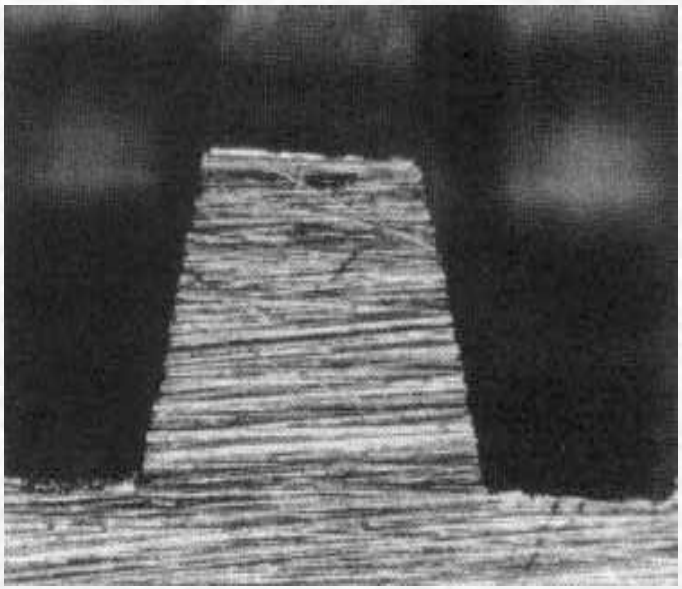
The concerns about poor mobility and high torques can cause problems with being able to operate the actuators at low temperatures but also for longer term reliability and increased costs because of wear. This is for the actuators but also for the stem nuts and the valve stem threads.

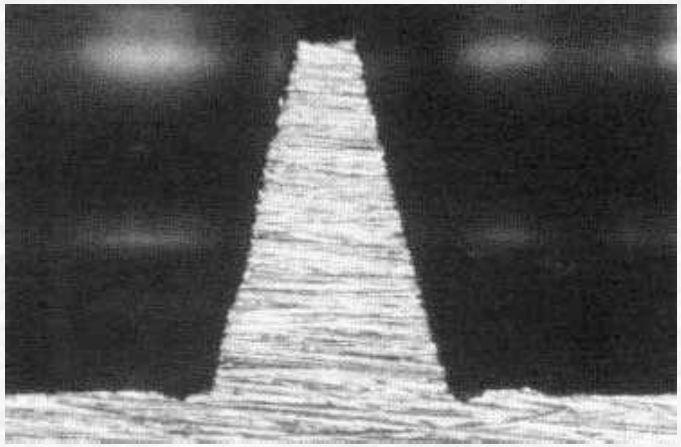
Even at indoor temperatures wear of the stem nuts is occurring and it has been found that a number of stations are using greases without EP antiwear performance. This is unfortunate.

Stem Nut Wear, Antiseize

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

EPRI





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

Lube Note #3 May 1990

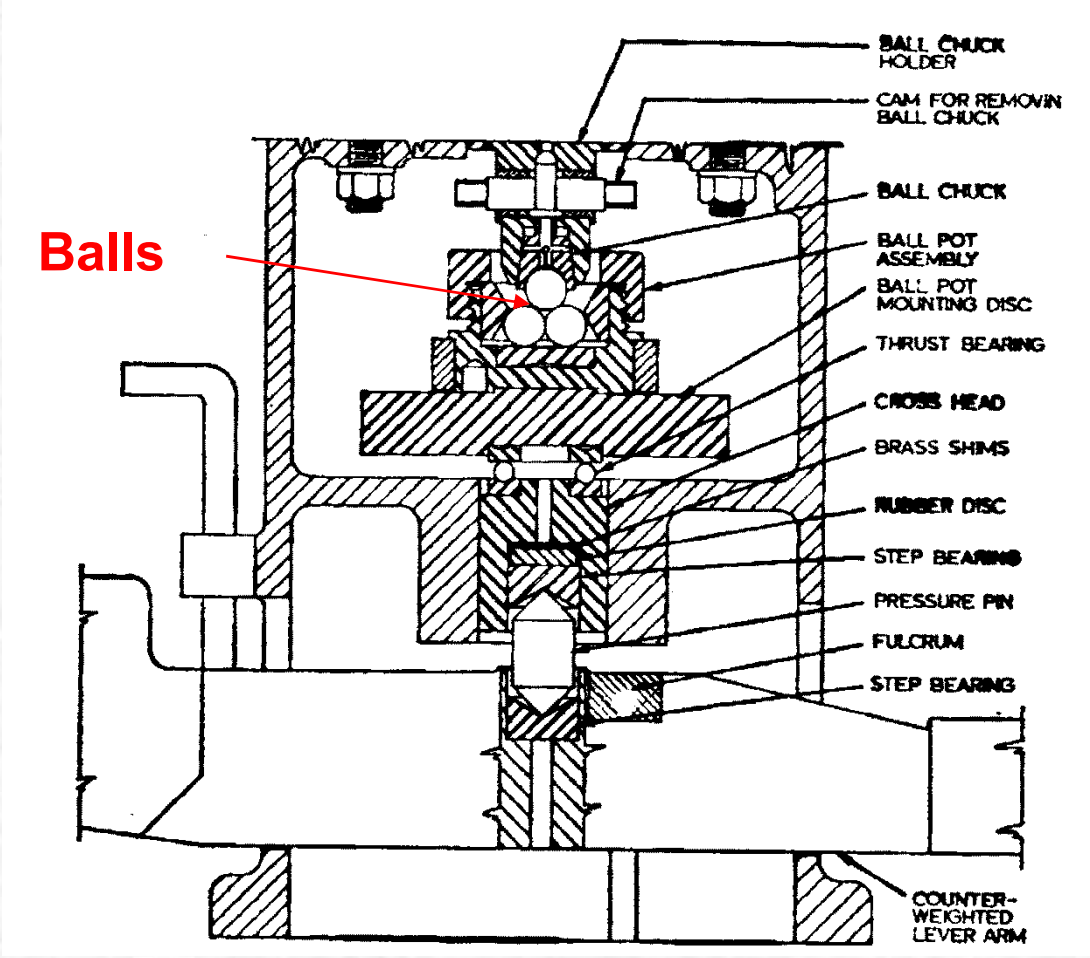
New 4-Ball Wear Testing

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

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

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

ASTM D2266 Four-Ball EP Test



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

Grease	Wear Scar (mm)	
Loctite N-5000	2.63	worst
Chevron SRI #2	2.60	
Loctite N-7000	2.40	
Mobilgrease 28	1.73	
Mobilux EP2	1.55	
Conoco Dynalife L0	1.52	
Lubriplate 630AA	1.43	
MOV Long Life Grade 1	1.05	best

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

New Four-Ball Wear Testing

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

Test Conditions: 15 kg, 1200 rpm, 75˚C (162˚F), 60 minutes

Four-Ball Factors

- A grade 2 grease on the stems will have a much higher torque, especially at low temperatures.
- A Grade 0 has shown less wear at higher test temperatures
- MOV Long Life and Extra have inherent EP antiwear performance.

Conclusions

1. Greases for low temperature applications should be tested using a number of several specific tests for low temperatures. These include grease mobility and torque. Apparent viscosity can also be useful.
2. A softer grease or a synthetic base fluid by itself are not enough.
3. For low temperatures a 0 or 00 Grade is preferred as is a base oil with low oil viscosity but the grease must still have antiwear (EP) characteristics.

Our MUG Presentations

'All-in-one, An Update On MOV Long Life', 2003

'MOV Long Life Limitswitch Applications', 2004

'MOV Long Life Condition Monitoring', 2005

'MOV Long Life Condition Monitoring Update', 2006

'MOV Grease Stem Wear Testing', 2007

'Commercial Grade Dedication and In-service MOV Long Life Grease Testing', 2008

'MOV Long Life - Reducing Oil Seepage', 2009

'Semifluid Grease For Oil Filled MOV's', 2010

'MOV Long Life Grease – A Decade Later', 2013

'MOV Stem Grease Wear Testing – Update', 2014

Thank you

Canoil Canada Ltd.