MUG

MOV Users' Group

Presentation: January 2003, Clearwater, FL

All-in-one Grease, An Update on MOV Long Life

Ken Brown, Utility Service Associates (now Eco Fluid Center)

Ted Austin, Forsythe Lubrication Associates (now with Canoil)

Wayne Mackwood, Crompton Co/Cie (now Lanxess)

Abstract: Three different lubricants were recommended for the limit switch gearboxes, main gearbox and the valve stems but now just one will do the job. It is a calcium sulphonate thickened grease. This paper will present new third party test data on MOV Long Life and the current products. Included will be thin film and bulk oxidation testing, pin on disc testing, corrosion testing and an environmental qualification update.

minor update 8/19

Background

Several of the current products have well known problems with poor antiscuff performance and age hardening for the stems, the main gearbox and the limit switch gearbox. See Figure 1. These problems could lead to wear and the requirement for more frequent replacement of the grease. As well, there were concerns about the actual performance and the limits to be used for the torque settings on safety related equipment. The NRC had cautioned in 1979 about the use of one grease above 140°F because of hardening to the point of excessive wear. See Reference 1.

The desired characteristics of a replacement grease includes; good antiscuff performance, low oil bleed and good performance in thin film oxidation tests. The new candidate must also have good mechanical stability, offer corrosion protection, resist the effects of radiation, have a high dropping point, and good resistance to water. It would also be an advantage if that grease could be used to lubricate the two gearboxes on Limitorque valve actuators and the stems. The advantages of this include: simplified inventories, less chance of mixing incompatible greases, an improvement in performance, and possibly less maintenance.

Fortunately, a calcium sulfonate complex grease offered the desired properties. This technology has been on the market for some time, see References 2 and 3, with the inherent advantages of good anti-scuff performance, outstanding corrosion protection and excellent mechanical stability. It is also compatible with the calcium complex grease which was the previous, but now discontinued, technology used for this application.

Initially the focus of development was for a valve stem lubricant and included products such as MOV and MOV Plus as a NLGI Grade 2. With the new interest in the main gearbox, a product with a more highly refined base oil was preferred and this was MOV Long Life. See Reference 4. Considerable testing has shown the benefits of MOV Long Life greases for the stem and for the main gearbox. It is clear that MOV Long Life is a very suitable replacement and is in fact an upgrade for the older calcium complex greases. The potential use of calcium sulphonate complex greases in all three applications was reported back in 1996. See Reference 5.

The stem stem/nut work is reported in References 6 and 7. In the earlier COG work was on an early formulation called MOV Plus and it was one of only two greases to meet their objectives of a five-year service life. The other grease was found to have poor stability in the presence of heat and water making it a less desirable choice. In more recent stem/stem nut testing by INEL, the current MOV Long Life did very well and was one of the few greases that did not show a significant increase in the coefficient of friction with temperature.

Environmental qualification work subjecting MOV Long Life to both radiation and aging plus radiation and steam is reported in References 8 and 9 respectively. MOV Long Life grease did very well, but it was determined that the current calcium complex product was not able to survive the target of five years aging before testing. This further indicates the need to find a replacement grease for this application.

The more recent COG study also looked at mixing aged calcium complex grease with new MOV Long Life – there were no issues regarding compatibility. In addition, EPRI will shortly be releasing their work on aging and irradiation to 220 Mrad MOV Long Life Grade 1 and mixtures with the previous calcium complex grease. Verbal reports indicate that MOV Long Life and mixtures are qualified. See Reference 10.

MOV Long Life has performed very well in the previously mentioned testing for the stem/stem nut and gearbox applications, however for the limit switch gearbox application one on one comparative testing against the two approved products would be very useful data.

Evaluation

Oxidation testing was performed by Herguth Laboratories in California, the same lab used by NMAC for lubrication related work. The copper strip corrosion testing was done at Kinectrics, formerly Ontario Hydro Research. Kinectrics had also already performed this test on samples of MOV Long Life that had been environmentally qualified.

In addition, MOV Long Life meets all the lubrication requirements given by Limitorque, see Appendix A, but it was thought prudent to evaluate the product for gear wear . The test considered most suitable was the US Navy gear test and it was run at Petro-Lubricant Test Labs, Inc. in Lafayette, NJ.

Results

1. Thin Film Aging Tests

Thin film tests are thought to better simulate a film of lubricant on a gear and also are more severe in that they can highlight problems with oil bleeding. The tests were conducted on vertical steel panels at 350°F (177°C). The results in Table 1 show that MOV Long Life did the best.

2. Bulk Aging

Bulk aging in a container might be more typical of a gearbox application. Grease was aged at 177°C (350°F) until the greases showed signs of distress characterized by an increase in consistency.

As shown in Table 2 MOV Long Life in both Grades 0 and 1 did very well. They far exceeded the life of the current products which failed because of excessive hardening. Many stations change out grease when it stiffens to a Grade 3. See Photos 1-6 of the post aged grease samples. The current limit switch gearbox greases did poorly. The calcium complex grease used in the main gearbox was run as well for comparison; it hardened considerably going from a Grade 1 to a Grade 6 while in the same test the MOV Long Life grease showed no significant changes. This should be indicative of a much longer service life.

3. Pin-on-Disc

Pin on disc test data has shown that MOV Long Life grease performed as well as the best, see Table 3. When the superior resistance to thermal breakdown is considered it is clearly the best choice.

4. Copper Strip Corrosion

One utility requested that testing be done to push MOV Long Life and the two competitors in the bulk aging tests until one failed and then to do copper corrosion testing on MOV Long Life. There has been some concern expressed about actual corrosion differences between active sulfur additives in some other products and inactive sulfur in the sulphonate. Active sulfur can be a concern when sulfur/phosphorous extreme pressure (EP) additives are used, especially with yellow metal alloys such as the bronze gears in the gearbox and the limit switch gearbox. However, MOV Long Life does not require the use of extra EP additives (Chlorine, Sulfur/Phosphorous) some of which may be found in competitive products.

A sample of the aged MOV Long Life Grade 1, taken after the competitors had failed the aging, was tested in the ASTM D-4048 copper strip corrosion test. See Table 4. It was rated as a 1b which is unchanged from the unaged rating for MOV Long Life. This demonstrates that the sulphonate thickener of MOV Long Life does not form corrosive species even after extended aging. past the point of use for the current products.

In addition, copper strip corrosion testing has previously been run on the following; new MOV Long Life, MOV Long Life tested at four times the normal duration and then on a sample that had been subjected to the COG environmental qualification (EQ) testing including thermal aging plus irradiation. MOV Long Life remained a 1b in all these tests.

5. Gear Wear

FTM 335 Gear Wear or Navy Gear Wear test uses a 1.1 cm brass gear meshing at right angles with a 1.2 cm steel gear. The reciprocal motion of the gear results in a measure, of gear wear, and of the ability of a lubricant to protect the metals under dynamic load.

MOV Long Life showed acceptable wear, see Table 5, and approached that of other premium products as well as meeting the requirements given in several MIL specifications. Unfortunately, data was not available for the current products.

6. Comparative Data

Table 6 lists the typical tests and describes their characteristics. Tables 7 and 8 compare MOV Long Life with the current products being used in the limit switch gearbox. Overall, MOV Long Life exceeds the performance of the competitive greases.

Discussion

Based on this data as well as the other advantages of MOV Long Life with respect to compatibility, radiation resistance, corrosion protection and stability it is expected that using MOV Long Life for this application would be a very effective upgrade.

It is recognized that the current products may have strengths in other applications, however they do not appear suited to meet the requirements for motor operated valves in power stations. In fact for the main gearbox the manufacturer stated this at a meeting in 2002.

Testing on the current calcium complex grease has also confirmed that MOV Long Life should provide a much longer service life because of the better resistance to age hardening, while providing better corrosion and wear protection.

Recently, concerns have been raised about the health effects of outgassed products after heating from one of the current greases when it used in confined spaces. Testing is ongoing but one possible source is an added rust inhibitor. This additive is not required with the calcium sulphonate thickener of MOV Long Life.

In view of the benefits of MOV Long Life and concerns about the actual qualification of the current calcium complex grease, using up existing stocks first might not be the best option.

Conclusion

MOV Long Life is a superior product and should be more than suitable for the limitswitch gearbox as well as for the main gearbox and the stem stem/nut applications.

References

1. NRC IE Information Notice 79-03.

2. Muir, Ronald, J., “High Performance Calcium Sulfonate Complex Lubricating Grease”, 1987 NLGI Annual Meeting, Toronto, ON

3. Mackwood, W., and Muir, Ronald, “Calcium Sulfonate Grease … One Decade Later”, 1998 NLGI Annual Meeting, Naples, FL.

4. Mackwood, W, and Brown, K.J., “Proper Grease Selection Reduces Steam Valve Maintenance”, 2001 NLGI Annual Meeting, West Palm Beach, FL

5. NMAC Lube Notes, July 1996, Volume 7, Number 5.

6. DeWall, K.G. and Watkins, J.C., “MOV Stem Lubricant Aging Research”, INEEL/EXT-02-00975, September 2002.

7. Guérout, F.M., Houot R., Grandison, D.A.E., and Janis, J., “Qualification of Greases for Motor-Operated Valve Stem/Stem Nut Lubrication”, COG-970331, February 1998. (Also issued as EPRI R TR-106825, October 1998).

8. Janis, J., McCutcheon, R., and Staniewski, G., “Qualification of MOV Long Life Grease for Limitorque Main Gearbox Application”, CANDU Owners Group Report COG-JP-01-009, February 22, 2002.

9. COMED (now Exelon) Technical Support Laboratory Report A2000-178S, Evaluation of Cor-Tek MOV Long Life and MOV Plus Greases Following Radiation Exposure”, August 24, 2000.

10. EPRI 1003483 "Comparative Analysis of Nebula And MOV Long Life Greases For Limitorque Main Gearbox Applications", Final Report December 2002.

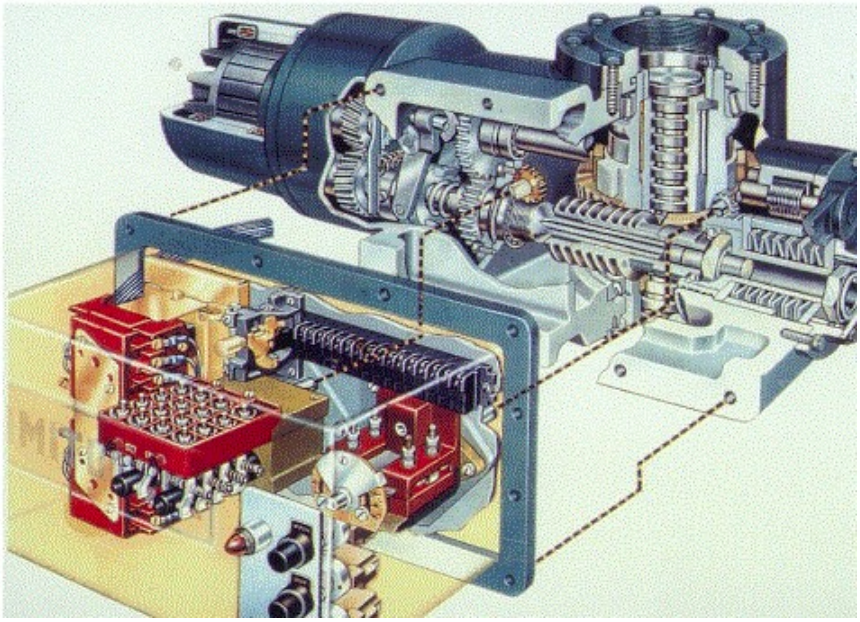

Figure 1: Limitorque Actuator

TABLE 1 OXIDATION TESTS THIN FILM OVEN AGING AT 350°F (177°C)					
HOURS	**GREASE ' A'**	**GREASE ' B'**	**CALCIUM COMPLEX EP1**	**MOV LONG LIFE GRADE 0**	**MOV LONG LIFE GRADE 1**
65½	slightly dry, but okay	dry, no oil	dry, no oil	moist, lots of oil	moist, lots of oil
146½	slightly malleable but no oil	complete dust	complete dust	moist, lots of oil	moist, lots of oil

PROCEDURE: Thin film was used because it is expected to more severe and to also simulate a film of grease on a gear tooth and on a valve stem.

COMMENTS: Tests were taken past the point of actual failure. This is considered to be <65½ hours for Greases 'A' and 'B' as well as the calcium complex grease. Grease 'A', unlike the calcium complex grease and MOV Long Life, has a clay thickener which likely has no lubricating properties once the oil is lost. Consequently Grease 'A' is also expected to have been unsuitable for use after 146½ hours.

TABLE 2
BULK SAMPLES OVEN AGED AT 177°C (350°F) FOR 66 HOURS

	GREASE ' A'	GREASE ' B'	CALCIUM COMPLEX EP1	MOV LONG LIFE GRADE 1	MOV LONG LIFE GRADE 0
Description	Stiff and dry, looks like wet sand.	Very stiff and dry, little oil and cracked on attempts to mix.	Very stiff and dry, little oil and had turned black.	Still grease-like, moist, lots of oil. Could still be mixed.	Still grease-like, moist, lots of oil. Could still be mixed.
Penetration (mm/10@25°C)					
Before	310	280	325	317	361
After	193	116	81	324	365
Change	stiffer by 38%	stiffer by 59%	stiffer by 75%	softer by 2%	softer by 1%
% of Original	62%	41%	25%	102%	101%
NLGI Grade					
Before	1	2	1	1	0
After	4	6	6	1	0

Condemning limit at many stations is NLGI Grade 3 which has a worked penetration range of 220 - 250. The competitive products had stiffened far past this point. MOV Long Life in both grades was essentially unchanged.

TABLE 3
PIN ON DISK TRIBOMETER TESTS

52100 PIN ON A 52100 DISK
LOAD 50N, SLIDING SPEED 5 RPM, AMBIENT TEMPERATURE, 50M SLIDING DISTANCE

Grease	Worked Pen (mm)	Thickener	Base Oil		Coefficient of Friction				Wear (mm)	
			Oil Type	Vis. @40°C	Start	Mid	End	Avg.	Pin Scar dia.	Disk Scar width
MOV LONG LIFE	360 Grade 0	Calcium Sulphonate	Group II mineral oil	95	.11	.11	.11	.11	0.17	0.20
MOV LONG LIFE (sample 1)	325 Grade 1	Calcium Sulphonate	Group II mineral oil	95	.11	.11-.12	.11	.11	0.19	0.20
MOV LONG LIFE (sample 2)	325 Grade 1	Calcium Sulphonate	Group II mineral oil	95	.11	.11	.12	.11	0.23	0.22
GREASE 'B'	280 Grade 2	Lithium	Synthetic diester	12	.09-.11	.09-.11	.09-.11	.10	0.20	0.20
CALCIUM COMPLEX EP1	325 Grade 1	Calcium Complex	Naphthenic mineral Oil	100	.11	.10-.11	.10	.10	0.30	0.30
GREASE 'A'	310 Grade 1½*	Non soap	Synthetic hydrocarbon	30	.10-.13	.10-.15	.11-.12	.12	0.32	0.22

* Not a NLGI Grade

TABLE 4

MOV LONG LIFE GRADE 1

COPPER STRIP CORROSION TESTING ASTM D-4048

NEW GREASE	1b
AGED FOR 66 HOURS AT177°C(350°F)*	1b

* After some current products had failed in the aging.

TABLE 5

MOV LONG LIFE

NLGI GRADE 1

NAVY GEAR WEAR*

DURATION	WEAR (mg)
1000 cycles	4.7

***Procedure - FTM 335:** The FTM Gear Wear or Navy Gear Wear test uses a 1.1 cm brass gear meshing at right angles with a 1.2 cm steel gear. The reciprocal motion of the gear results in a measure (as gear wear) of the ability of a lubricant to protect the metals under dynamic load. The test can be run with either 5 lb or 10 lb applied loads and for 1,000, 3,000 or 6,000 cycles. One combination is 10 lb for 1,000 cycles.

TABLE 6
MOV LONG LIFE
EXPLANATION OF COMPARISON DATA

CHARACTERISTIC	SIGNIFICANCE
Color	A natural color can be better because dyes can have lower stability.
Thickener	Better if compatible with existing product.
NLGI Grade	Typically Grade 0 or a 1 which only indicates consistency.
Penetration: worked @25°C, ASTM D-217	Must be in grade.
Stability: % change, ASTM D-217	Less of a change is better.
Dropping Point: (°C), ASTM D-2265	Higher can be better.
Base Oil Viscosity: (cSt), ASTM D-445 @40°C @100°C	Should not be too low or too high. Too low can affect low speed performance.
Shell Roll Stability: % change, 2 hours ASTM D-1831 @ 20°C	Less of a change is better.
Bearing Life: hours, ASTM D-3527	Longer is better.
Bomb Oxidation: kPa drop, ASTM D-942 (500hr)	Less of a pressure drop is better.
Oven Panel: 96 hours @ 150°C, 30 mils per a modified GM 9075-P.	The longer with less of a change or oil bleed the better.
Timken OK Load: (kg), ASTM D-2509	Higher should be better.
4 Ball EP: ASTM D-2596 load wear index (kg) weld point (kg)	Higher is better for both.
4 Ball Wear: scar dia. (mm), ASTM D-2266	Lower is better.
Copper Strip Corrosion:(rating), ASTM D-4048	The lower the better.
Salt Fog: hours to failure, ASTM B-117	The longer the better.

TABLE 7
MOV LONG LIFE
COMPARISON WITH CURRENT 'A'

CHARACTERISTIC	Grease 'A'	MOV Long Life NLGI 1
Color	Dark Red	Tan
Thickener	"Nonsoap"	Calcium Sulphonate
Penetration: worked, ASTM D-217	305	325
Stability: 100,000 strokes, ASTM D-217	2% change	3% change
Dropping Point: (°C), ASTM D-2265	232	>318
Base Oil Viscosity: (cSt), ASTM D-445 @40°C @100°C	 30 5.8	 95 10.8
Shell Roll Stability: %change, ASTM D-1831	?	3.7
Bearing Life: hours, ASTM D-3527	?	220
Bomb Oxidation: kPa drop, ASTM D-942	?	5.5 (500hr)
Oven Panel: 96 hours @ 150°C, 30 mils per a modified GM 9075-P.	?	Pass
Timken OK Load: (kg), ASTM D-2509	?	27.5
4 Ball EP: load wear index (kgf) weld point (kgf), ASTM D-2596	30 ?	63.4 500
4 Ball Wear: scar dia. (mm), ASTM D-2266	1.30	0.49
Oil Separation: (mass%), ASTM D-1742	2-6	0
Copper Strip Corrosion: (rating) ASTM D-4048	?	1b
Salt Fog: (hours to failure) ASTM B-117	?	>300
Hazardous Materials or Heavy Metals	1-5% pentaerythritol	none added

TABLE 8
MOV LONG LIFE
COMPARISON WITH CURRENT 'B'

CHARACTERISTIC	Grease 'B'	MOV Long Life NLGI 1
Color	Light Tan	Tan
Thickener	Lithium	Calcium Sulphonate
Base oil	Organic diester	Severely Hydrotreated
Penetration: worked, ASTM D-217	280	325
Dropping Point: (°C), ASTM D-2265	195	318
Base Oil Viscosity: (cSt), ASTM D-445 @40°C @100°C	 11.8 3.15	 95 10.8
Shell Roll Stability: % change, ASTM D-1831	?	2.7
Bearing Life: hours, ASTM D-3527	?	220
Bomb Oxidation: kPa drop, ASTM D-942	41.4 (500hr)	38 (500hr)
Oven Panel: 96 hours @ 150°C, 30 mils per a modified GM 9075-P.	?	Pass
Timken OK Load: (kg), ASTM D-2509	?	27.2
4 Ball EP: load wear index (kgf) weld point (kgf), ASTM D-2596	? ?	62.5 500
4 Ball Wear: scar dia. (mm), ASTM D-2266	?	0.49
Oil Separation: (mass%), ASTM D-1742	4.0	0.1
Hazardous Materials or Heavy Metals	?	none added

Photo 1: Calcium Complex EP1

Photo 2: Grease ‘A’

Photo 3: Grease ‘B’

Photo 4: MOV Long Life - 0

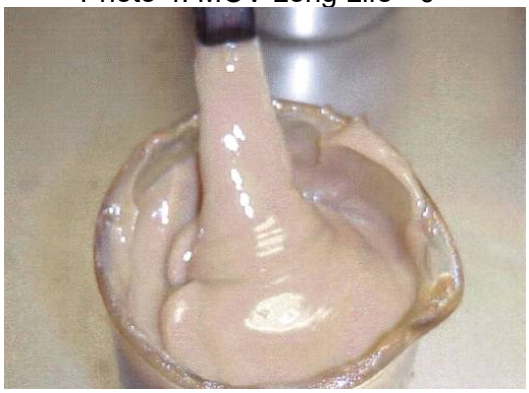

Photo 5: MOV Long Life - 1, Sample 1

Photo 6: MOV Long Life –1, Sample 2

Photographs 1-6
Bulk Aged Samples: 66 Hours at 177˚C (350˚F)

LUBRICANTS
STANDARD/SUBSTITUTES/REQUIREMENTS

Standard Lubricants:

▲ **Main Unit:** Exxon EP-O for unit sizes thru SMB-4. See chart below.

Geared Limit Switch: Exxon—Beacon 325—Light Gray—acceptable substitute Mobil 28.

Motor Bearings: Motors furnished with Limitorque valve controls are lubricated for life.

▲ **Note:** SMB/SB/SBD 000,00 standard lubricant was Sun Oil Co. 50EP (XC-421-39) for serial no.'s up to 295809. Sun 50 EP (XC-421-39) cannot be mixed with Nebula EP-O.

Lubricant Substitutes:

Typical commercially available lubricants other than those used by Limitorque for which manufacturers data indicates compatability with Limitorque operators are shown below with the temperature range recommended by the manufacturer.

The standard lubricants used by Limitorque have been proven extremely reliable over many years of service. There are, however, many other lubricants available which may be used **in place of** the standard.

Do not add a different lubricant to a Limitorque operator unless it is of the same soap base as the existing lubricant unless you have received the approval of the lubricant manufacturer.

The minimum lubricant qualities required by Limitorque are:

1. Should contain an "EP" additive.
2. Must be suitable for the temperature range intended.
3. Must be water and heat resistant and non-separating.
4. Must not create more than 8% swell in Buna N or Viton.
5. Must not contain any grit, abrasive, or fillers.
6. Must slump—prefer NLGI grade 0 to 1.
7. Must not be corrosive to steel gears, ball or roller bearings.
8. Dropping point must be above 316°F for temperature ranges of −20°F to 150°F.

UNIT SIZE	APPROX. VOLUME GALLONS	APPROX. WEIGHT POUNDS
SMB/SB/SBD-000	.50	3.5
SMB/SB/SBD-00	.50	4.0
SMB/SB/SBD-0	1.00	9.5
SMB/SB/SBD-1	1.50	15.0
SMB/SB/SBD-2	1.75	14.5
SMB/SB/SBD-3	5.50	50.0
SMB/SB/SBD-4	8.50	75.0
SMB-4T	8.00	71.0
SMB-5T	7.50	65.0
SMB-5	8.50	72.0

STANDARD LUBRICANTS −20°F TO 150°F

UNIT SIZE	TYPE	MANUFACTURER	COLOR	BASE
*SMB/SB/SBD 000,00	NEBULA EPO	EXXON	DARK TAN	CALCIUM COMPLEX
*SMB/SB/SBD/WB 0 TO 5/5T	NEBULA EPO	EXXON	DARK TAN	CALCIUM COMPLEX

*FOR NUCLEAR CONTAINMENT UNITS, NEBULA EP-0 AND EP-1 ARE THE ONLY APPROVED LUBRICANTS FOR SMB-000 TO 5.

LUBRICANT SUBSTITUTES

MANUFACTURER	TYPE	TEMPERATURE RANGE	BASE
EXXON	**BEACON P290	−40°F TO 120°F	LITHIUM LINE
ARCO	LITHOLINE HEP1	−10°F TO 220°F	LITHIUM
GULF OIL	GULFCROWN EPO	−20°F TO 220°F	LITHIUM
CITIES SERVICE	CITY AP	−0°F TO 220°F	LITHIUM
MOBIL OIL CO.	MOBILUX EPO	−10°F TO 220°F	LITHIUM 12
SHELL OIL	DARINA 0	−10°F TO 250°F	HYDROXYSTEARATE NO SOAP
FISKE	LUBRIPLATE LOW TEMP.	−40°F TO 150°F	LITHIUM
TEXACO	MARFAK 0	+20°F TO 200°F	SODIUM
	LOW TEMP. EP	−40°F TO 200°F	LITHIUM
TIDEWATER OIL	VEEDOL ALITHO 10	−10°F TO 150°F	LITHIUM

**TESTED AND USED BY LIMITORQUE FOR APPLICATIONS AT LOW TEMPERATURES (−50°F TO −70°F). CONSULT LIMITORQUE IF THE TEMPERATURE RANGE IS BEYOND THE LIMITATIONS SHOWN ABOVE.