2007 MOV Users' Group Meeting

MOV STEM GREASE WEAR TESTING

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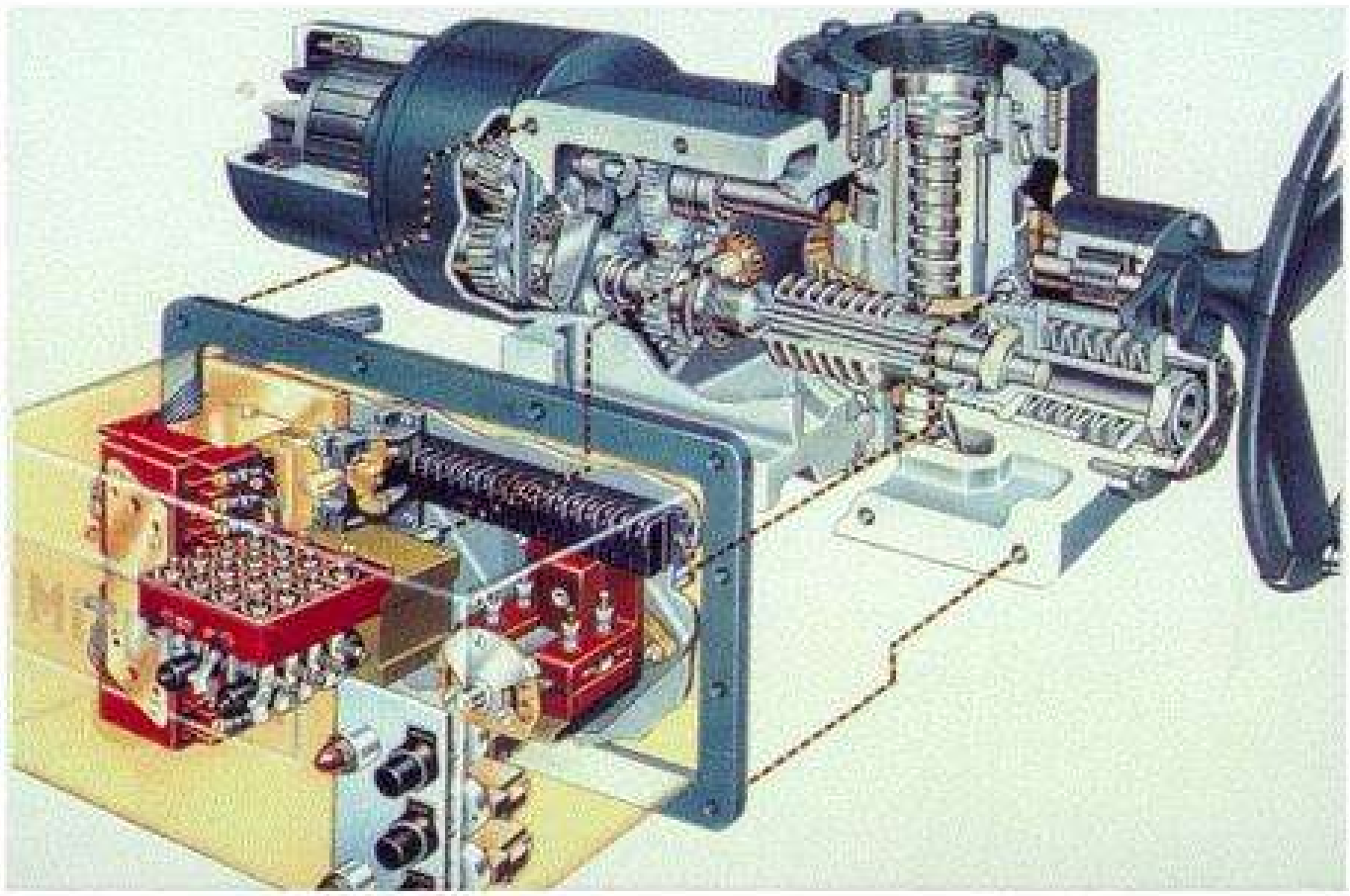
LIMITORQUE SMB



INTRODUCTION

AT THE 2006 MUG MEETING ONE 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.

STEM NUT WEAR

Stem Nut Wear, Antiseize

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

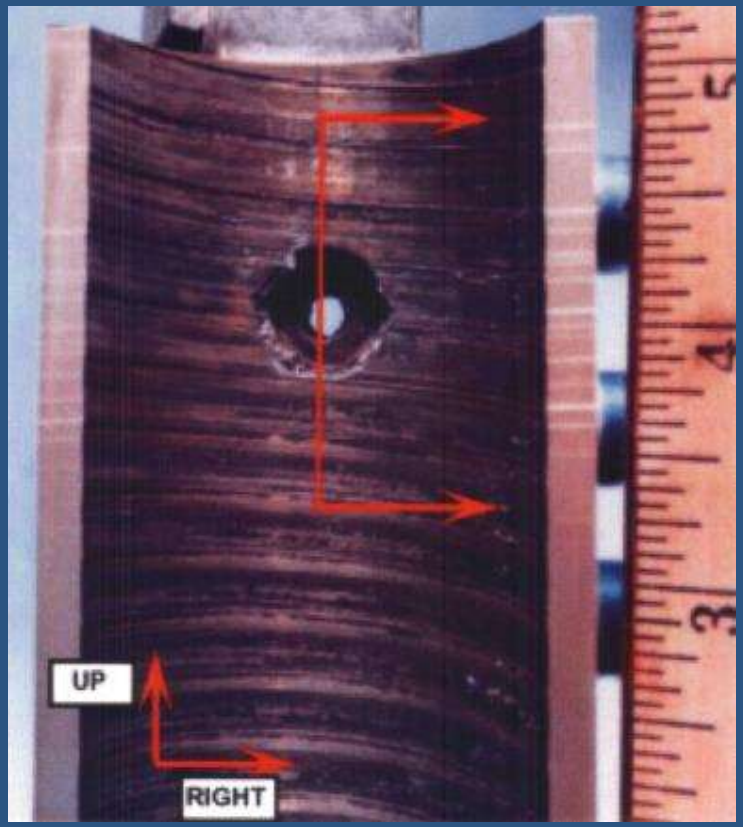
EPRI 1996 SURVEY

GREASE	USERS %
CALCIUM COMPLEX	26
(e.g. NEBULA EP)	
NICKEL ANTISEIZE COMPOUND	24
(e.g. N-5000)	
EP LITHIUM SOAP	16
(e.g. MOBILUX AND OTHER)	
CLAY SYNTHETIC HYDROCARBON	14
(e.g. MOBILGREASE 28)	
OTHER TYPES	20

SIGNIFICANCE

- PROPER LUBRICATION OF THE STEM / STEMNUT IS IMPORTANT TO ACHIEVE CONSISTENT TORQUES AND TO PROVIDE LUBRICATION OF THE WORKING SURFACES.
- MOV CONTACT SURFACES TEND TO BE BRONZE AND STAINLESS STEEL WHICH ARE DIFFERENT THAN THE STEEL ON STEEL PAIRS USED IN MANY POWER STATION APPLICATIONS.
- WHILE THE REQUIREMENTS FOR A GOOD GEARBOX LUBRICANT ARE GIVEN, DEMANDS FOR THE STEM LUBRICANT ARE LESS CLEARLY DEFINED. ONE CONCERN IS THAT A WORN STEM NUT COULD FAIL IF THE TEETH STRIP.

WORST CASE?



ALASKA AIRLINES FLIGHT 261
STRIPPED ACME THREAD STABILIZER NUT
ALUMINUM BRONZE – MG28 & AEROSHELL 33 GREASES

APPLICATION DEMANDS

- IN MANY WAYS THE STEM APPLICATION IS MORE SEVERE THAN THE GEARBOX BECAUSE THE LUBRICANT CAN BE DIRECTLY EXPOSED TO HEAT (BOTH AMBIENT AND RADIANT), WATER, AND/OR RADIATION.

- IT CAN ALSO BE SUBJECTED AIRBORNE CONTAMINANTS AND VOLATILITY OF THE CONSTITUENTS CAN ALSO PLAY A ROLE BECAUSE THE LUBRICANT IS NOT IN A SEALED COMPARTMENT.

STEM GREASE REQUIREMENTS

COULD INCLUDE SOME OR ALL OF THE FOLLOWING;

1. **NOT CONTAIN HAZARDOUS MATERIALS NOR MATERIALS THAT MIGHT REQUIRE SPECIAL HANDLING OR DISPOSAL OR BREAK DOWN INTO SUCH MATERIALS.**
2. **SUITABLE FOR THE TEMPERATURE CONDITIONS (I.E. DROPPING POINT, OXIDATION RESISTANCE AND VOLATILITY)**
3. **PROVIDE A CONSISTENT COEFFICIENT OF FRICTION AND HENCE OPERATING TORQUE.**
4. **PROVIDE CORROSION PROTECTION.**
5. **NOT AGE HARDEN, WORK SOFTEN OR BE SUBJECT TO EXCESSIVE OIL BLEEDING.**
6. **NOT BE SUBJECT TO LOSS OF PERFORMANCE WHEN SUBJECTED TO WORKING, HEAT AND/OR WATER AND POSSIBLY RADIATION OR COMBINATIONS OF THESE CONDITIONS.**
7. **PROVIDE WEAR PROTECTION FOR BOTH COMPONENTS.**

TEST PROGRAM

- TO GET A BETTER UNDERSTANDING OF THE WEAR PROTECTION CHARACTERISTICS A NUMBER OF GREASES AND ANTI-SEIZE PASTES WERE SUBJECTED TO A VARIETY OF WEAR TESTS.

- THE PRODUCTS TESTED INCLUDED MOV LONG LIFE, MOV EXTRA, NEBULA EP1, MOBILGREASE 28 AS WELL AS N-5000 & N-7000 ANTI-SEIZE PASTES.

NLGI GREASE GRADES

- GREASES HAVE A CONSISTENCY THAT IS DETERMINED BY THE THICKER, ADDITIVES AND BOTH THE AMOUNT AND TYPE OF BASE FLUID. THIS IS DESCRIBED IS BY THE NATIONAL LUBRICATING GREASE INSTITUTE (NLGI) CLASSIFICATION SYSTEM WHICH GIVES THE DEPTH THAT A CONE PENETRATES INTO A LIGHTLY WORKED (60 STROKES) SAMPLE.

- THE FIRMER THE GREASE, THE LESS THE CONE PENETRATES THE SAMPLE AND THE SMALLER THE NUMBER. THE CONE WILL SINK MORE IN SOFTER GREASE. RANGES OF PENETRATIONS ARE GIVEN NUMBERS FROM 000 TO 6. THE LARGER THE NUMBER, THE STIFFER THE GREASE. IT IS POSSIBLE TO HAVE PRODUCTS THAT ARE PART WAY BETWEEN GRADES LIKE A 12 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	PEN	BASE OIL VISCOSITY	
		60 STROKES	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
N-5000	~0-1	300-390**	?	?
N-7000	~0-1	325-375**	?	?

HISTORICAL VARIATIONS IN ONE GREASE (CAN AFFECT WEAR DATA)

MOBILGREASE 28				
	NLGI GRADE	PENETRATION 60 STROKES	VISC	
			40˚C	100˚C
1995	1½	300	32	5.2
2001	1-2	305	-	-
2003	1-2	280	29.3	-
2006	1½*	295	29.3	5.6

*** WITHIN NLGI GRADE 2 RANGE OF 265-295**

GREASE/PASTE COMPONENTS

NAME	DESCRIPTION
MOV LONG LIFE	CALCIUM SULPHONATE COMPLEX (ALSO CCS) GROUP II+ HYDROTREATED PARAFFINIC OIL
MOV EXTRA	CALCIUM SULPHONATE COMPLEX (ALSO CCS) GROUP I OIL
NEBULA	CALCIUM COMPLEX, GROUP II HYDROTREATED NAPTHENIC OIL
MOBILGREASE 28	CLAY THICKENER AND GROUP IV SYNTHETIC HYDROCARBON (PAO) OIL
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%)

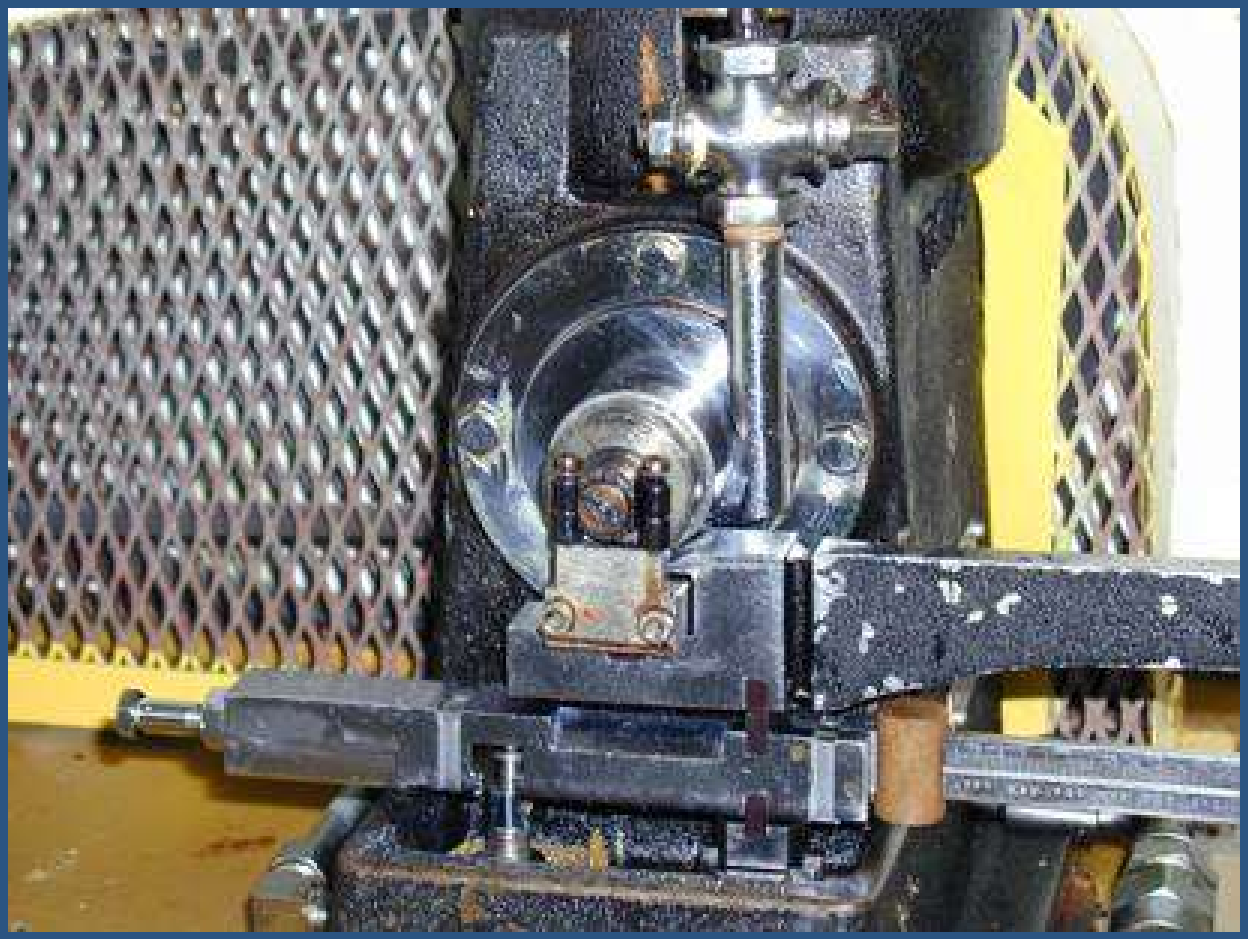
ASTM D2509-03 STANDARD TEST METHOD FOR MEASUREMENT OF LOAD-CARRYING CAPACITY OF LUBRICATING GREASE (TIMKEN METHOD)

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 OKAY LOAD (NO SCUFFING) IS ≥15 LB. IN THIS TEST A HIGHER NUMBER IS BETTER.

ASTM D2509 TIMKEN WEAR TESTER

ASTM D2509 TIMKEN WEAR TESTER



CLOSE-UP OF TIMKEN RING ON BLOCK

TIMKEN 'OKAY' 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
N-5000	-	-
N-7000	-	-

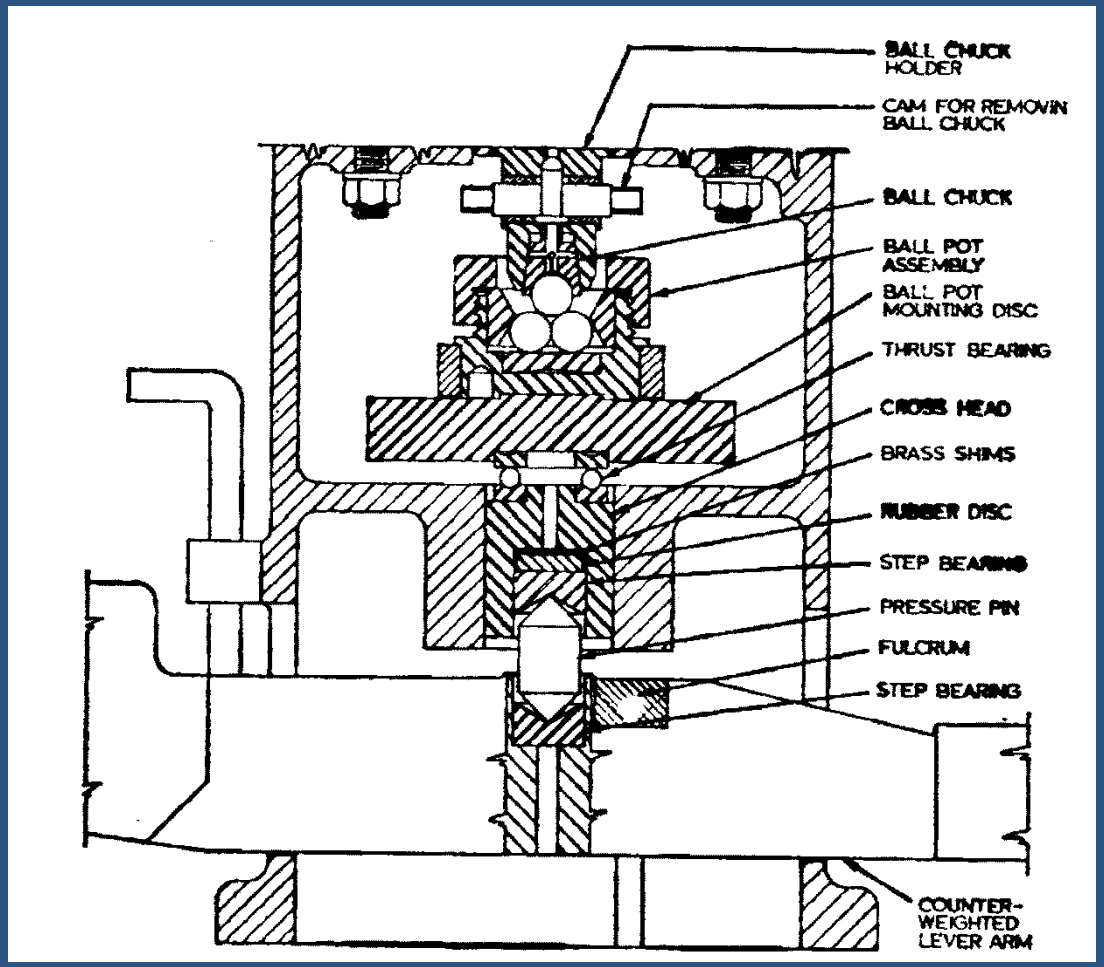
DATA SHEET VALUES

ASTM D2596-97(2002)E1 STANDARD TEST METHOD FOR MEASUREMENT OF EXTREME-PRESSURE PROPERTIES OF LUBRICATING GREASE (FOUR-BALL METHOD)

THIS TEST METHOD COVERS THE DETERMINATION OF THE LOAD-CARRYING PROPERTIES OF LUBRICATING GREASES. TWO DETERMINATIONS ARE MADE:

- LOAD-WEAR INDEX (FORMERLY CALLED MEAN-HERTZ LOAD) IS A MEASURE OF THE ABILITY OF A LUBRICANT TO PREVENT WEAR AT APPLIED LOADS. A HIGHER NUMBER IS BETTER.
- WELD POINT IS THE LOWEST APPLIED LOAD AT WHICH SLIDING SURFACES SEIZE AND THEN WELD. A HIGHER NUMBER IS BETTER.

ASTM D 2596 FOUR-BALL EP TEST



ASTM FOUR-BALL EP TEST RESULTS

	LOAD WEAR INDEX		WELD POINT (kgf)	
	DATA	TEST	DATA	TEST
MOV LL GRADE 0	55	53.2	400	400
GRADE 1	62.5	59.9	500	400
GRADE 2	63.4	64.4	500	500
MOV EXTRA GRADE 0	50	-	400	-
GRADE 1	55	55.1	400	400
NEBULA EP0	50	-	200	-
EP1	54	50	315	315
MOBILGREASE 28	42	30.9	-	200
N-5000	-	32.8	-	315
N-7000	-	63.8	-	250

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 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	0.4
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

PREVIOUS FOUR-BALL WEAR DATA

PRODUCT	ASTM D-2266 FOUR-BALL WEAR (mm)		
	75°C	150°C	225°C
MOBILUX EP1	0.45	0.50	0.84
UNIREX EP2	0.50	0.60	0.68
NEBULA EP1	0.57	0.71	1.06
MOV LONG LIFE	0.49	0.54	0.48
MOV LL GIVES CONSISTENT VALUES			

FOUR-BALL WEAR (2006 MUG MEETING)

PRODUCT	ASTM D-2266 FOUR-BALL WEAR SCAR (mm)
NEW MOV LONG LIFE 1	0.45
300 HOURS AGED	0.43
450 HOURS AGED	0.45
600 HOURS AGED	0.44
AGING WAS DONE AT 150°C (300°F). LITTLE CHANGE FOR MOV LONG LIFE.	

TESTS - 4-BALL WEAR

SAMPLE	4-BALL WEAR (ASTM D-2266) Scar (mm)
NEW	0.45
300 HOURS AGED	0.43
450 HOURS AGED	0.45
600 HOURS AGED	0.44

AGING WAS DONE AT 150°C (300°F)

FOUR-BALL WEAR
COEFFICIENT OF FRICTION

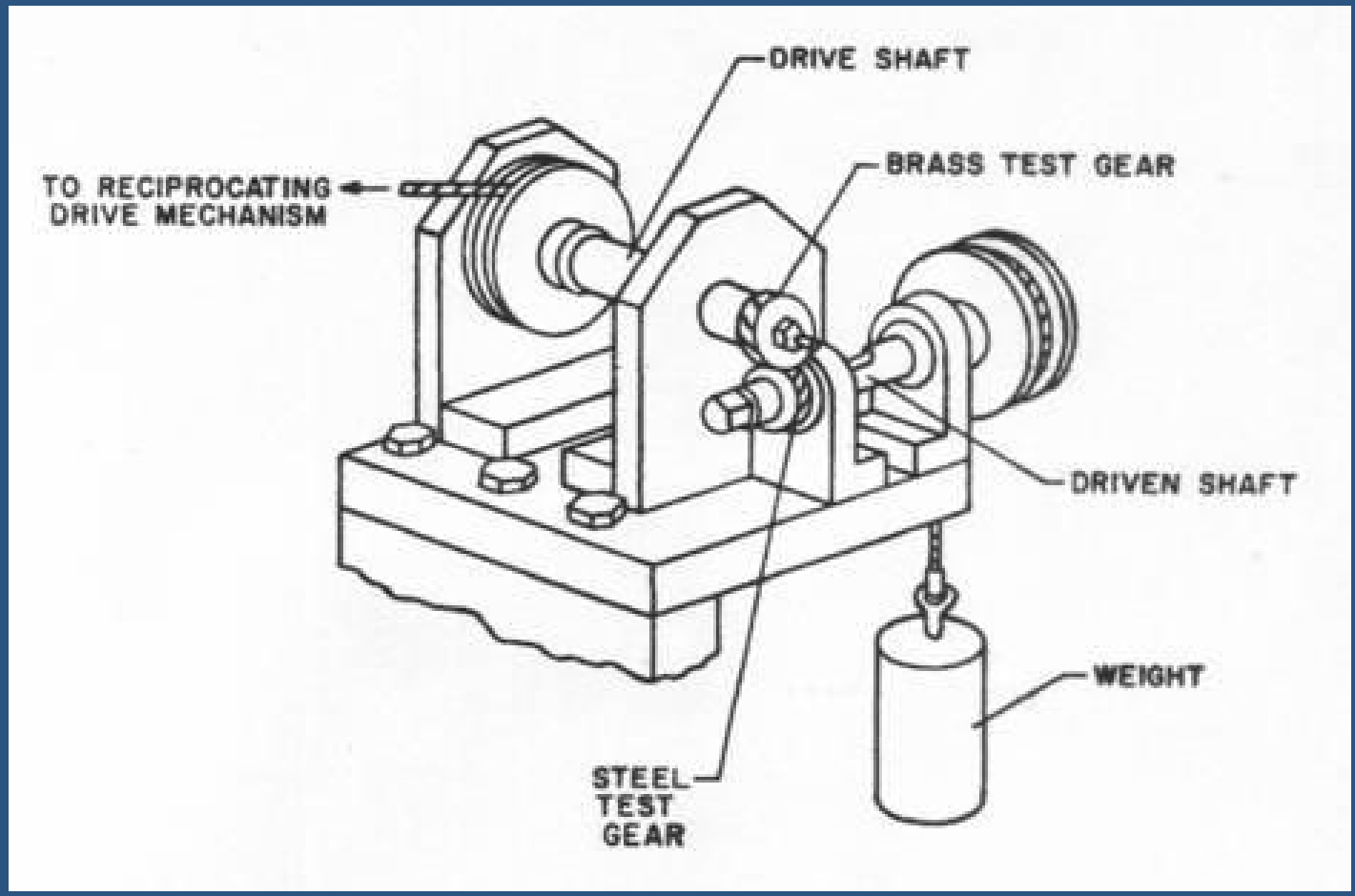
EARLIER DATA				
		FRICTION COEFFICIENT		
		75°C	**150°C**	**225°C**
MOBILUX EP1	START	0.097	0.099	0.071
	RUNNING	0.119	0.124	0.106
UNIREX EP2	START	0.076	0.079	0.057
	RUNNING	0.102	0.081	0.077
NEBULA EP1	START	0.113	0.1	0.096
	RUNNING	0.124	0.119	0.145
MOV LONG LIFE	START	0.1	0.098	0.099
	RUNNING	0.09	0.085	0.085
MOV LONG LIFE SHOWS LITTLE CHANGE.				

FTM 335: GEAR WEAR (NAVY GEAR WEAR TEST)

PROCEDURE 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 (2.3 KG) OR 10 LB (4.5) APPLIED LOADS AND FOR 1,000, 3,000 OR 6,000 CYCLES. THE WEAR IS REPORTED AS MG/1000 CYCLES.

NAVY GEAR WEAR TEST



US NAVY GEAR WEAR - FTM-335

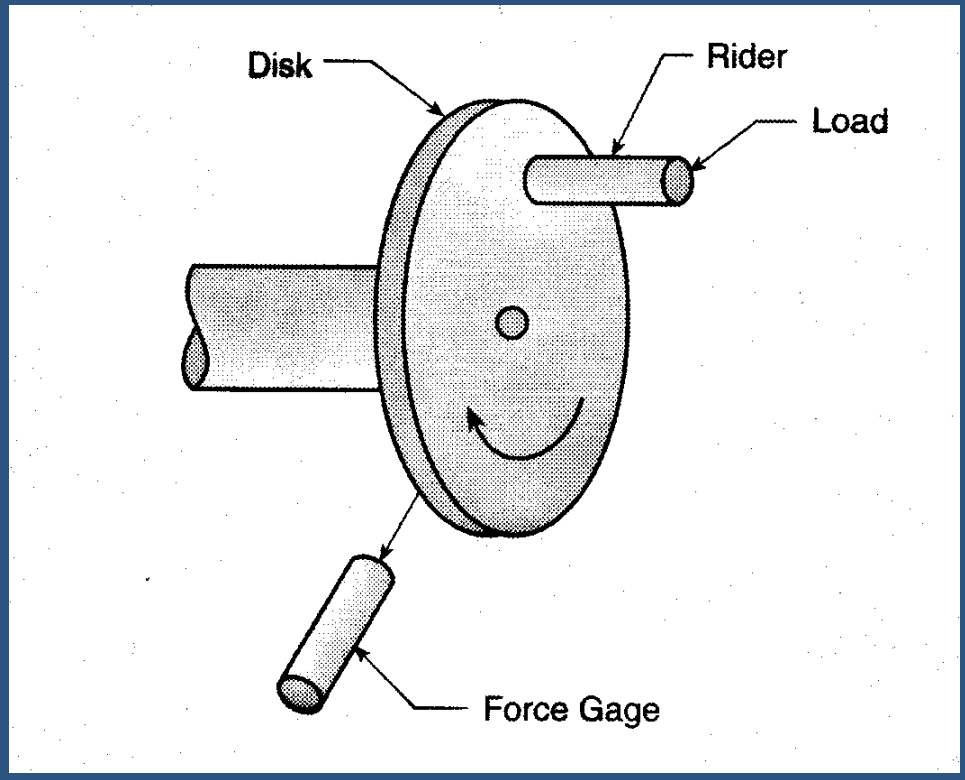
LOAD	5lb (2.3 kg)			10lb (4.5 kg)		
	mg/1000			mg/1000		
	STEEL	BRASS	TOTAL	STEEL	BRASS	TOTAL
MOV LL GRADE 1	0.05	0.22	0.27	0.03	0.8	0.83
GRADE 2			0.25			0.93
MOV EXTRA GRADE 0	-	-	0.55	-	-	1.27
NEBULA EP0	-	-	0.17	-	-	0.30
EP1	0.07	0.07	0.07	0	0.37	0.37
MOBILGREASE 28	0.03	0.15	0.18	0.03	0.47	0.50
N-5000	0.08	0.15	0.23	0.03	0.7	0.73
N-7000	0.55	0.38	0.93	0.73	0.56	1.29

ASTM G99-05 STANDARD TEST METHOD FOR WEAR TESTING WITH A PIN-ON-DISK APPARATUS

THIS TEST METHOD COVERS A LABORATORY PROCEDURE FOR DETERMINING THE WEAR OF MATERIALS DURING SLIDING USING A PIN-ON-DISK APPARATUS.

- MATERIALS ARE TESTED IN PAIRS UNDER NOMINALLY NON-ABRASIVE CONDITIONS. THE PRINCIPAL AREAS OF EXPERIMENTAL ATTENTION IN USING THIS TYPE OF APPARATUS TO MEASURE WEAR ARE DESCRIBED. THE COEFFICIENT OF FRICTION MAY ALSO BE DETERMINED.

ASTM G99 PIN ON DISC (P-O-D) TEST



ASTM G-99 PIN-ON-DISK RESULTS

	COEFFICIENT OF FRICTION		WEAR SCAR	
	RANGE	AVG	PIN	DISC
MOV LONG LIFE GRADE 2	0.13-0.13	0.13	1.06	0.32
MOV EXTRA GRADE 1	0.13-0.13	0.13	0.66	0.30
N-7000	0.16-0.18	0.17	1.54	1.40

HERGUTH TEST CONDITIONS: 9.8 N, 60 minutes, 93˚C (200˚F), Bronze pin and 310SS disc, 5.3 cm/sec, 600 grit finish, 24 rpm

ASTM G-99 PIN-ON-DISK RESULTS

	WEAR SCAR APPEARANCE	
	PIN	**DISC**
MOV LONG LIFE GRADE 2	POLISHED WITH GRAY AND BROWN STREAKS	CLEANED WITH SOME BROWN FILM
MOV EXTRA GRADE 1	GRAY STREAKED FILM	BROWN STREAKED FILM
N-7000	GRAY STREAKED FILM	HEAVILY WORN WITH GRAY STREAKS AND ABRASIONS

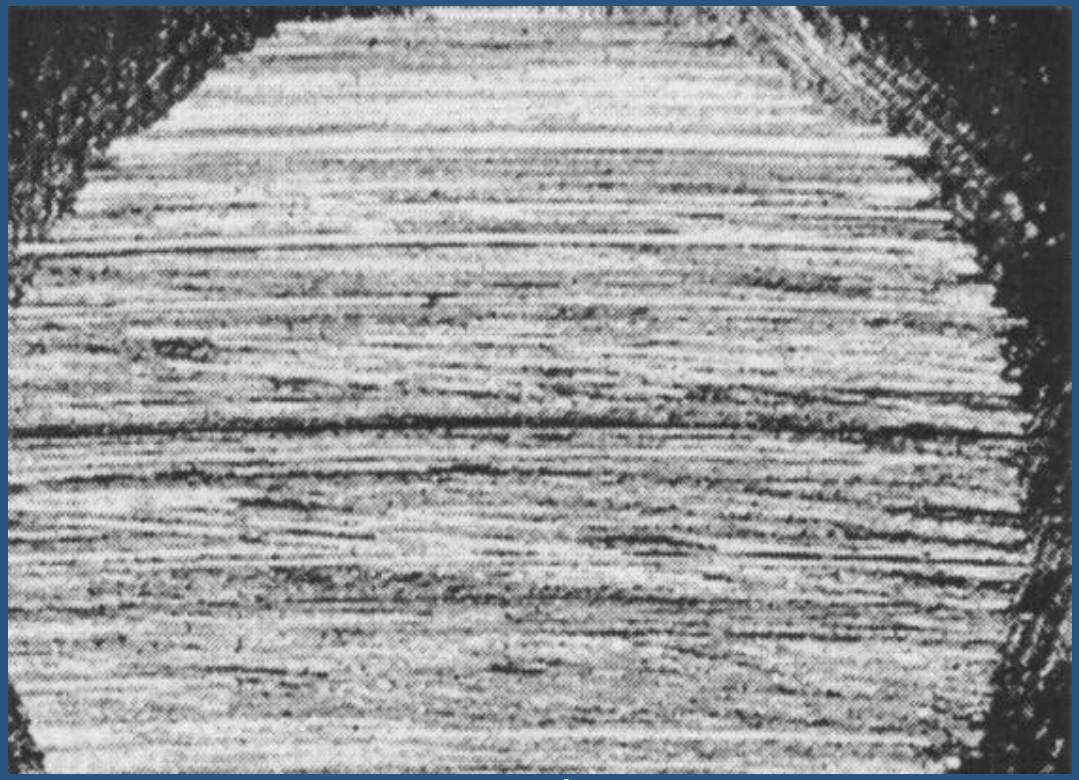
HERGUTH TEST CONDITIONS: 9.8 N, 60 minutes, 93˚C (200˚F), Bronze pin and 310SS disc, 5.3 cm/sec, 600 grit finish, 24 rpm

ASTM G-99 PIN-ON-DISK RESULTS

	COEF. OF FRICTION	WEAR SCAR (mm)	
	AVG	PIN	DISC
MOV LONG LIFE GRADE 1	0.11	1.16	0.78
50/50 MOVLL/NEB	0.11	1.32	0.66
20/80 MOVLL/NEB	0.11	0.92	0.45
NEBULA EP1	0.1	1.75	1.34

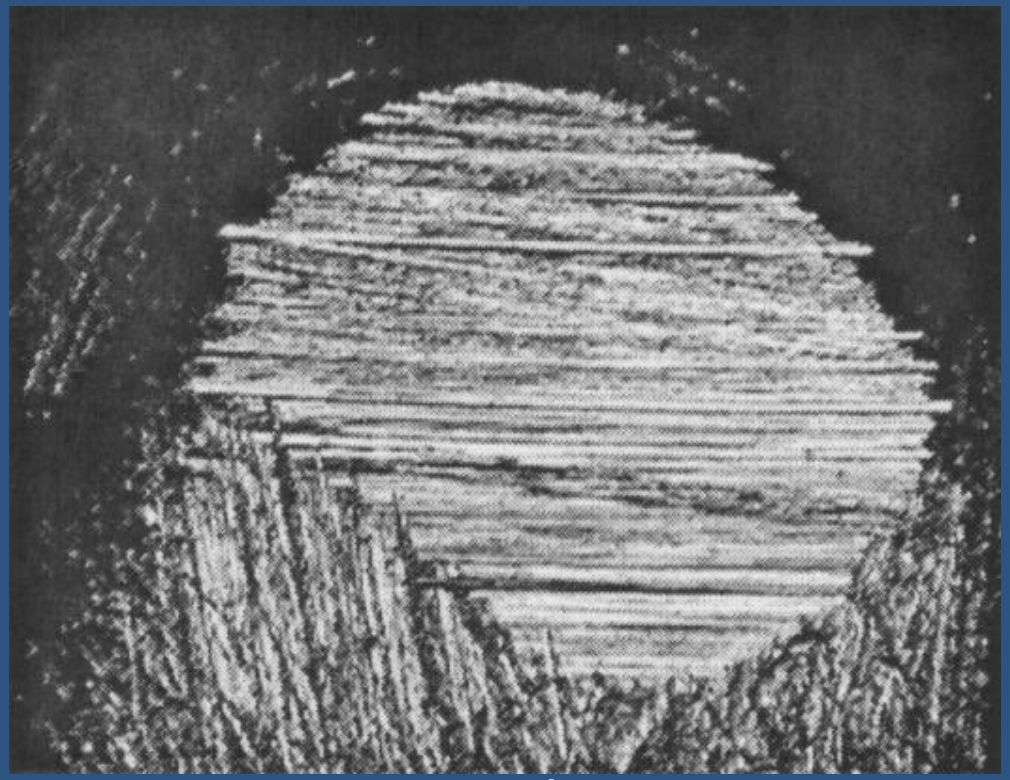
EPRI REPORT TEST CONDITIONS: 9.8 N, 60 minutes, 93˚C (200˚F),
Bronze pin and 310SS disc, 31 rpm

EPRI POD PIN WEAR SCAR



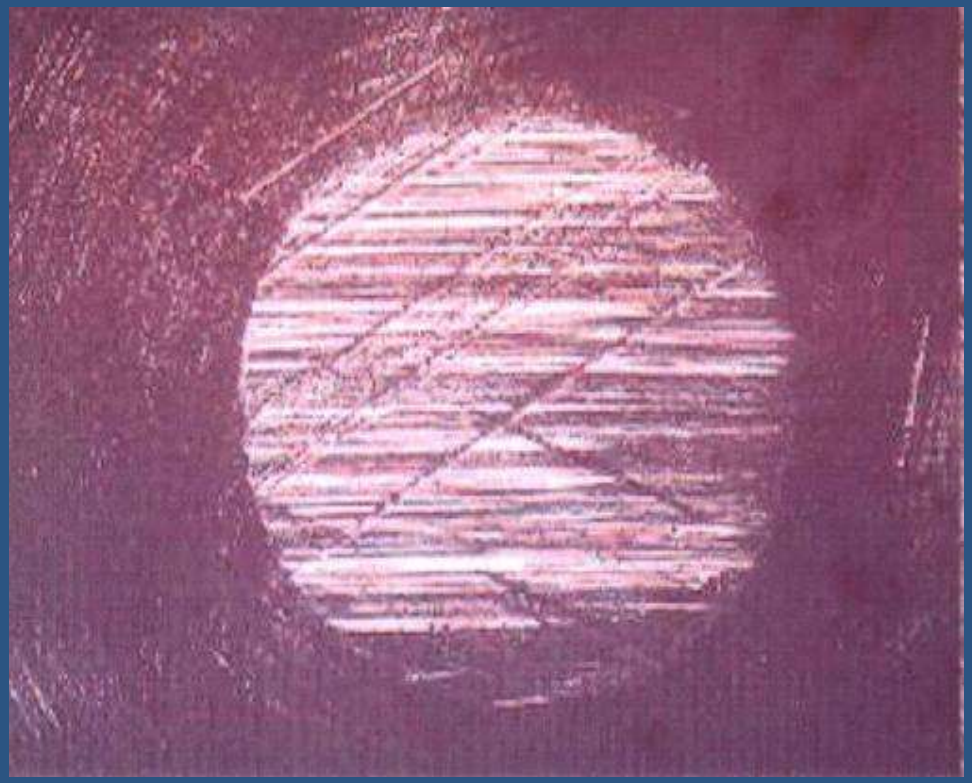
50X*
NEBULA EP1
EPRI POD PIN WEAR SCAR
*** ORIGINAL IN REPORT**

EPRI POD PIN WEAR SCAR



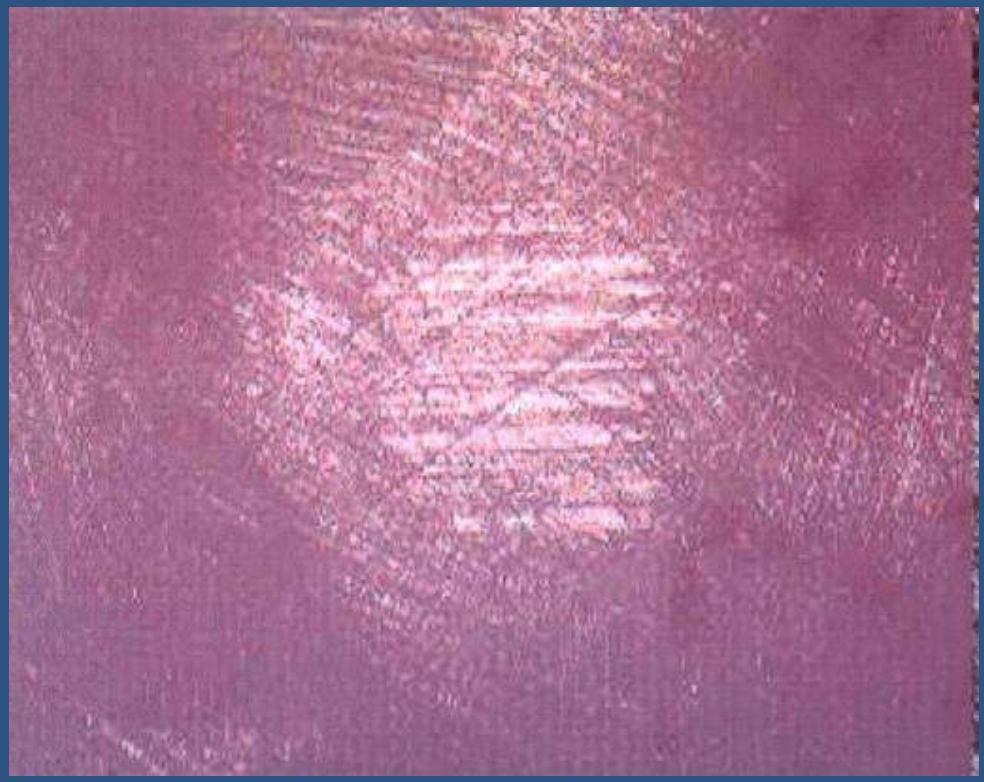
50X*
MOV LONG LIFE GRADE 1
EPRI POD PIN WEAR SCAR
*** ORIGINAL IN REPORT**

HERGUTH POD PIN WEAR SCAR



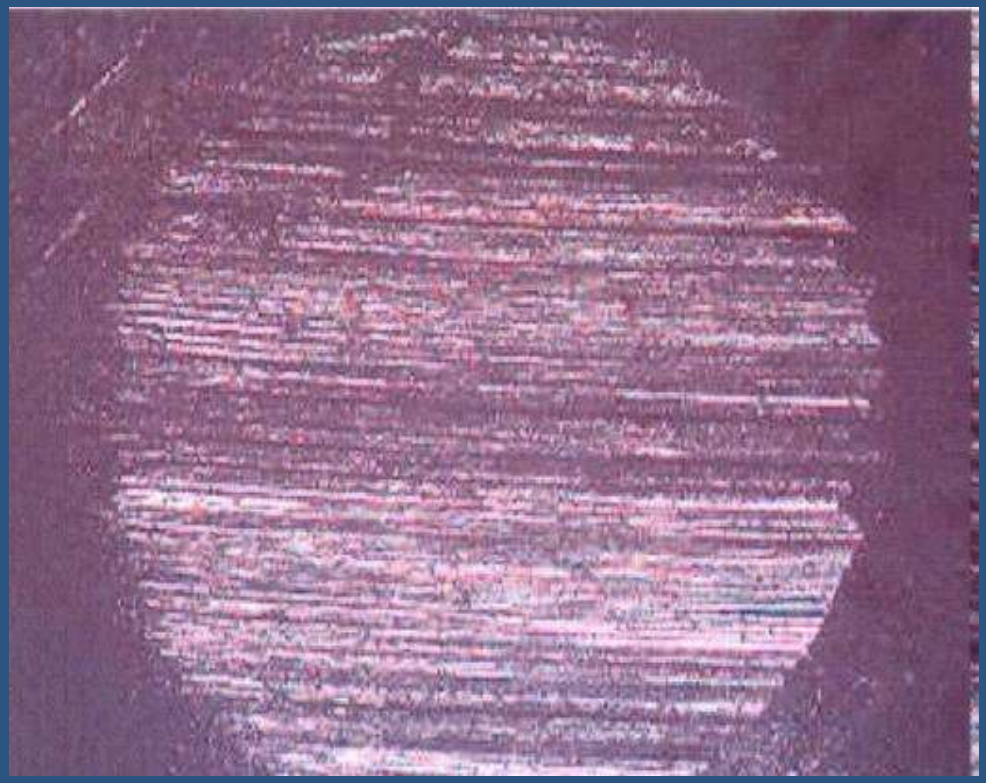
50X*
MOV EXTRA GRADE 1
HERGUTH POD PIN WEAR SCAR
*** ORIGINAL IN REPORT**

HERGUTH POD PIN WEAR SCAR



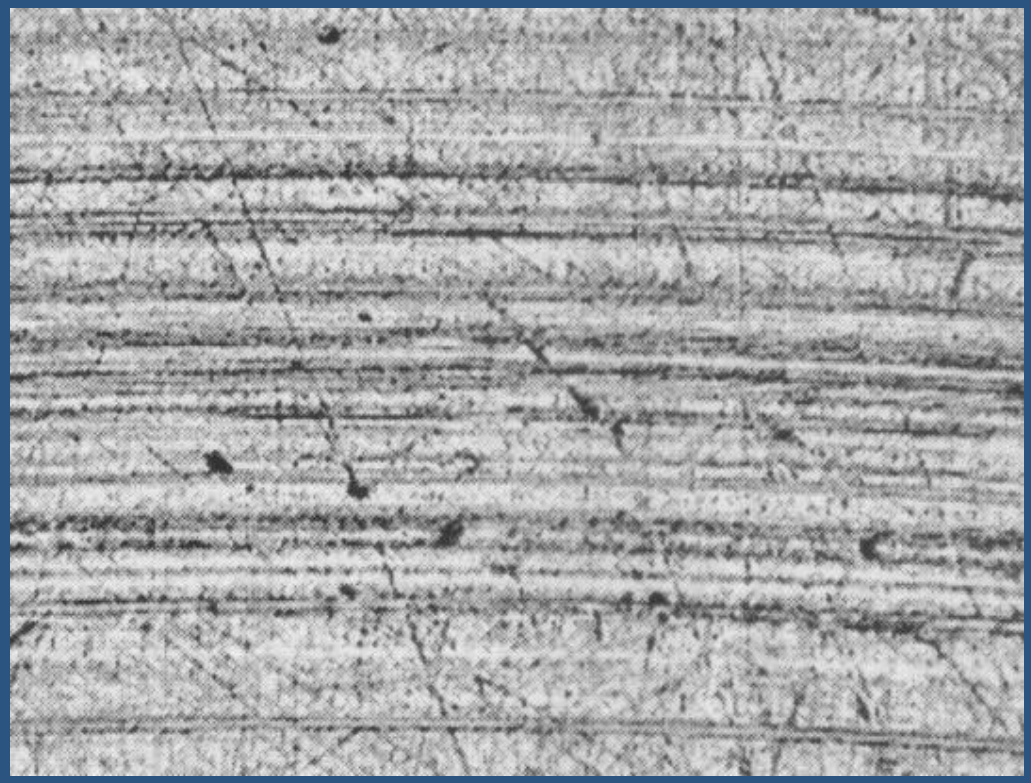
50X*
MOV LONG LIFE GRADE 2
HERGUTH POD PIN WEAR SCAR
*** ORIGINAL IN REPORT**

HERGUTH POD PIN WEAR SCAR



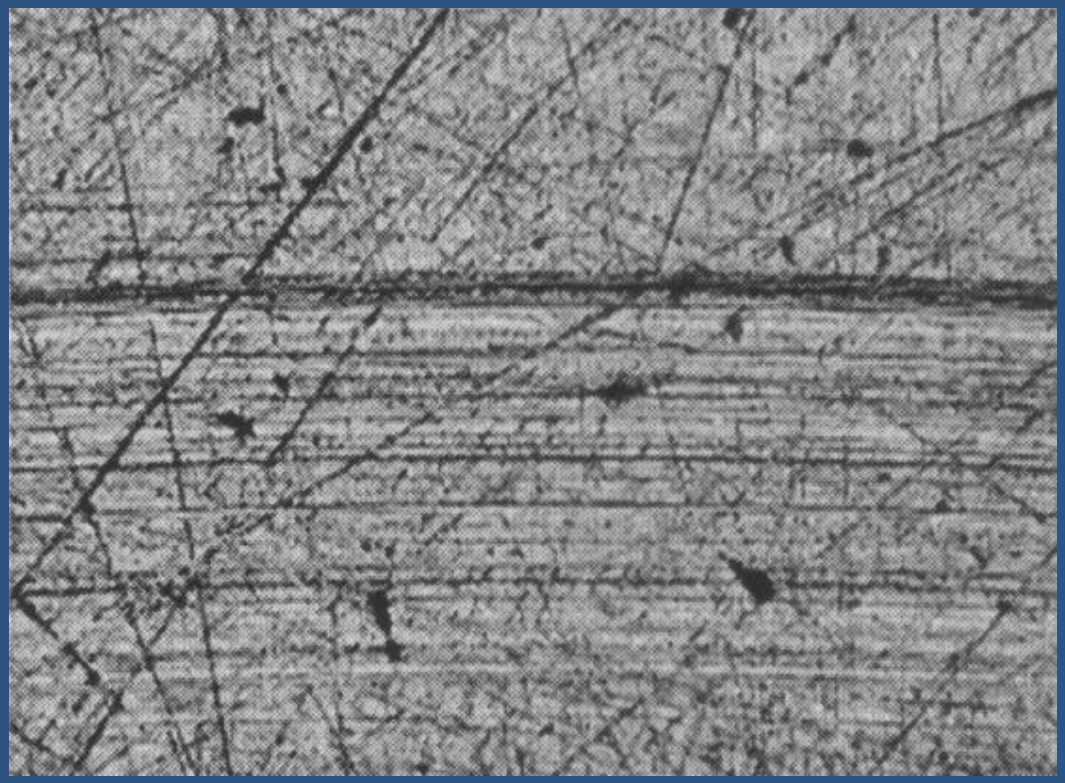
50X*
N-7000
HERGUTH POD PIN WEAR SCAR
*** ORIGINAL IN REPORT**

EPRI POD SS DISC WEAR SCAR



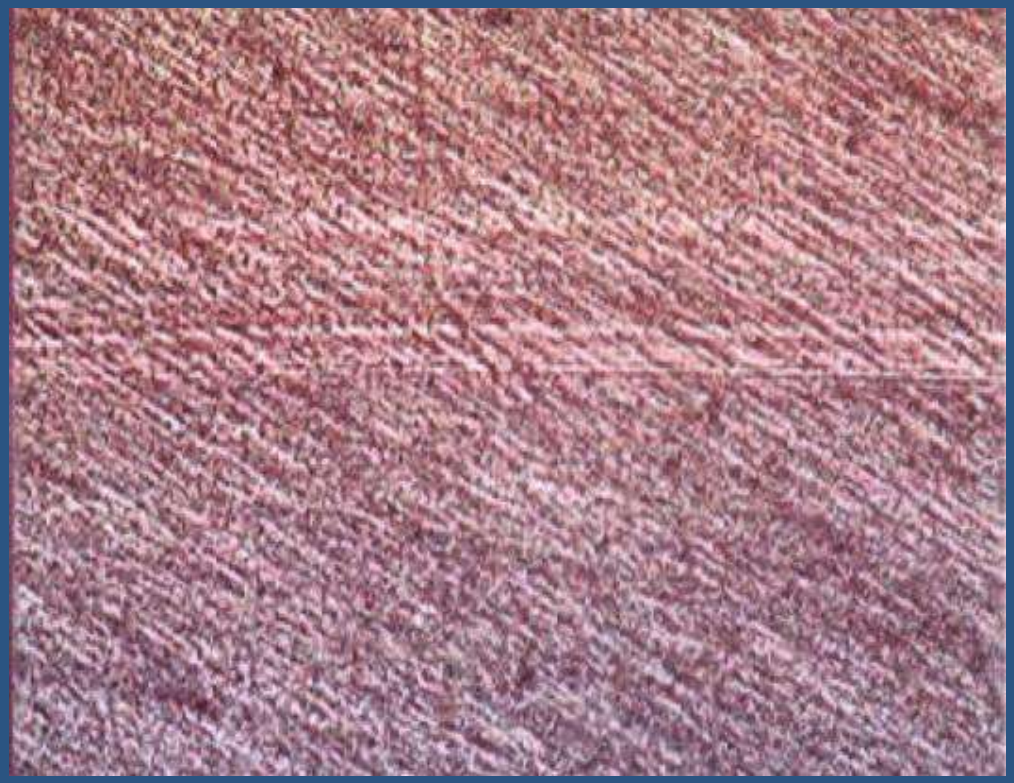
50X*
NEBULA EP1
EPRI POD SS DISC WEAR SCAR
*** ORIGINAL IN REPORT**

EPRI POD SS DISC WEAR SCAR



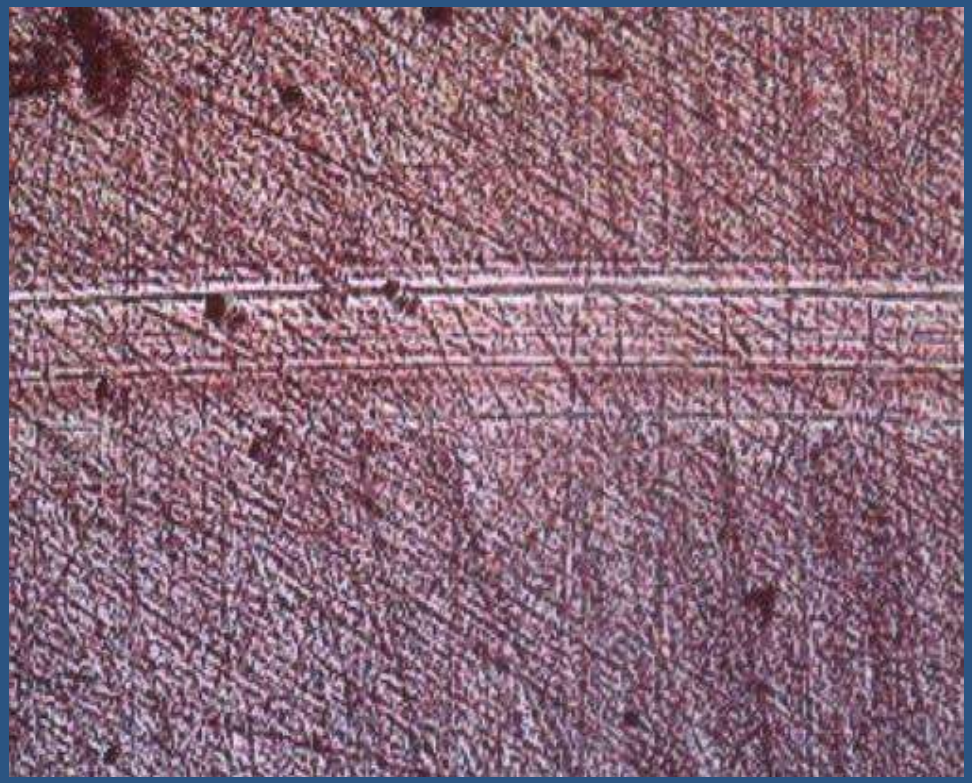
50X*
MOV LONG LIFE GRADE 1
EPRI POD SS DISC WEAR SCAR
*** ORIGINAL IN REPORT**

HERGUTH POD SS DISC WEAR SCAR



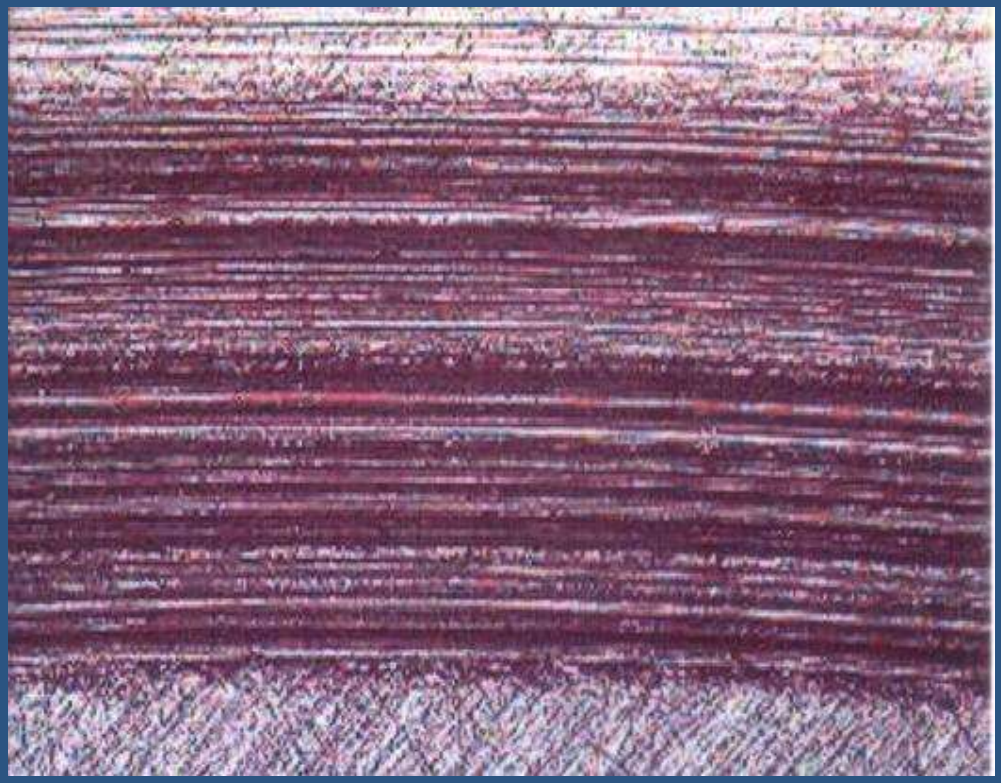
50X*
MOV EXTRA 1
HERGUTH POD SS DISC WEAR SCAR
*** ORIGINAL IN REPORT**

HERGUTH POD SS DISC WEAR SCAR



50X*
MOV LONG LIFE 2
HERGUTH POD SS DISC WEAR SCAR
*** ORIGINAL IN REPORT**

HERGUTH POD SS DISC WEAR SCAR



50X*
N-7000
HERGUTH POD SS DISC WEAR SCAR
*** ORIGINAL IN REPORT**

EPRI LUBRICATION GUIDE
SMB-0 500 STROKE
STEM NUT WEAR WITH SOLIDS

	WEAR (MILS)	
	0.05” ABOVE TOOTH ROOT	0.10” ABOVE TOOTH ROOT
MOLY 101	2	3
NEVER-SEEZ 165	4	4
N-5000	2	3
RF GRAPHITE	4	5
NEBULA EP1	2	2

A LARGER NUMBER IS WORSE

WEAR DETECTION

TRACE METAL ANALYSIS IS COMMONLY USED ON LUBRICATING OILS BUT IT CAN ALSO BE USED FOR GREASES. TYPICALLY THE GREASE SAMPLE IS DISSOLVED IN A SOLVENT AND RUN LIKE AN OIL IN AN ICP SPECTROMETER.

- HOWEVER, LARGE WEAR DEBRIS, GREATER THAT 8 MICRONS OR SO, MIGHT NOT BE DETECTED PROPERLY SO THAT ROTRODE TYPE SPECTROMETERS OR FERROGRAPHY MIGHT BE USEFUL.
- AN OPTION IS TO ASH THE SAMPLE IN A MUFFLE FURNACE AT 750°C AND THEN AFTER ASHING TO ADD IN HNO3 TO DIGEST THE METALS FOLLOWED BY ICP SCANNING.

IN-SERVICE WEAR TESTING

GREASE SAMPLES ARE BEING COLLECTED AND NEXT YEAR WE HOPE TO HAVE ACTUAL ANALYSIS DATA ON EIGHTEEN TRACE METAL AND WEAR ASSESSMENT INFO FROM OVERHAULED ACTUATORS.

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)

WEAR PROTECTION PROCESSES

GREASES CAN HELP PREVENT MECHANICAL WEAR IN A NUMBER OF WAYS BY PROVIDING SOME OR ALL OF THE FOLLOWING;

- **A LIQUID FILM BETWEEN MOVING SERVICES**
- **FILMS TO HELP PREVENT METAL TO METAL CONTACT**
- **SOLIDS OR SEMISOLIDS TO SEPARATE SURFACES.**

WEAR PROTECTING CHARACTERISTICS

THIS CAN BE ACHIEVED IN DIFFERENT WAYS INCLUDING;

- HIGH BASE OIL VISCOSITY
- HIGH BASE OIL VISCOSITY INDEX AND/OR A HIGH PRESSURE VISCOSITY COEFFICIENT
- 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. HOWEVER, THE GREASE ALSO HAS TO GET TO RIGHT PLACES, STAY IN PLACE AND NOT CHANGE TO BE MOST EFFECTIVE.

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 ≥15 LBS OR IN THE FOUR-BALL EP TEST ANYTHING OVER A 200 KG WELD POINT.

IN WHICH CASE OVER HALF OF THE GREASE/PASTES BEING USED MIGHT BE BORDERLINE.

DISCUSSION

- IT WAS NOT POSSIBLE TO PROVIDE TEST DATA FOR ALL THE GREASES UNDER THE SAME CONDITIONS IN ALL THE TESTING BUT DATA WAS PROVIDED FOR MOST COMMON PRODUCTS BEING USED ON THE STEMS.

- ALSO AGED GREASE AND AGED ANTI-SEIZE PASTE PRODUCTS WERE NOT TESTED BUT THESE COULD BE THE FOCUS OF FUTURE WORK.

DISCUSSION CONT'D

- MOST OF THE STANDARD WEAR TESTS (FOUR-BALL AND TIMKEN) USE BALL BEARING STEEL (52100) PAIRS WHICH ARE NOT THE SAME AS THE BRONZE STEM NUT AND THE STAINLESS STEEL STEMS USED IN ACTUATORS.

- IT MIGHT BE POSSIBLE TO OBTAIN BRONZE AND STAINLESS STEEL BALLS FOR THE FOUR-BALL TESTING BUT THE PIN-ON-DISC TESTING MIGHT BE MORE SUITABLE FOR MOV TESTING PURPOSES. THE PIN WEAR SCAR APPEARS TO BE THE EASIEST TO QUANTIFY. THIS VARIED CONSIDERABLY FROM GOOD TO VERY BAD.

CONCLUSIONS

1. Depending on the test some greases gave different wear results. But in terms of ranking the two calcium sulphonates greases did well in all the tests.

2. MOV Extra, with a lower viscosity oil, still provided good wear protection.

3. The stiffer MOV Long Life grade 2 provided better wear protection in some tests. It might be better for the stems.

CONCLUSIONS

4. In EPRI pin od disk (p-o-d) wear testing MOV Long Life and mixtures with Nebula EP had less wear than just Nebula EP1 but still had similar coefficients of friction.

5. In this work, plus that by EPRI, greases and pastes with solids, used by at least 24% in the EPRI survey, had higher wear than with Nebula or with MOV Long Life.

6. In most cases for the p-o-d and navy gear wear testing the wear is much higher on the bronze component. This would mean higher stem nut wear in actuators. This was not true for N-7000 that wore the stainless steel more.

CONCLUSIONS

7. The clay synthetic hydrocarbon grease used by 14% in the survey also provided poor wear protection in some tests. Less wear in-service should be achievable with some of the alternatives

8. If greases or pastes with solids or one showing higher wear rates are being used or were used, it might be appropriate to assess stem nut wear for important MOVs.

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Thank you