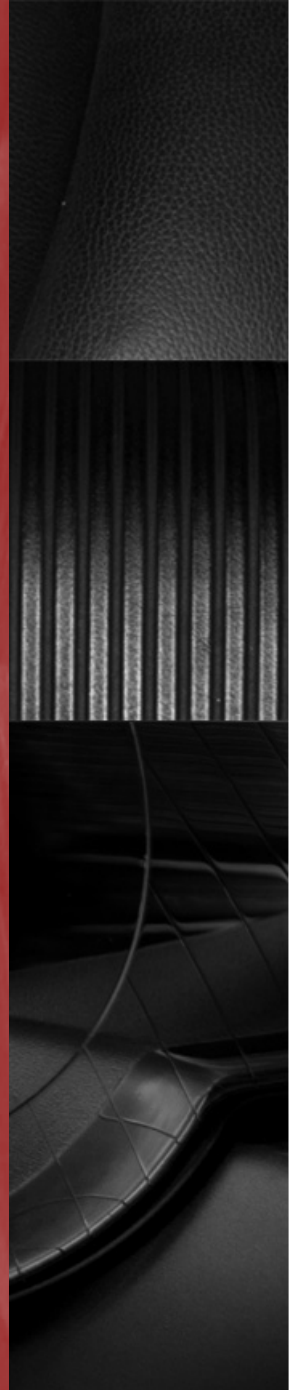


Maintenance for Improved Gearbox Performance

By

John Campbell

Amarillo Gear Company





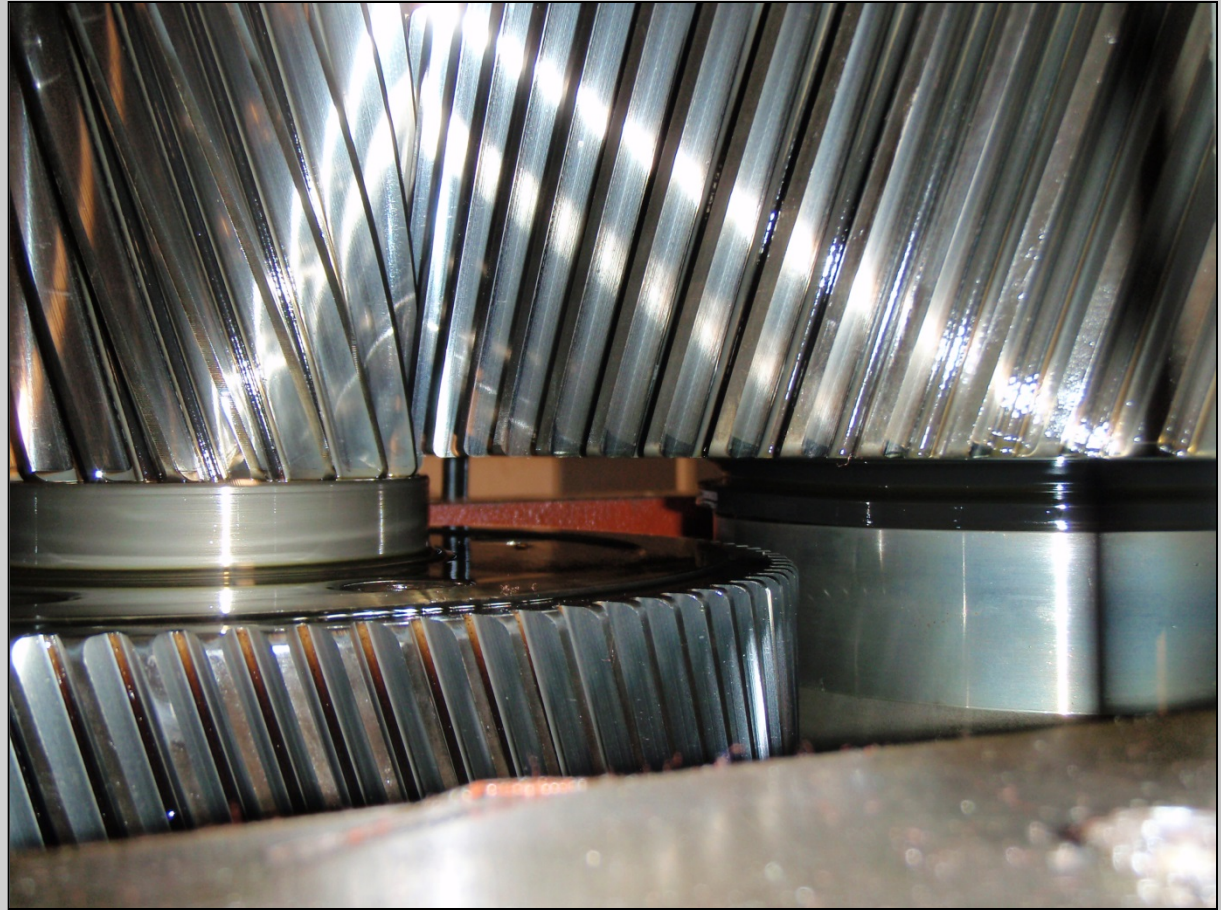
The ACC Installation

Source: GEA, Dominion

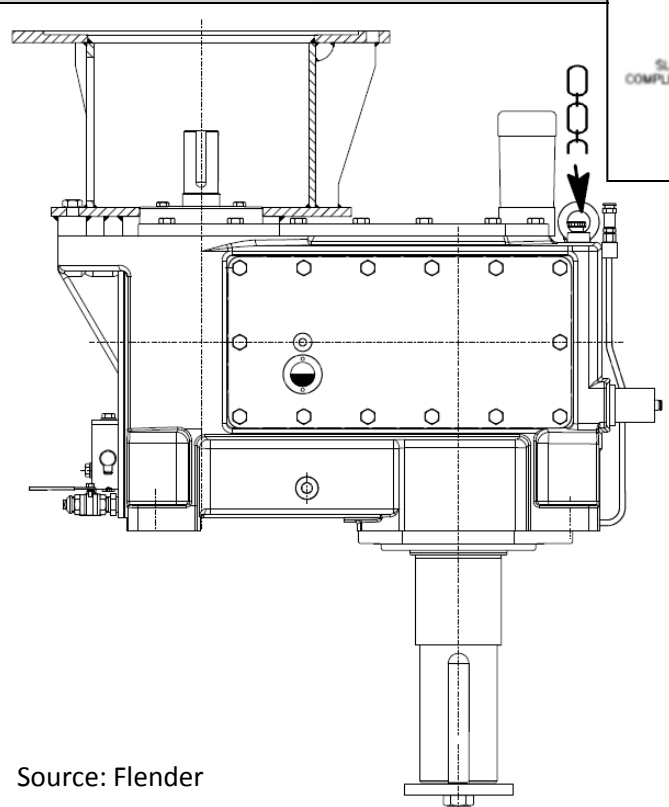


Source: GEA

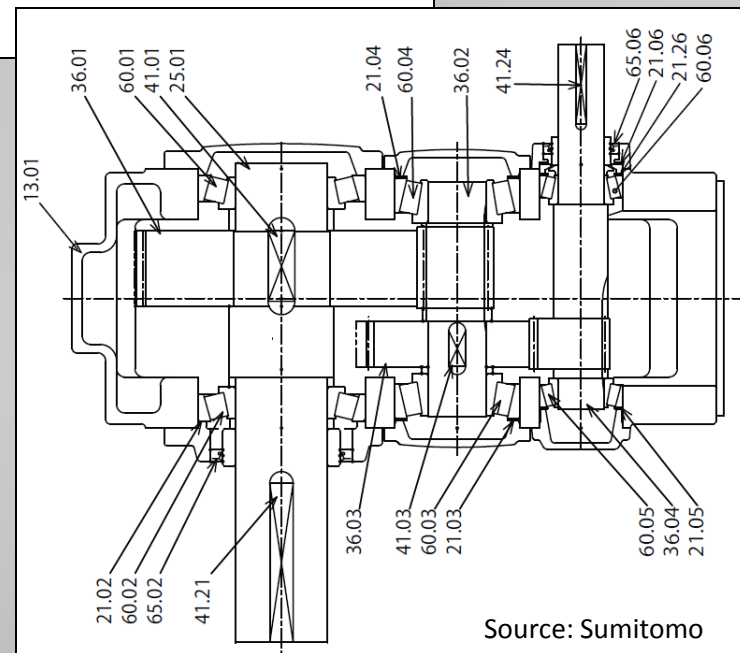
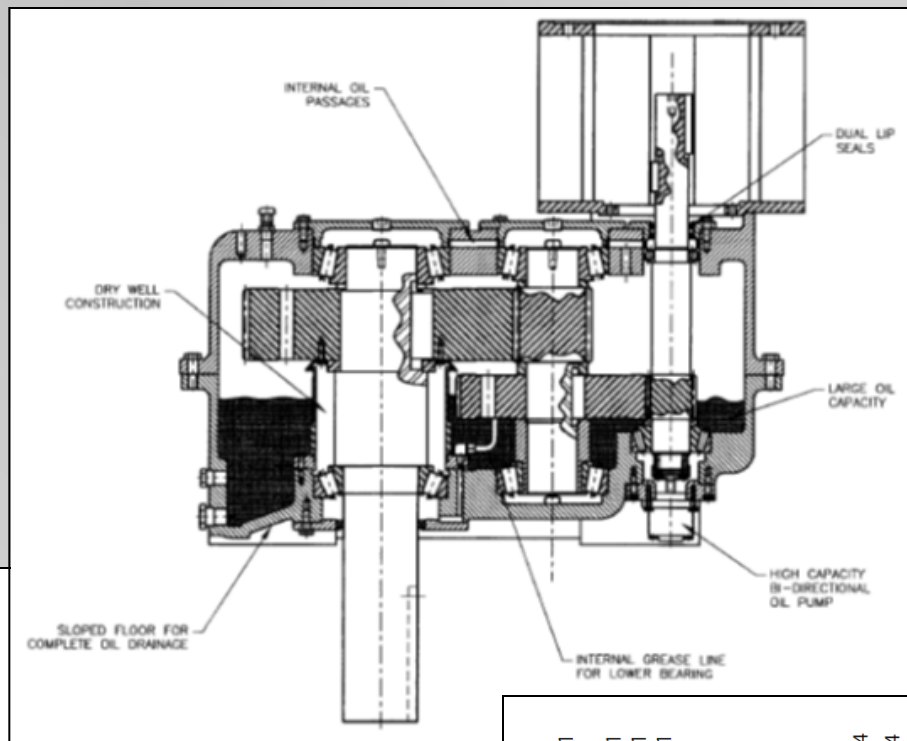




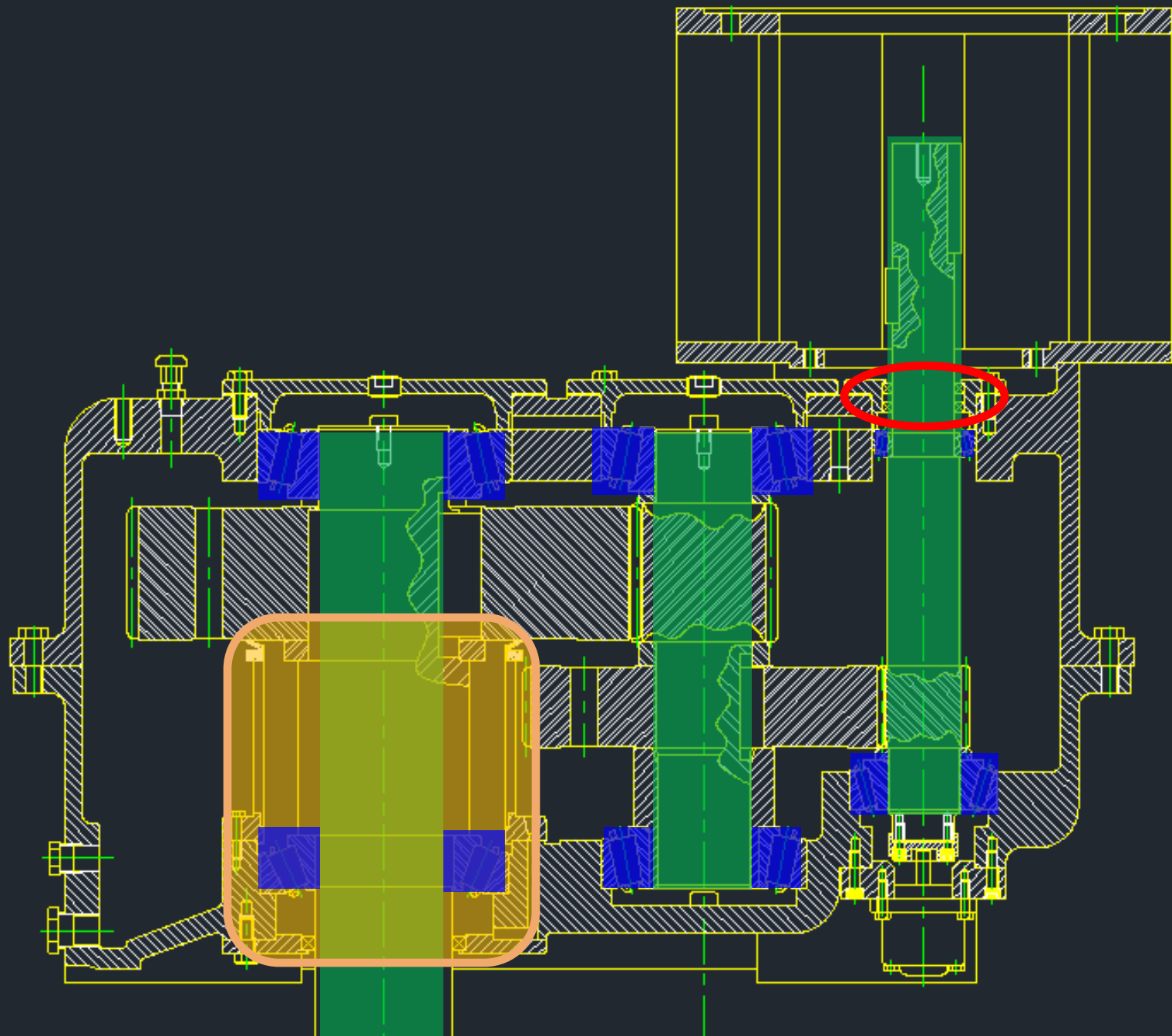
Inside the Gearbox



Source: Flender

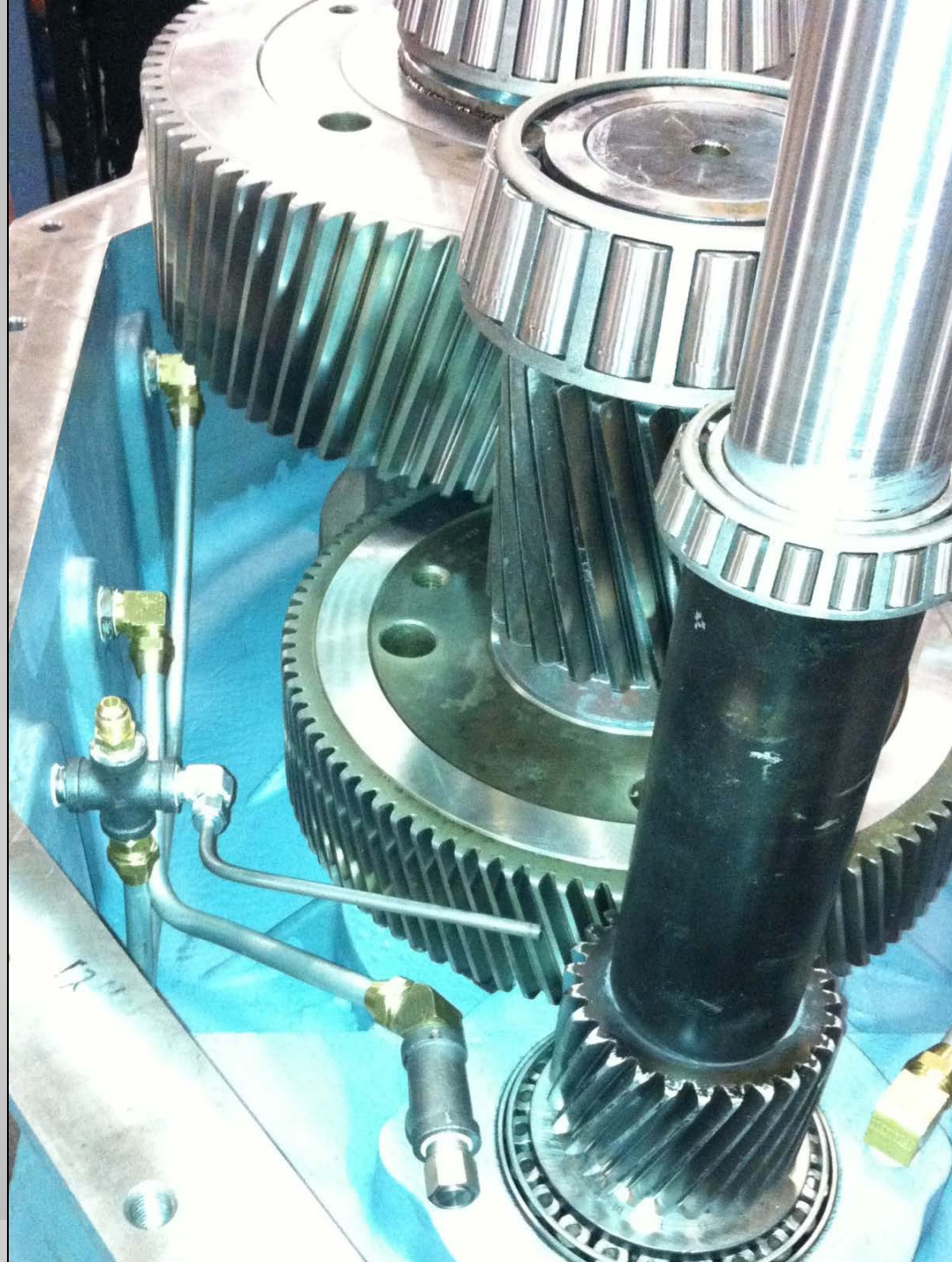


Source: Sumitomo



Helical Gears

- Parallel shafts
- Smooth transmission through mesh
- Run quiet





Source: SKF

Lip Seal

- Nitrile rubber
- Good resistance to mineral oils
- Tolerant of brief dry running
- Temperature range -40°F to 210°F



Lubrication



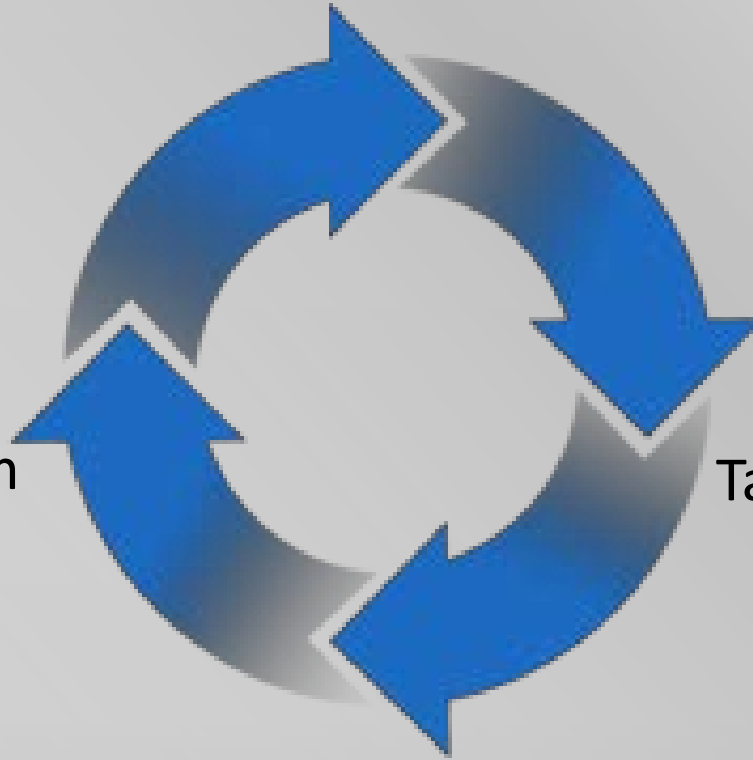
Purpose of Oil in a Gearbox

- Carry the load
- Remove heat
- Control friction
- Protect against corrosion
- Remove contaminants



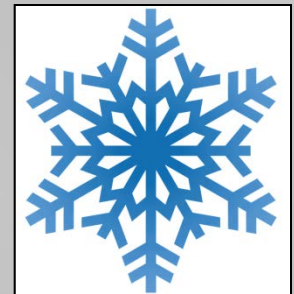
CLEAN

Target: 17/15/12



COOL

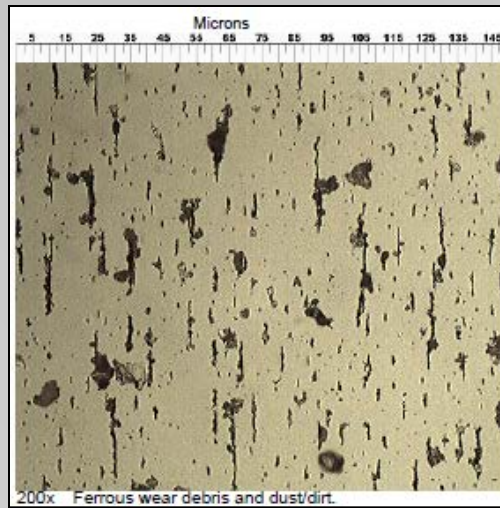
Target: 160°F - 180°F



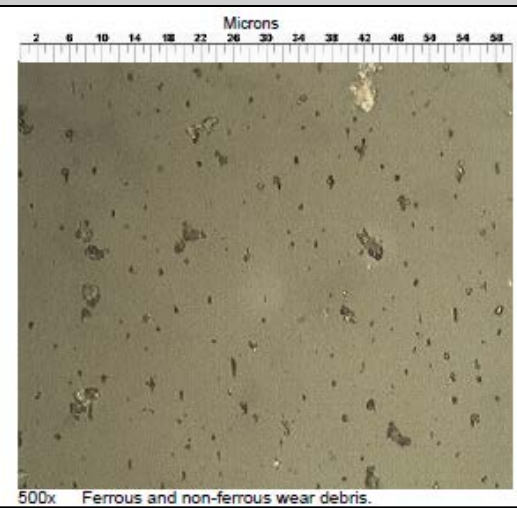
DRY

Target: ≤ 400 ppm

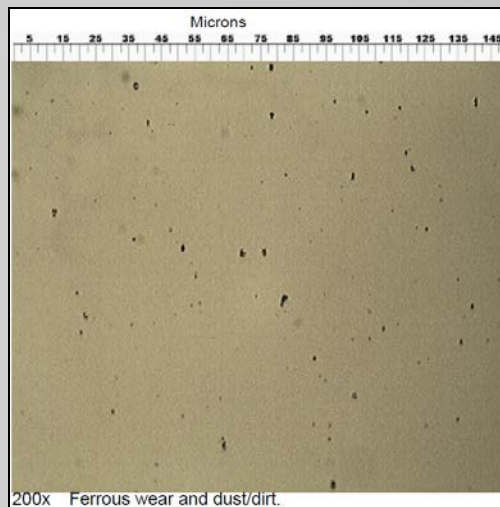




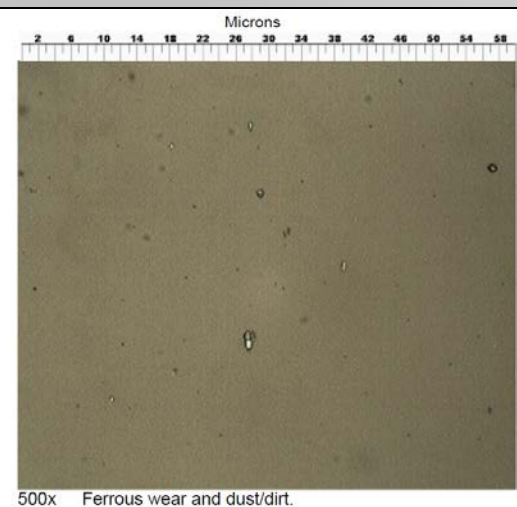
200x Ferrous wear debris and dust/dirt.



500x Ferrous and non-ferrous wear debris.

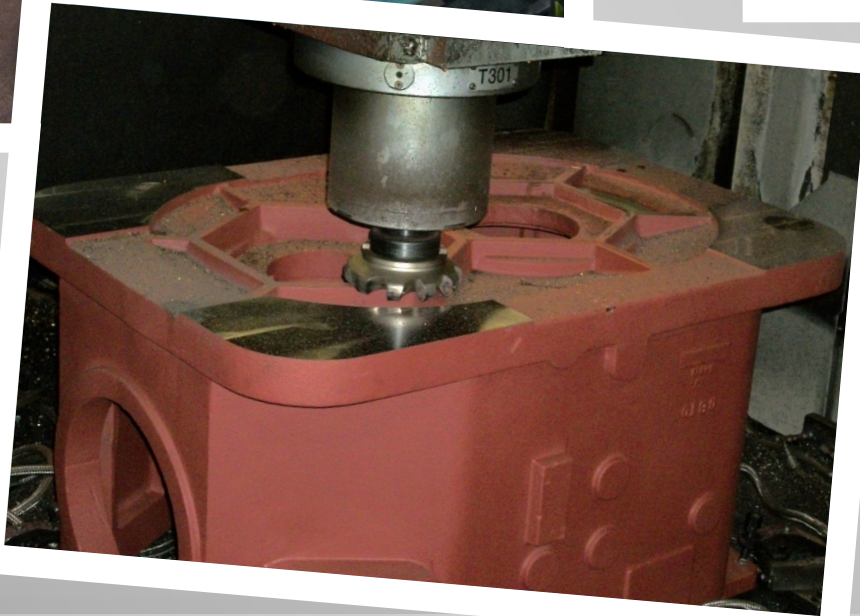


200x Ferrous wear and dust/dirt.

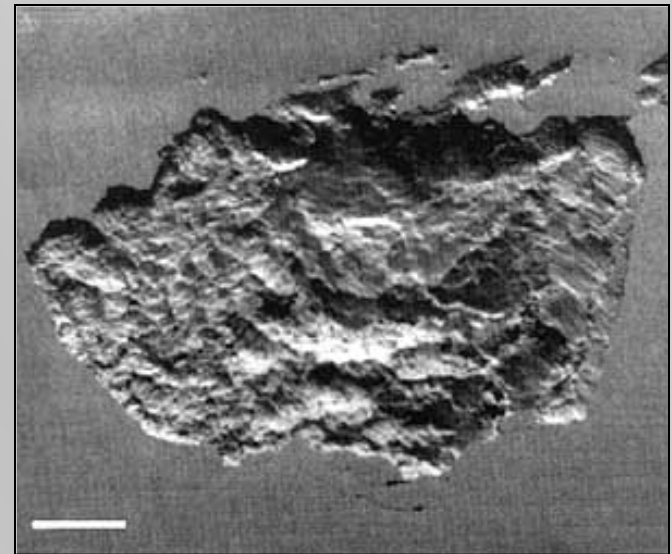
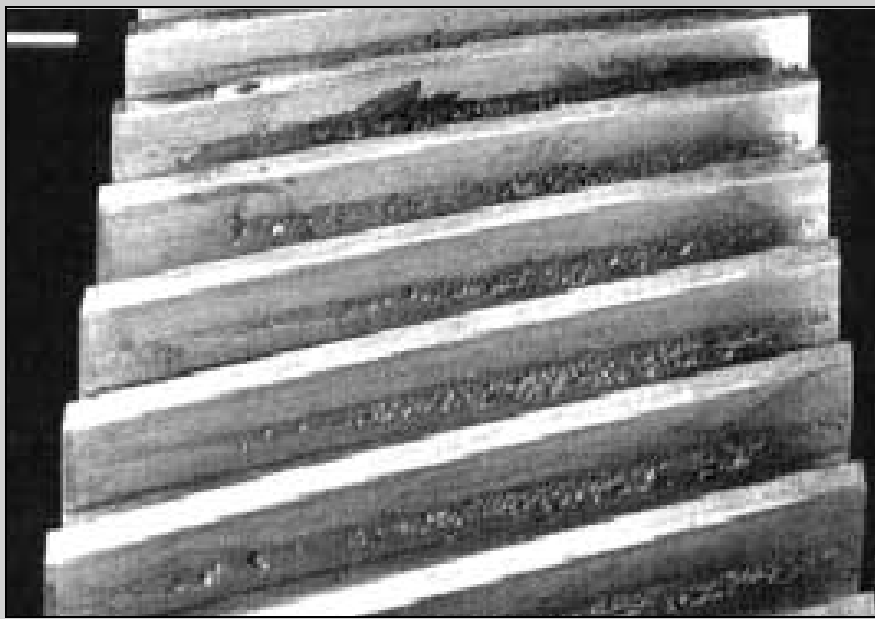


500x Ferrous wear and dust/dirt.

Lubrication > Clean



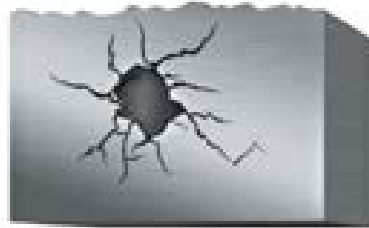




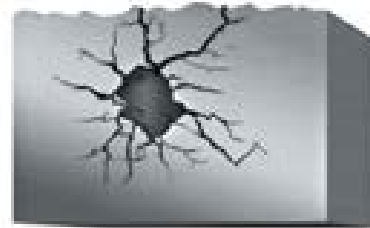
SUBSURFACE



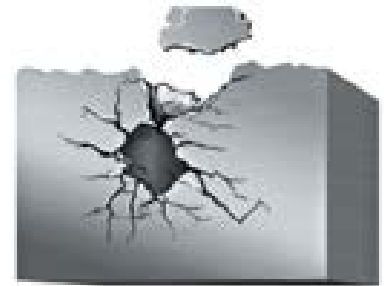
Hard inclusion



Crack initiation



Crack network



Spall

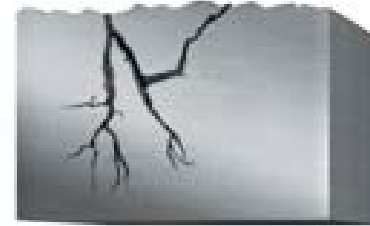
SURFACE



Surface defect



Crack initiation



Crack network



Spall

PARTICLE COUNT (particles per ml) ISO 4406-99

ISO Code		25/ 23/ 20
>4 Micron		195318
>6 Micron		75959
>14 Micron		5793
>50 Micron		253
>100 Micron		15

Nickel	0
Chromium	0
Titanium	0
Vanadium	0
Silicon	0
Sulfur	0
Boron	0
Calcium	9
Magnesium	1
Phosphorus	118
Zinc	17
Barium	0
Molybdenum	0
Sodium	0
Potassium	0

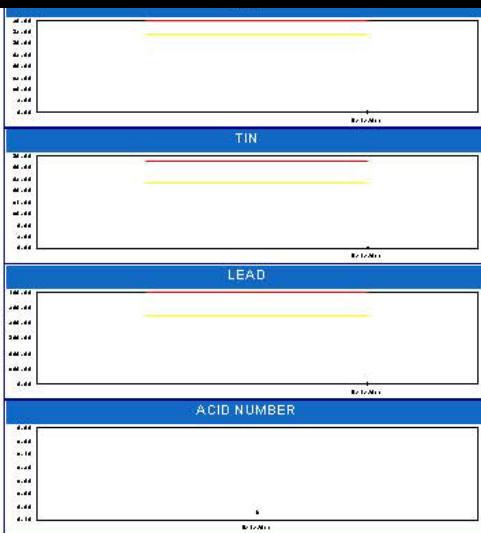
VISCOSITY (centistokes) ASTM D 445

ISO 4406-99

ISO Code	25/ 23/ 20
>4 Micron	195318
>6 Micron	75959
>14 Micron	5793
>50 Micron	253
>100 Micron	15

SINGLE COMPONENT TESTS

Acid number	24.1
Water ppm	120



PARTICLE O 4406:99

ISO Code **25/ 23/ 20**

>4 Micron 195318

>6 Micron 75959

>14 Micron 5793

O 4406:99

21/ 20/ 16

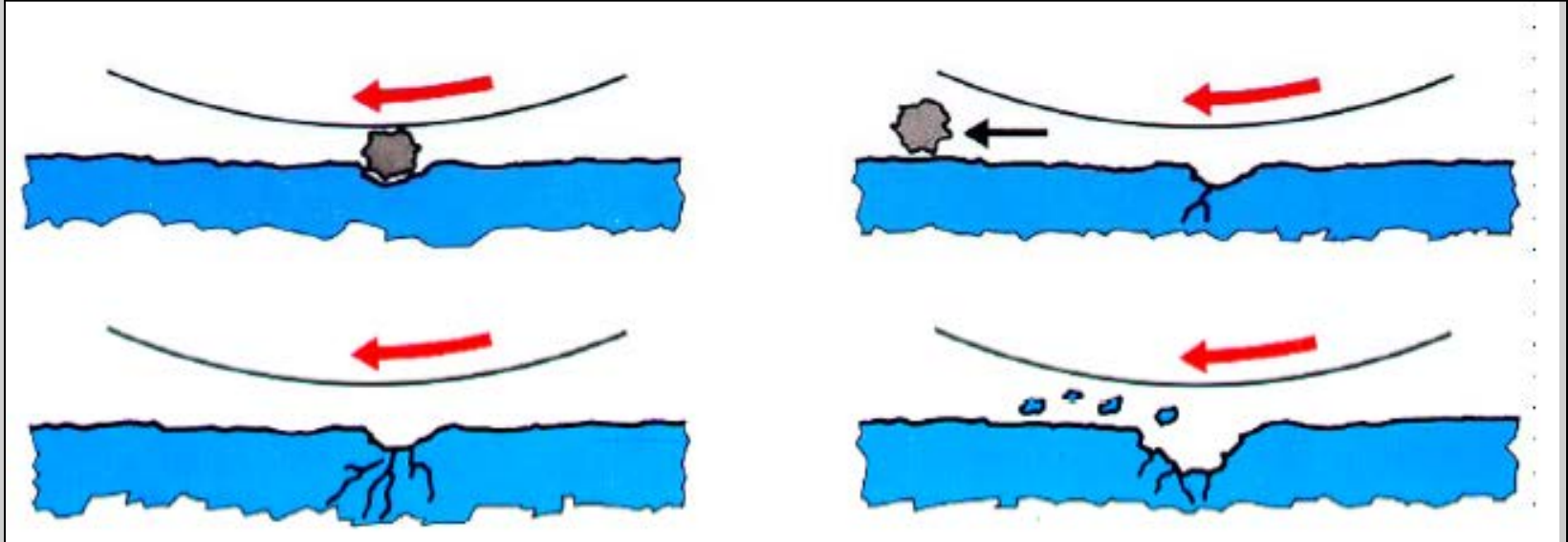
13217

5140

392

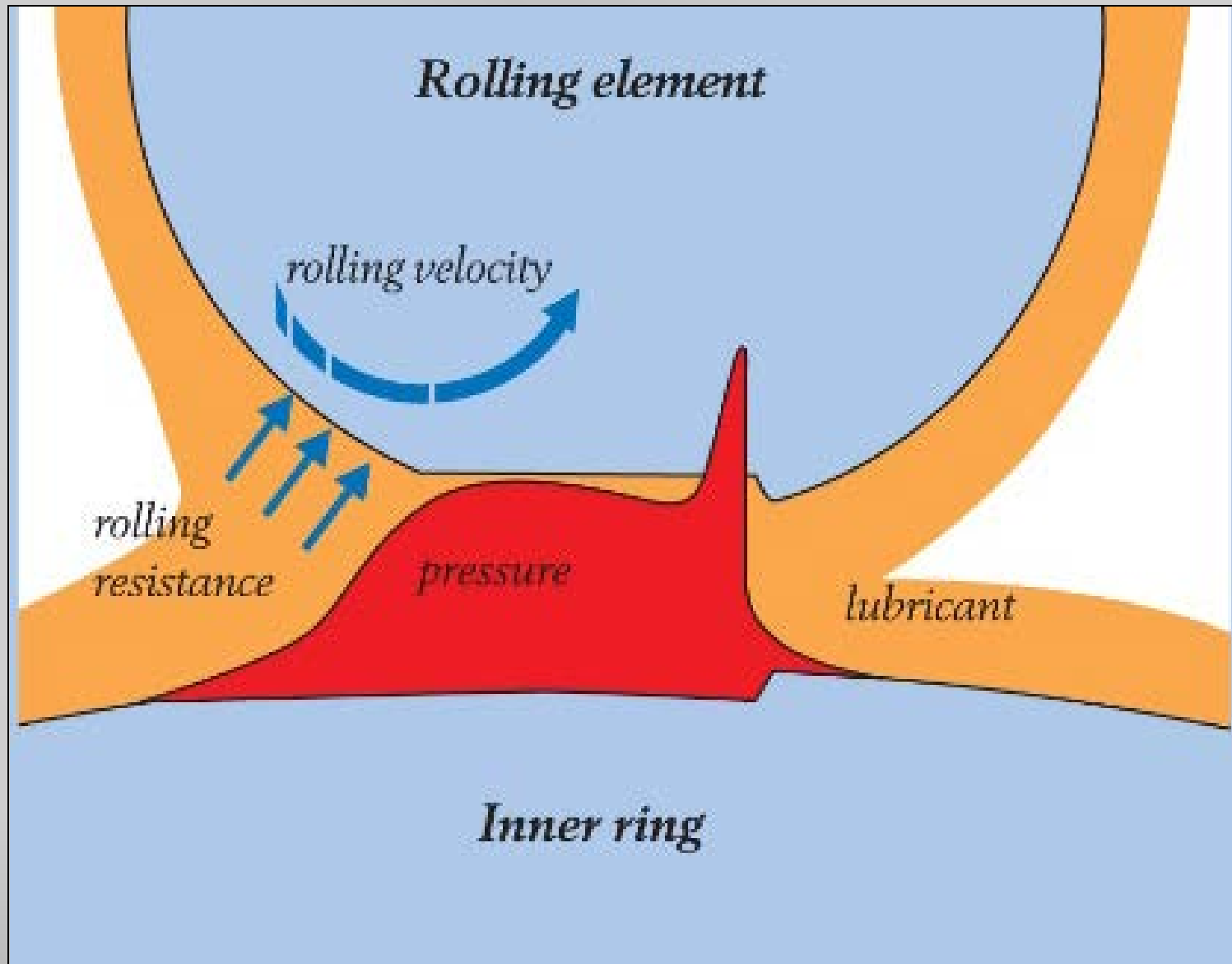
ISO/Range Code	Min particles /ml	Max particles /ml < or equal to
1	0	0.02
2	0.02	0.04
3	0.04	0.08
4	0.08	0.15
5	0.15	0.3
6	0.3	0.6
7	0.6	1.3
8	1.3	2.5
9	2.5	5
10	5	10
11	10	20
12	20	40
13	40	80
14	80	160
15	160	320
16	320	640
17	640	1,300
18	1,300	2,500
19	2,500	5,000
20	5,000	10,000
21	10,000	160,000
22	160,000	320,000
23	320,000	640,000
24	640,000	1,300,000
25	1,300,000	2,500,000

**Particulate
Target
17/15/12**



Source: SKF

- Oil film thickness = 0.5 to 3 micron (if maintained)
- Keep the oil clean
- Maintain the viscosity

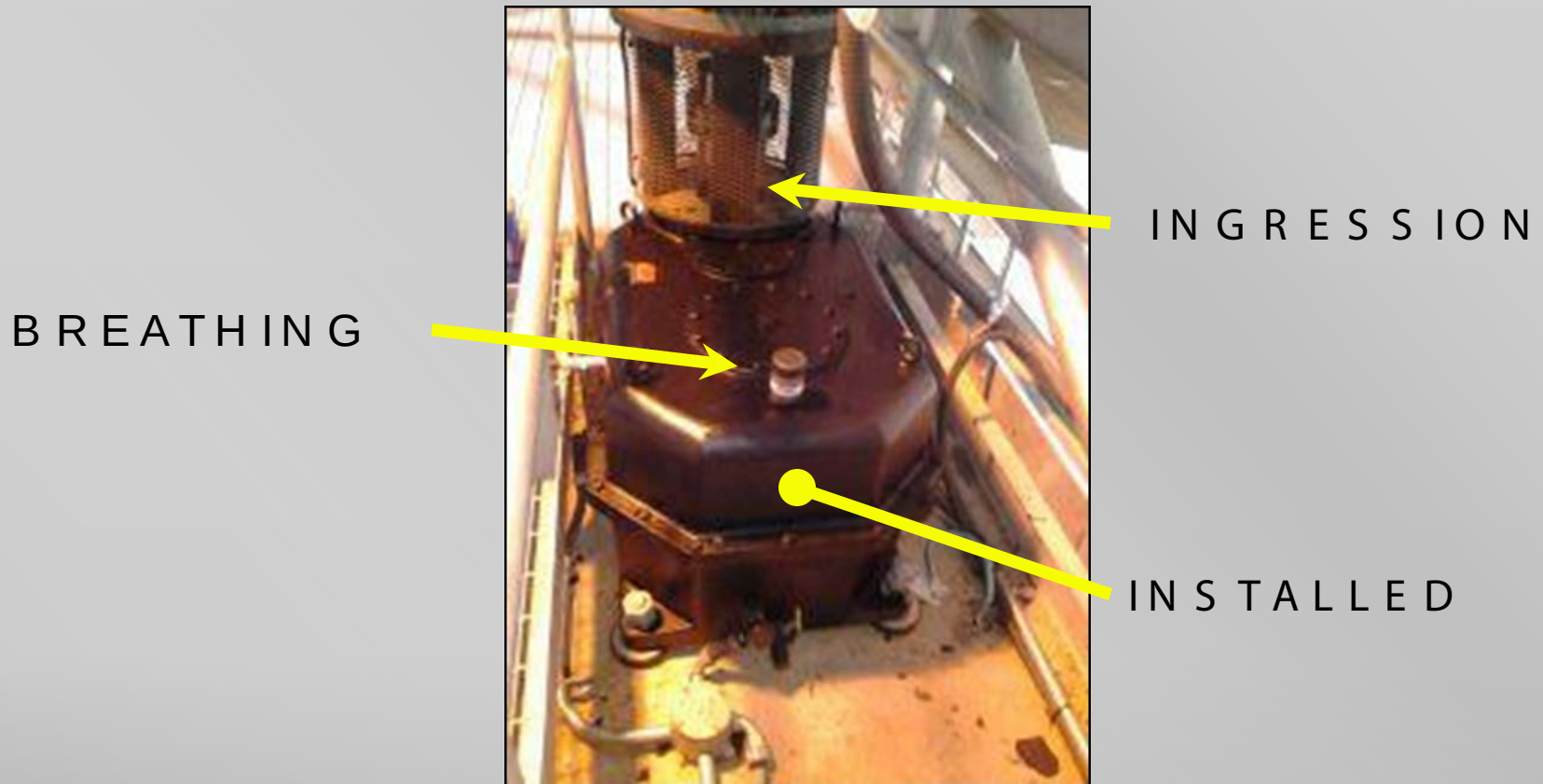


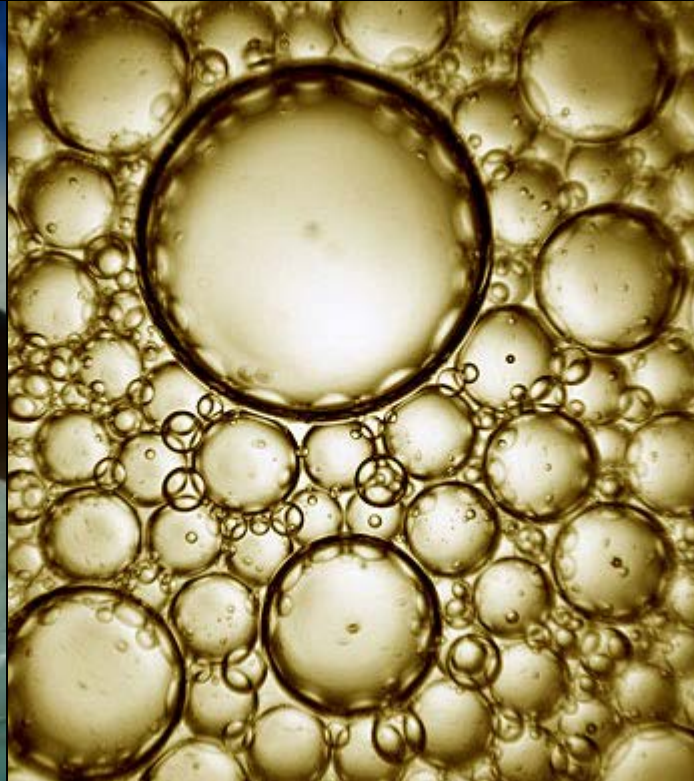
Source: SKF



Lubrication > Dry

Lubrication > Dry





Machine Condition: **NORMAL**

Lubricant Condition: **MARGINAL**

FP&L GSU - Cell #26 - 0.2 Run Hours - 5/3/11

Oil Temperature: 115

SINGLE COMPONENT TESTS

Acid # mg KOH/g 0.71

Water ppm 120

Tin	0
Nickel	0
Chromium	0
Titanium	0
Vanadium	0
Silicon	0
Sulfur	7
Boron	0
Calcium	9
Magnesium	1
Phosphorus	118
Zinc	17
Barium	0
Molybdenum	0
Sodium	0
Potassium	0

VISCOSITY (centistokes) ASTM D 445
@ 40 22.2

PARTICLE COUNT (particles per ml) ISO 4406:99	
ISO Code	25/23/20
<4 Micro	195318
<6 Micro	75959
<10 Micro	15
<15 Micro	253
<100 Micro	15

SINGLE COMPONENT TESTS

Acid # mg KOH/g 0.71

Water ppm 120

IRON



TIN



LEAD



ACID NUMBER



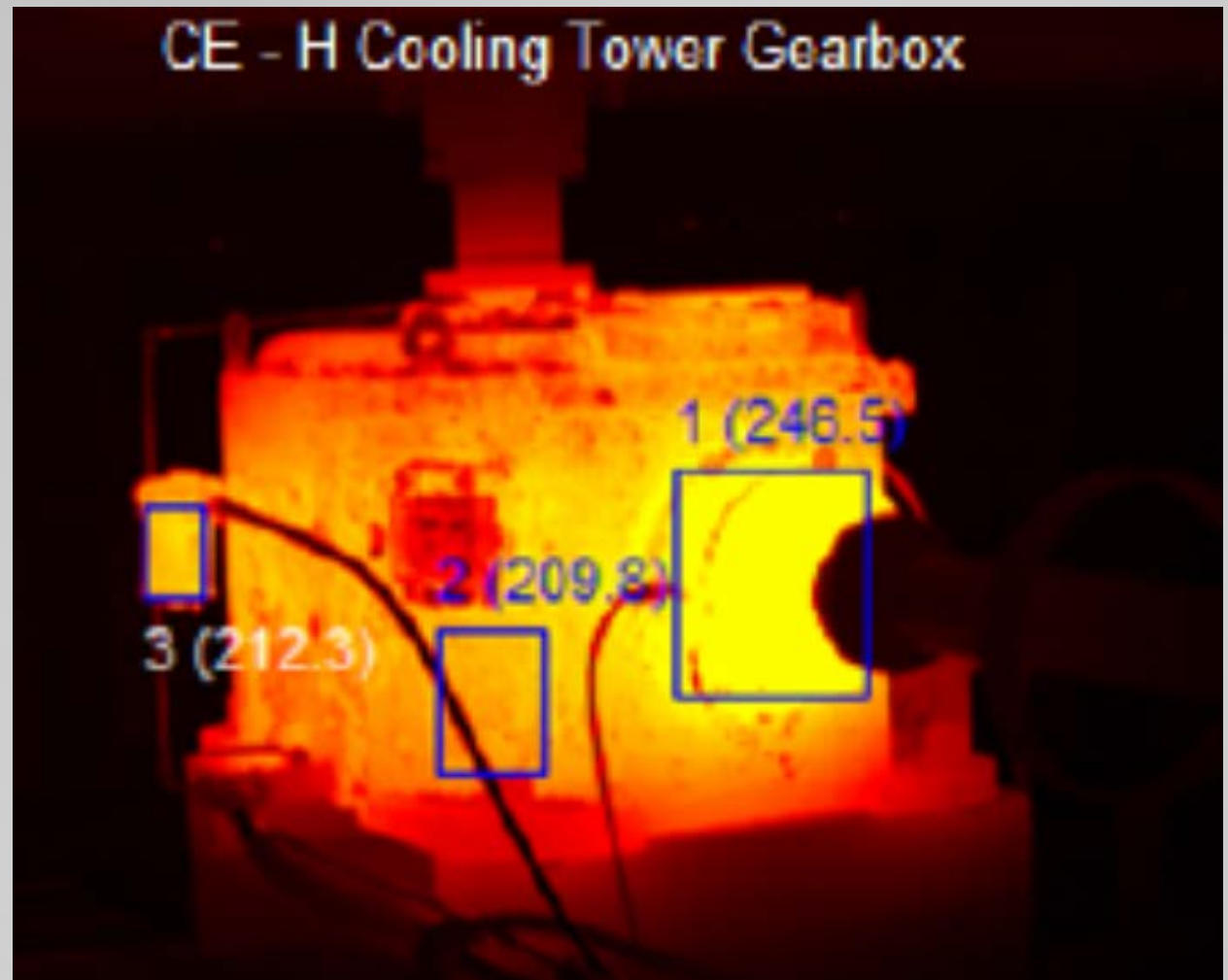
Target: ≤ 400 ppm



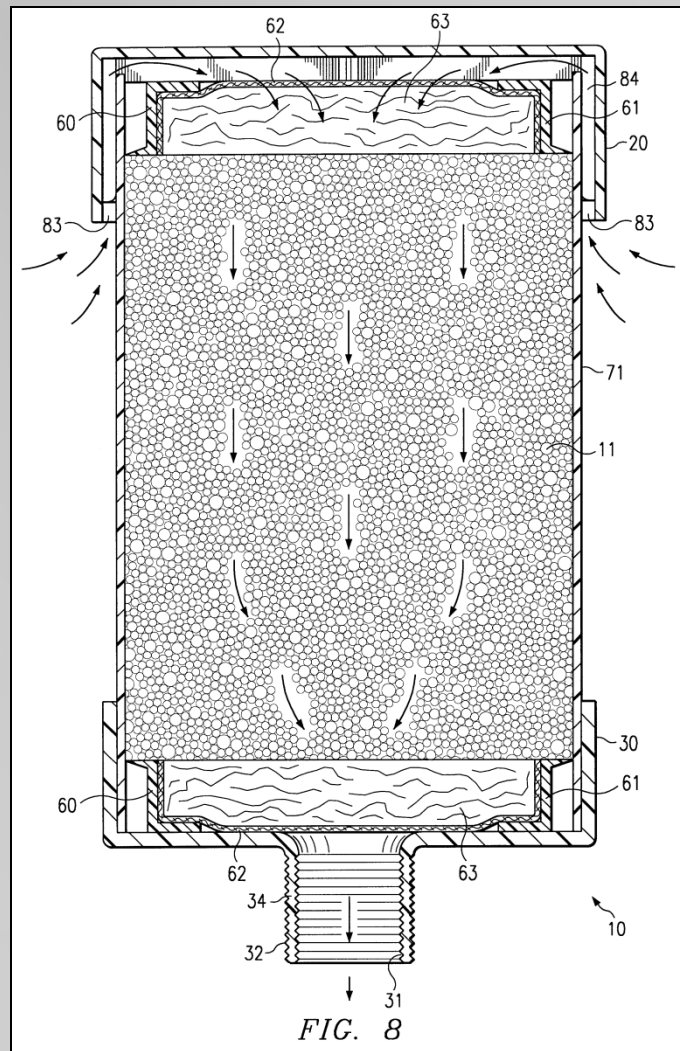
Lubrication > Cool



Svante Arrhenius
(1859-1927)



Mineral Oil:
Every 18°F above 165°, life is cut in half.



Breathers

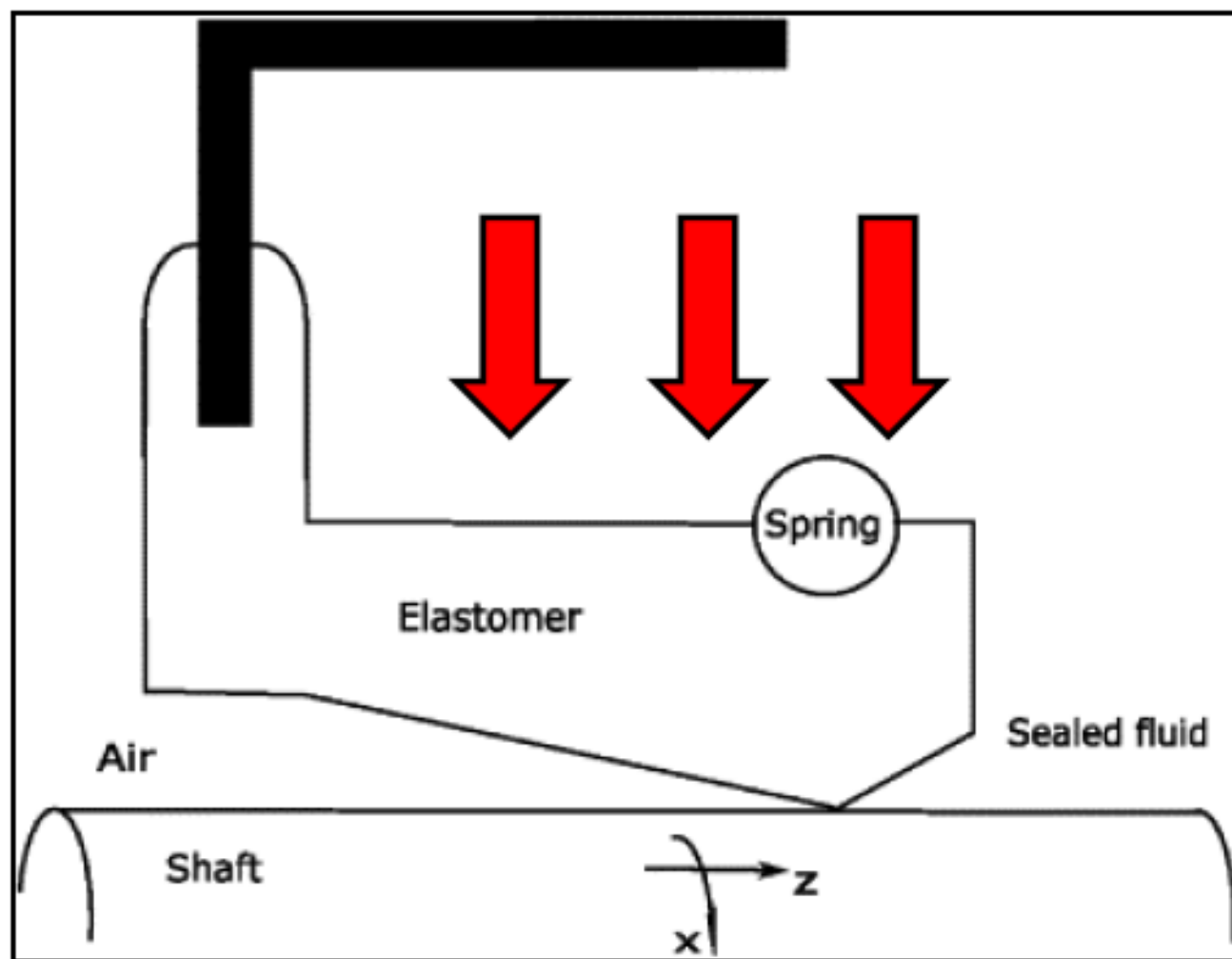




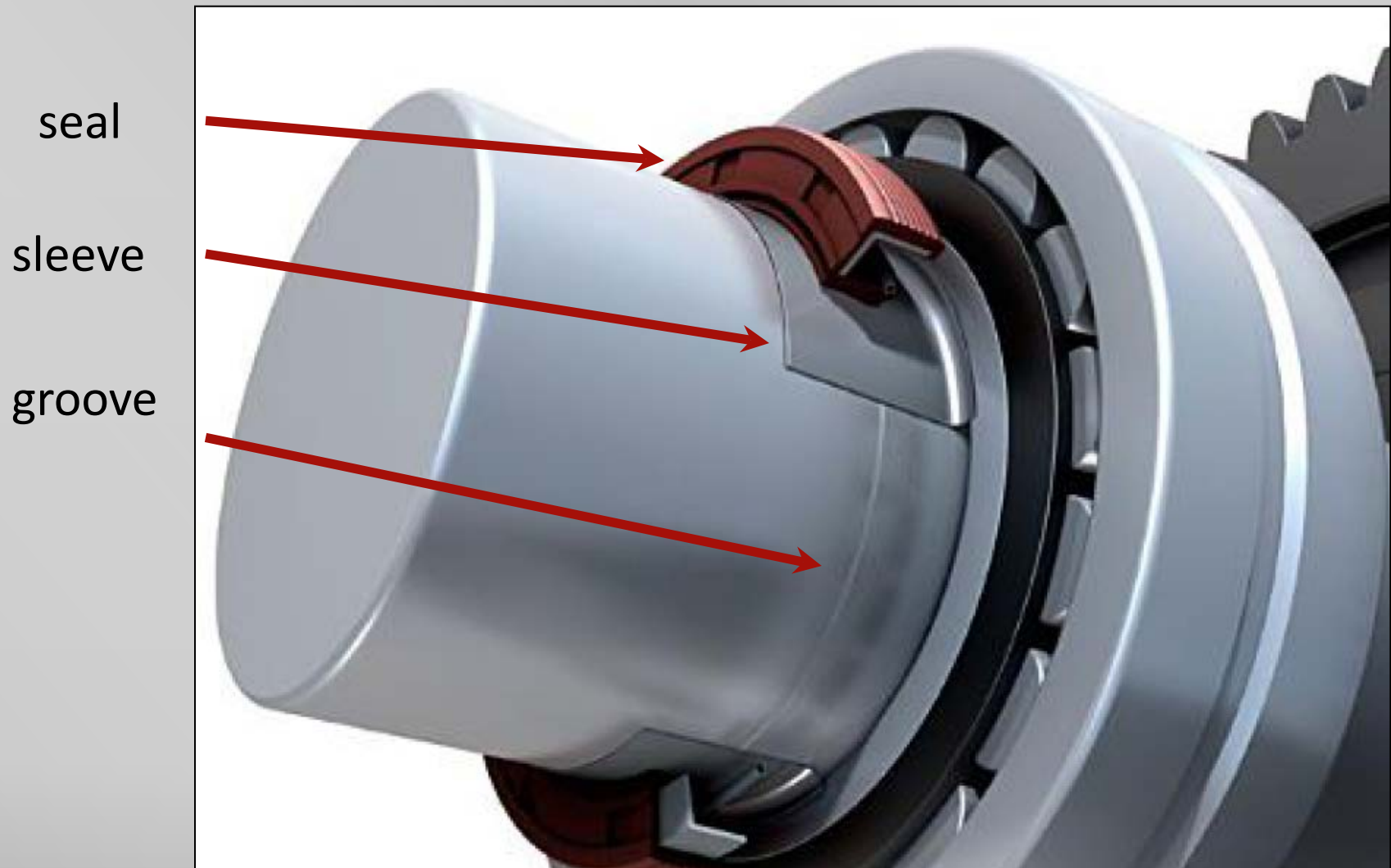










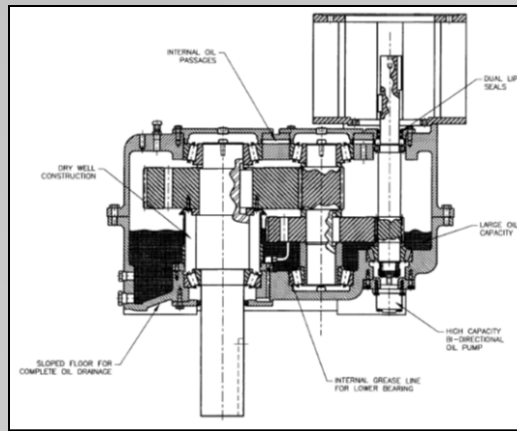


Source: SKF

HORSEPOWER												
11	12	13	14	15	Ratio		16	17	18	19	20	21
216	203	190	175	163	150	140	130	125	120	116		
180	169	158	145	135	125	116	108	104	100	96		
146	137	128	118	110	101	95	88	84	81	78		
291	272	255	243	231	215	207	197	187	180	177		
250	233	219	209	198	185	177	169	160	154	149		
208	194	182	174	165	155	145	141	131	125	120		
460	437	412	385	368	350	333	315	300	285	271		
382	363	342	320	305	291	276	261	250	237	225		
308	293	276	267	247	235	223	211	201	191	182		

	1800	32	38	51	72	91	119	146	179	169	164	330	380
56	1500	27	32	43	61	76	100	123	139	144	234	273	304
	1200	21	25	34	47	59	82	108	133	159	194	216	254
	1000	17.9	21	29	40	50	66	82	110	126	153	175	201
63	1800	29	35	47	65	82	108	133	159	194	216	254	304
	1500	24	29	38	54	68	89	110	126	153	175	201	239
	1200	19	23	30	43	54	71	87	105	128	146	181	216
	1000	15.9	19	25	36	45	59	72	87	105	128	146	181
71	1800	25	30	40	56	71	93	114	136	166	202	239	270
	1500	21	25	34	47	59	78	96	112	136	169	193	225
	1200	16.9	20	27	38	48	63	77	93	113	129	160	192
	1000	14.1	17	22	32	40	52	64	77	93	113	129	160
80	1800	23	27	37	52	65	85	105	125	151	173	214	240
	1500	18.8	22	30	42	53	70	86	99	121	138	171	200
	1200	15	18	24	34	42	56	68	83	101	115	142	167
	1000	12.5	15	20	28	35	46	57	68	83	101	115	142
90	1800	20	24	32	41	56	76	91	111	134	153	190	213
	1500	16.7	20	27	34	47	60	73	88	107	122	151	177
	1200	13.3	16	21	27	37	48	60	73	88	107	122	151
	1000	11.1	13	18	23	31	40	50	60	73	88	107	122

Gear Ratings



American

ANSI/AGMA 2001

Gear Industry Professionals

Empirical Basis

European

ISO 6336

Academic Professionals

Theoretical Basis

Qualify your Service Factors!

USE:

ANSI/AGMA 2.0 SF

- OR -

ISO 3.6 SF



Thank You