

Appendix A Abbreviation

ASTM --- American Society for Testing Material
CCW ---- Counterclockwise
CW ----- Clockwise
DIA ----- Diameter
DIN ----- German Industry Standard
DRO ---- Dynamic Runout
FPM ----- Feet Per Minute
I.D. ----- Inside Diameter
ISO ----- International Standards Organization
MAX. ---- Maximum
MIN. ----- Minimum
MM ----- Millimeter
MPM ---- Meters Per Minute
NO. ----- Number
P.F. ----- Press Fit
PSI ----- Pounds Per Square Inch
RMA ----- Rubber Manufacturers Association
RPM ----- Revolutions Per Minute
SAE ----- Society of Automotive Engineers
SPEC. --- Specification
SS ----- Stainless Steel
STBM ---- Shaft to Bore Misalignment
THK ----- Thick
TIR ----- Total Indicator Reading
W/ ----- With
W/O ----- Without
WD ----- Width

Appendix B Hardness Conversion Tables(1/2)

Approximate Equivalents of Vicker's Hardness Numbers for Steel											ASTM		
Vicker's (DPH)	Brinell (HBN)			Rockwell Superficial				Rockwell			HS	Approx. Tensile Strength 1000 psi	HV
	Standard Ball	Hultgren Ball	Tungsten Carbide Ball	HRA	HRB	HRC	HRD	HR 15-N	HR 30-N	HR 45-N			
940	—	—	—	85.6	—	68.0	76.9	93.2	84.4	75.4	97	—	940
920	—	—	—	85.3	—	67.5	76.5	93.0	84.0	74.8	96	—	920
900	—	—	—	85.0	—	67.0	76.1	92.9	83.6	74.2	95	—	900
880	—	—	767	84.7	—	66.4	75.7	92.7	83.1	73.6	93	—	880
860	—	—	757	84.4	—	65.9	75.3	92.5	82.7	73.1	92	—	860
840	—	—	745	84.1	—	65.3	74.8	92.3	82.2	72.2	91	—	840
820	—	—	733	83.8	—	64.7	74.3	92.1	81.7	71.8	90	—	820
800	—	—	722	83.4	—	64.0	73.8	91.8	81.1	71.0	88	—	800
780	—	—	710	83.0	—	63.3	73.3	91.5	80.4	70.2	87	—	780
760	—	—	698	82.6	—	62.5	72.6	91.2	79.7	69.4	86	—	760
740	—	—	684	82.2	—	61.8	72.1	91.0	79.1	68.6	84	—	740
720	—	—	670	81.8	—	61.0	71.5	90.7	78.4	67.7	83	—	720
700	—	—	656	81.3	—	60.1	70.8	90.3	77.6	66.7	81	—	700
690	—	615	647	81.1	—	59.7	70.5	90.1	77.2	66.2	—	—	690
680	—	610	638	80.8	—	59.2	70.1	89.3	76.8	65.7	80	—	680
670	—	603	630	80.6	—	58.8	69.8	89.7	76.4	65.3	—	329	670
660	—	597	620	80.3	—	58.3	69.4	89.5	75.9	64.7	79	—	660
650	—	590	611	80.0	—	57.8	69.0	89.2	75.5	64.1	—	324	650
640	—	585	601	79.8	—	57.3	68.7	89.0	75.1	63.5	77	—	640
630	—	578	591	79.5	—	56.8	68.3	88.8	74.6	63.0	—	314	630
620	—	571	582	79.2	—	56.3	67.9	88.5	74.2	62.4	—	309	620
610	—	564	573	78.9	—	55.7	67.5	88.2	73.6	61.7	75	—	610
600	—	557	564	78.6	—	55.2	67.0	88.0	73.2	61.2	—	299	600
590	—	550	554	78.4	—	54.7	66.7	87.8	72.7	60.5	74	—	590
580	—	542	545	78.0	—	54.1	66.2	87.5	72.1	59.9	—	289	580
570	—	535	535	77.8	—	53.6	65.8	87.2	71.7	59.3	72	—	570
560	—	527	525	77.4	—	53.0	65.4	86.9	71.2	58.6	—	279	560
550	—	519	512	77.0	—	52.3	64.8	86.6	70.5	57.8	71	—	550
540	—	512	507	76.7	—	51.7	64.4	86.3	70.0	57.0	—	274	540
530	—	503	497	76.4	—	51.1	63.9	86.0	69.5	56.2	69	—	530
520	505	495	488	76.1	—	50.5	63.5	85.7	69.0	55.6	—	264	520
510	496	487	479	75.7	—	49.8	62.9	85.4	68.3	54.7	67	—	510
500	488	479	471	75.3	—	49.1	62.2	85.0	67.7	53.9	—	254	500
490	480	471	460	74.9	—	48.4	61.6	84.7	67.1	53.1	66	—	490
480	473	460	452	74.5	—	47.7	61.3	84.3	66.4	52.2	—	244	480
470	465	452	442	74.1	—	46.9	60.7	83.9	65.7	51.3	64	—	470
460	456	442	433	73.6	—	46.1	60.1	83.6	64.9	50.4	—	234	460
450	448	433	425	73.3	—	45.3	59.4	83.2	64.3	49.4	62	—	450
440	441	425	415	72.8	—	44.5	58.8	82.8	63.5	48.4	—	224	440
430	433	415	405	72.3	—	43.6	58.2	82.3	62.7	47.4	—	220	430
420	425	405	397	71.8	—	42.7	57.5	81.8	61.9	46.4	59	—	420
410	415	397	388	71.4	—	41.8	56.8	81.4	61.1	45.3	—	214	410
400	405	388	379	70.8	—	40.8	56.0	81.0	60.2	44.1	57	—	400
390	397	379	369	70.3	—	39.8	55.2	80.3	59.3	42.9	—	204	390
380	388	369	360	69.8	—	38.8	54.4	79.8	58.4	41.7	—	195	380
370	379	360	350	69.2	—	37.7	53.6	79.2	57.4	40.4	55	—	370
360	369	350	341	68.7	—	36.6	52.8	78.6	56.4	39.1	52	—	360
350	360	341	331	68.1	—	35.5	51.9	78.0	55.4	37.8	—	185	350
340	350	331	322	67.6	—	34.4	51.1	77.4	54.4	36.5	—	175	340
330	341	322	313	67.0	(110.0)	33.3	50.2	76.8	53.6	35.2	50	—	330
	331	313			—						47	—	
	322				(109.0)						—	161	
	313				(108.0)						—	156	

Appendix B Hardness Conversion Tables(2/2)

Approximate Equivalents of Vicker's Hardness Numbers for Steel											ASTM		
Vicker's (DPH)	Brinell (HBN)			Rockwell Superficial				Rockwell			HS	Approx. Tensile Strength 1000 psi	HV
	Standar d Ball	Hultgren Ball	Tungsten Carbide Ball	HRA	HRB	HRC	HRD	HR 15-N	HR 30-N	HR 45-N			
320	303	303	303	66.4	(107.0)	32.2	49.4	76.2	52.3	33.9	45	151	320
310	294	294	294	65.8	—	31.0	48.4	75.6	51.3	32.5	—	146	310
300	284	284	284	65.2	(105.5)	29.8	47.5	74.9	50.2	31.1	42	141	300
295	280	280	280	64.8	—	29.2	47.1	74.6	49.7	30.4	—	139	295
290	275	275	275	64.5	(104.5)	28.5	46.5	74.2	49.0	29.5	41	136	290
285	270	270	270	64.2	—	27.8	46.0	73.8	48.4	28.7	—	134	285
280	265	265	265	63.8	(103.5)	27.1	45.3	73.4	47.8	27.9	40	131	280
275	261	261	251	63.5	—	26.4	44.9	73.0	47.2	27.1	—	129	275
270	256	256	256	63.1	(102.0)	25.6	44.3	72.6	46.4	26.2	38	126	270
265	252	252	252	62.7	—	24.5	43.7	72.1	45.7	25.2	—	124	265
260	247	247	247	62.4	(101.0)	24.0	43.1	71.6	45.0	24.3	37	121	260
255	243	243	243	62.0	—	23.1	42.2	71.1	44.2	23.2	—	119	255
250	238	238	238	61.6	(99.5)	22.2	41.7	70.6	43.4	22.2	36	116	250
245	233	233	233	61.2	—	21.3	41.1	70.1	42.5	21.1	—	114	245
240	228	228	228	60.7	(98.1)	20.3	40.3	69.6	41.7	19.9	34	111	240
230	219	219	219	—	(18.0)	—	—	—	—	—	—	106	230
220	209	209	209	—	96.7	(15.7)	—	—	—	—	33	101	220
210	200	200	200	—	95.0	(13.4)	—	—	—	—	32	97	210
200	190	190	190	—	93.4	(11.0)	—	—	—	—	30	92	200
190	181	181	181	—	91.5	(8.5)	—	—	—	—	29	88	190
180	171	171	171	—	89.5	(6.0)	—	—	—	—	28	84	180
170	162	162	162	—	87.1	(3.0)	—	—	—	—	26	79	170
160	152	152	152	—	85.0	(0.0)	—	—	—	—	25	75	160
150	143	143	143	—	81.7	—	—	—	—	—	24	71	150
140	133	133	133	—	78.7	—	—	—	—	—	22	66	140
				—	75.0	—	—	—	—	—	21		
130	124	124	124	—	71.2	—	—	—	—	—	20	62	130
120	114	114	114	—	66.7	—	—	—	—	—	—	57	120
110	105	105	105	—	62.3	—	—	—	—	—	—	—	110
100	95	95	95	—	56.2	—	—	—	—	—	—	—	100
95	90	90	90	—	52.0	—	—	—	—	—	—	—	95
90	86	86	86	—	48.0	—	—	—	—	—	—	—	90
85	81	81	81	—	41.0	—	—	—	—	—	—	—	85
				—			—	—	—	—	—		

Appendix C Pressure Conversion Table

P R E S S U R E	Pa	kPa	MPa	bar	Kgf/cm ²	afm	mmH ₂ O	mmHg Torr
	1		1×10^{-6}	1×10^{-5}	$1.019\ 72 \times 10^{-5}$	$9.869\ 23 \times 10^{-6}$	$1.019\ 72 \times 10^{-1}$	$7.500\ 62 \times 10^3$
	1×10^3	1×10^{-3}	1×10^{-3}	1×10^{-2}	$1.019\ 72 \times 10^{-2}$	$9.869\ 23 \times 10^{-3}$	$1.019\ 72 \times 10^2$	7.500 62
	1×10^6	1	1	1×10	$1.019\ 72 \times 10$	9.869 23	$1.019\ 72 \times 10^5$	$7.500\ 62 \times 10^3$
	1×10^5	1×10^3	1×10^{-1}	1	1.019 72	$9.869\ 23 \times 10^{-1}$	$1.019\ 72 \times 10^4$	$7.500\ 62 \times 10^2$
	9.806×10^4	$9.806\ 65 \times 10$	$9.869\ 65 \times 10^{-2}$	$9.869\ 23 \times 10^{-1}$	1	$9.678\ 41 \times 10^{-1}$	1×10^4	7.35559×10^2
	$1.013\ 25 \times 10^5$	$1.013\ 25 \times 10^2$	$1.013\ 25 \times 10^{-1}$	1.013 25	1.033 23	1	$1.033\ 23 \times 10^4$	$7.600\ 00 \times 10^2$
	9.806 65	9.806×10^{-3}	$9.869\ 65 \times 10^{-6}$	$9.869\ 65 \times 10^{-5}$	1×10^{-4}	$9.869\ 41 \times 10^{-5}$	1	$7.355\ 59 \times 10^{-2}$
	$1.333\ 22 \times 10^2$	$1.333\ 22 \times 10^{-1}$	$1.333\ 22 \times 10^{-4}$	$1.333\ 22 \times 10^{-3}$	$1.359\ 51 \times 10^{-3}$	$1.315\ 79 \times 10^{-3}$	$1.359\ 51 \times 10$	1

Remark : 1P=1N/cm²

Appendix D Temperature Conversion Table

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F						
-73	-100	-148	-1.6	29	84.2	17.7	64	147.2	37.1	99	210.2	-23.3	-10	14	1.1	34	93.2	20.4	69	156.2	54	130	266
-62	-80	-112	-1.1	30	86.0	18.2	65	149.0	37.7	100	212.0	-17.7	0	32	1.6	35	95.0	21.0	70	158.0	60	140	284
-51	-60	-76	-0.6	31	87.8	18.8	66	150.8	38	100	212	-17.2	1	33.8	2.2	36	96.8	21.5	71	159.8	65	150	302
-40	-40	-40	0	32	89.6	19.3	67	152.6	43	110	230	-16.6	2	35.6	2.7	37	98.6	22.2	72	161.8	71	160	320
-29	-20	-4	-0.5	33	91.4	19.9	68	154.4	49	120	248	-16.1	3	37.4	3.3	38	100.4	22.7	73	163.4	76	170	338
-15.5	4	39.2	3.8	39	102.2	23.3	74	165.2	83	180	56	-15.0	5	41.0	4.4	40	104.0	23.8	75	167.0	88	190	374
-14.4	6	42.8	4.4	40	104.0	23.8	75	167.0	88	190	374	-14.4	6	42.8	4.9	41	105.8	24.4	76	168.8	93	200	392
-13.9	7	44.6	4.9	41	105.8	24.4	76	168.8	93	200	392	-13.9	7	44.6	5.5	42	107.6	25.0	77	170.6	121	250	482
-13.3	8	46.4	5.5	42	107.6	25.0	77	170.6	121	250	482	-13.3	8	46.4	6.0	43	109.4	25.5	78	172.4	149	300	572
-12.7	9	48.2	6.0	43	109.4	25.5	78	172.4	149	300	572	-12.7	9	48.2	6.6	44	111.2	26.2	79	174.2	177	350	662
-12.2	10	50.0	6.6	44	111.2	26.2	80	176.0	204	400	752	-12.2	10	50.0	7.1	45	113.0	26.8	80	176.0	204	400	752
-11.6	11	51.8	7.1	45	113.0	26.8	80	176.0	204	400	752	-11.6	11	51.8	7.7	46	114.8	27.3	81	177.8	232	450	842
-11.1	12	53.6	7.7	46	114.8	27.3	81	177.8	232	450	842	-11.1	12	53.6	8.2	47	116.6	27.7	82	179.6	260	500	932
-10.5	13	55.4	8.2	47	116.6	27.7	82	179.6	260	500	932	-10.5	13	55.4	8.8	48	118.4	28.2	83	181.4	288	550	1022
-10.0	14	57.2	8.8	48	118.4	28.2	83	181.4	288	550	1022	-10.0	14	57.2	9.3	49	120.2	28.8	84	183.2	315	600	1112
-9.4	15	59.0	9.3	49	120.2	28.8	84	183.2	315	600	1112	-9.4	15	59.0	9.9	50	122.0	29.3	85	185.0	343	650	1202
-8.8	16	61.8	9.9	50	122.0	29.3	85	185.0	343	650	1202	-8.8	16	61.8	10.4	51	123.8	9.9	86	186.8	371	700	1292
-8.3	17	63.6	10.4	51	123.8	9.9	86	186.8	371	700	1292	-8.3	17	63.6	11.1	52	125.6	30.4	87	188.6	399	750	1382
-7.7	18	65.4	11.1	52	125.6	30.4	87	188.6	399	750	1382	-7.7	18	65.4	11.5	53	127.4	31.0	88	190.4	426	800	1472
-7.2	19	67.2	11.5	53	127.4	31.0	88	190.4	426	800	1472	-7.2	19	67.2	12.1	54	129.2	31.5	89	192.2	454	850	1562
-6.6	20	68.0	12.1	54	129.2	31.5	89	192.2	454	850	1562	-6.6	20	68.0	12.6	55	131.0	32.1	90	194.0	482	900	1652
-6.1	21	69.8	12.6	55	131.0	32.1	90	194.0	482	900	1652	-6.1	21	69.8	13.2	56	132.8	32.6	91	195.8	510	950	1742
-5.5	22	71.6	13.2	56	132.8	32.6	91	195.8	510	950	1742	-5.5	22	71.6	13.7	57	134.6	33.3	92	197.6	538	1000	1832
-5.0	23	73.4	13.7	57	134.6	33.3	92	197.6	538	1000	1832	-5.0	23	73.4	14.3	58	136.4	33.8	93	199.4	538	1000	1832
-4.4	24	75.2	14.3	58	136.4	33.8	93	199.4	538	1000	1832	-4.4	24	75.2	14.8	59	138.2	34.4	94	201.2	593	1100	2012
-3.9	25	77.0	14.8	59	138.2	34.4	94	201.2	593	1100	2012	-3.9	25	77.0	15.6	60	140.0	34.9	95	203.0	648	1200	2192
-3.3	26	78.8	15.6	60	140.0	34.9	95	203.0	648	1200	2192	-3.3	26	78.8	16.1	61	141.8	35.5	96	204.8	704	1300	2372
-2.8	27	80.6	16.1	61	141.8	35.5	96	204.8	704	1300	2372	-2.8	27	80.6	16.8	62	143.6	36.1	97	206.6	760	1400	2552
-2.2	28	82.4	16.8	62	143.6	36.1	97	206.6	760	1400	2552	-2.2	28	82.4	17.1	63	145.4	36.6	98	208.4	815	1500	2732

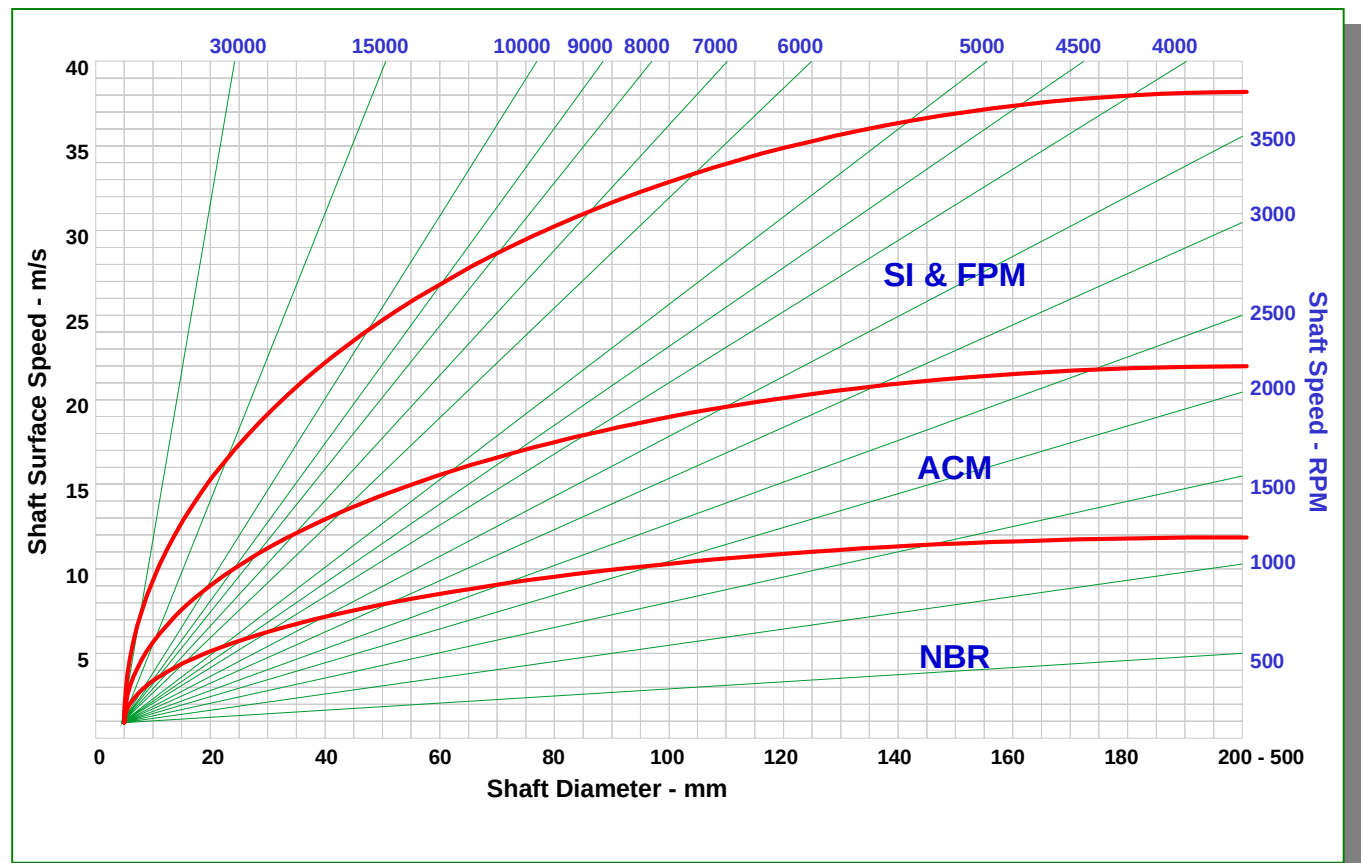
Appendix E Shaft Tolerance Table

Dimension (mm)	IT 5	m5	k5	j5	h5	IT 6	r6	p6	n6	m6	k6	j6	h6	g6	f6	IT 7	s7	r7	p7	n7	m7	k7	j7	h7	g7	f7	e7	IT 8	h8	f8	e8	d8	IT 9	h9	e9	d9	c9	b9	IT 10	h10	IT	h11		
		Upper Tolerance Lower Tolerance					Upper Tolerance Lower Tolerance										Upper Tolerance Lower Tolerance												Upper Tolerance Lower Tolerance					Upper Tolerance Lower Tolerance										
1 < Dia. < 3	4	+6 +4	+4 +0	+4 -1	0 -4	6	+16 +10	+12 +6	+10 +4	+8 +2	+6 0	+6 -1	0 -6	-2 -8	-6 -12	10	+24 +15	+21 +12	+18 +9	+15 +6	— —	— —	+7 -2	0 -10	-3 -12	-6 -16	-14 -24	14	0 -14	-6 -20	-14 -28	-20 -34	25	0 -25	-14 -39	-20 -45	-60 -85	-140 -165	40	0 -40	60	0 -60		
3 ≤ Dia. < 6	5	+9 +4	+6 +1	+4 -1	0 -5	8	+23 +15	+20 +12	+16 +8	+12 +4	+9 +1	+7 -1	0 -8	-4 -12	-10 -18	12	+31 +19	+27 +15	+24 +12	+20 +8	— —	— —	+9 -3	0 -12	-4 -16	-10 -22	-20 -32	18	0 -18	-10 -28	-20 -38	-30 -48	30	0 -30	-20 -50	-30 -60	-70 -100	-140 -170	48	0 -48	75	0 -75		
6// 10//	6	+12 +6	+7 +1	+4 -2	0 -6	9	+28 +19	+24 +15	+19 +10	+15 +6	+10 +1	+7 -2	0 -9	-5 -14	-13 -22	15	+38 +23	+34 +19	+30 +15	+25 +10	+21 +6	+16 +1	+10 -5	0 -15	-5 -20	-13 -28	-25 -40	22	0 -22	-13 -35	-25 -47	-40 -62	36	0 -36	-25 -61	-40 -76	-80 -116	-150 -186	58	0 -58	90	0 -90		
10// 14// 14// 18//	8	+15 +7	+9 +1	+5 -3	0 -8	11	+34 +23	+29 +18	+23 +12	+18 +7	+12 +1	+8 -3	0 -11	-6 -17	-16 -27	18	+46 +28	+41 +23	+36 +18	+30 +12	+25 +7	+19 +1	+12 -6	0 -18	-6 -24	-16 -34	-32 -50	27	0 -27	-16 -43	-32 -59	-50 -77	43	0 -43	-32 -75	-50 -93	-95 -138	-150 -193	70	0 -70	110	0 -110		
18// 24// 24// 30//	9	+17 +8	+11 +2	+5 -4	0 -9	13	+41 +28	+35 +22	+28 +15	+21 +8	+15 +2	+9 -4	0 -13	-7 -20	-20 -33	21	+56 +35	+49 +28	+43 +22	+36 +15	+29 +8	+23 +2	+13 -8	0 -21	-7 -28	-20 -41	-40 -61	33	0 -33	-20 -53	-40 -73	-65 -98	52	0 -52	-40 -92	-65 -117	-110 -162	-160 -212	84	0 -84	130	0 -130		
30// 40//	11	+20 +9	+13 +2	+6 -5	0 -11	16	+50 +34	+42 +26	+33 +17	+25 +9	+18 +2	+11 -5	0 -16	-9 -25	-25 -41	25	+68 +43	+59 +34	+51 +26	+42 +17	+34 +9	+27 +2	+15 -10	0 -25	-9 -34	-25 -50	-50 -75	39	0 -39	-25 -64	-50 -89	-80 -119	62	0 -62	-50 -112	-80 -142	-120 -182	-170 -232	100	0 -100	160	0 -160		
40// 50//		-192 -242	-140 -190	-214 -264	-150 -200		-224 -274	-170 -220	-257 -307	-180 -240	-267 -327	-200 -300	-210 -310	-230 -330	-340 -410																													
50// 60//	13	+24 +11	+15 +2	+6 -7	0 -13	19	+60 +41 +62 +43	+51 +32	+39 +20	+30 +11	+21 +2	+12 -7	0 -19	-10 -29	-30 -49	30	+83 +53 +89 +59	+71 +41 +73 +43	+62 +32	+50 +20	+41 +11	+32 +2	+18 -12	0 -30	-10 -40	-30 -60	-60 -90	46	0 -46	-30 -76	-60 -106	-100 -146	74	0 -74	-60 -134	-100 -174	-140 -214	-190 -264	120	0 -120	190	0 -190		
65// 80//		-224 -274	-170 -220	-257 -307	-180 -240		-267 -327	-200 -300	-210 -310	-230 -330	-340 -410																																	
80// 100//	15	+28 +13	+18 +3	+6 -9	0 -15	22	+73 +51 +76 +54	+59 +37	+45 +23	+35 +13	+25 +3	+13 -9	0 -22	-12 -34	-36 -58	35	+106 +71 +114 +79	+86 +51 +89 +54	+72 +37	+58 +23	+48 +13	+38 +3	+20 -15	0 -35	-12 -47	-36 -71	-72 -107	54	0 -54	-36 -90	-72 -126	-120 -174	87	0 -87	-72 -159	-120 -207	-170 -257	-220 -307	140	0 -140	220	0 -220		
100// 120//		-267 -327	-200 -300	-210 -310	-230 -330		-340 -410																																					
120// 140//	18					25	+88 +63									40	+132 +92 +140	+103 +63 +105 +65										63								-200 -300	-260 -360	160						
140// 160//		+33 +15	+21 +3	+7 -11	0 -18		+90 +65	+68 +43	+52 +27	+40 +15	+28 +3	+14 -11	0 -25	-14 -39	-43 -68		+140 +100	+105 +65	+83 +43	+67 +27	+55 +15	+43 +3	+22 -18	0 -40	-14 -54	-43 -83	-85 -125		0 -63	-43 -106	-85 -148	-145 -208	10 0	0 -100	-85 -185	-145 -245	-210 -310		-280 -380	0 -160	250	0 -250		
160// 180//							+93 +68										+148 +108	+108 +68																		-230 -330	-310 -410							
180// 200//	20					29	+106 +77									46	+168 +122	+123 +77											72									-240 -355	-340 -455	185				
200// 225//		+37 +17	+24 +4	+7 -13	0 -20		+109 +80	+79 +50	+60 +31	+46 +17	+33 +4	+16 -13	0 -29	-15 -44	-50 -79		+176 +130	+126 +80	+96 +50	+77 +31	+63 +17	+50 +4	+25 -21	0 -46	-15 -61	-50 -96	-100 -146	0 -72		-50 -122	-100 -172	-170 -242	11 5	0 -115	-100 -215	-170 -285	-260 -275	-380 -495	0 -185		290	0 -290		
225// 250//							+113 +84										+188 +140	+130 +84																		-280 -395	-420 -535							
250// 280//	23	+43 +20	+27 +4	+7 -16	0 -23	32	+126 +94 +130 +98	+88 +56	+66 +34	+52 +20	+36 +4	+16 -16	0 -32	-17 -49	-56 -88	52	+210 +158 +222 +170	+146 +94 +150 +98										81	0 -81	-56 -137	-110 -191	-190 -271	13 0	0 -130	-110 -240	-190 -320	-300 -430	-480 -610	210	0 -210	320	0 -320		
280// 315//																																												
315// 355//	25	+46 +21	+29 +4	+7 -18	0 -25	36	+144 +108 +150 +114	+98 +62	+73 +37	+57 +21	+40 +4	+18 -18	0 -36	-18 -54	-62 -98	57	+247 +190 +265 +208	+165 +108 +171 +114										89	0 -89	-62 -151	-125 -214	-210 -299	14 0	0 -140	-125 -265	-210 -350	-360 -500	-600 -740	230	0 -230	360	0 -360		
355// 400//																																												
400// 450//	27	+50 +23	+32 +5	+7 -20	0 -27	40	+166 +126 +172 +132	+108 +68	+80 +40	+63 +23	+45 +4	+20 -20	0 -40	-20 -60	-68 -108	63	+295 +232 +315 +252	+189 +126 +195 +132										97	0 -97	-68 -165	-135 -232	-230 -327	15 5	0 -155	-135 -290	-230 -385	-440 -595	-760 -915	250	0 -250	400	0 -400		
450// 500//																																												

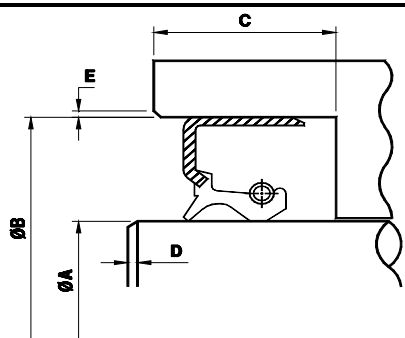
Appendix F Housing Tolerance Table

Dimension (mm)	IT 6	M6	K6	J6	G6	F6		p6	n6	m6	k6	j6	h6	g6	f6	IT 7	s7	r7	p7	n7	m7	k7	j7	h7	g7	f7	e7	IT 8	h8	f8	e8	d8	IT 9	h9	e9	d9	c9	b9	IT 10	h10	IT	h11	
		Upper Tolerance Lower Tolerance							Upper Tolerance Lower Tolerance								IT 7	Upper Tolerance Lower Tolerance													IT 8	Upper Tolerance Lower Tolerance				IT 9	Upper Tolerance Lower Tolerance					IT 10	Up. Tol. Low. Tol
1 < Dia. < 3	6	-2 -8						+12 + 6	+10 + 4	+8 + 2	+6 0	+6 -1	0 -6	-2 -8	- 6 -12	10		+24 +15	+21 +12	+18 + 9	+15 + 6	— —	— —	+7 -2	0 -10	-3 -12	- 6 -16	-14 -24	14	0 -14		- 6 -20	-14 -28	-20 -34	25		0 -25	-14 -39	-20 -45	-60 -85	-140 -165		40
3≤Dia.<6	8	-1 -9						+20 +12	+16 + 8	+12 + 4	+9 + 1	+7 -1	0 -8	-4 -12	-10 -18	12	+31 +19	+27 +15	+24 +12	+20 + 8	— —	— —	+9 -3	0 -12	-4 -16	-10 -22	-20 -32	18	0 -18	-10 -28	-20 -38	-30 -48	30	0 -30	-20 -50	-30 -60	-70 -100	-140 -170	48	0 -48	75	0 -75	
6// 10//	9	-3 -12						+24 +15	+19 +10	+15 + 6	+10 + 1	+7 -2	0 -9	-5 -14	-13 -22	15	+38 +23	+34 +19	+30 +15	+25 +10	+21 + 6	+16 + 1	+10 -5	0 -15	-5 -20	-13 -28	-25 -40	22	0 -22	-13 -35	-25 -47	-40 -62	36	0 -36	-25 -61	-60 -76	-80 -116	-150 -186	58	0 -58	90	0 -90	
10// 14// 14// 18//	11	-4 -15						+29 +18	+23 +12	+18 + 7	+12 + 1	+8 -3	0 -11	-6 -17	-16 -27	18	+46 +28	+41 +23	+36 +18	+30 +12	+25 + 7	+19 + 1	+12 -6	0 -18	-6 -24	-16 -34	-32 -50	27	0 -27	-16 -43	-32 -59	-50 -77	43	0 -43	-32 -75	-50 -93	-95 -138	-150 -193	70	0 -70	110	0 -110	
18// 24// 24// 30//	13	-4 -17						+35 +22	+28 +15	+21 + 8	+15 + 2	+9 -4	0 -13	-7 -20	-20 -33	21	+56 +35	+49 +28	+43 +22	+36 +15	+29 + 8	+23 + 2	+13 -8	0 -21	-7 -28	-20 -41	-40 -61	33	0 -33	-20 -53	-40 -73	-65 -98	52	0 -52	-40 -92	-65 -117	-110 -162	-160 -212	84	0 -84	130	0 -130	
30// 40// 40// 50//	16	-4 -20						+42 +26	+33 +17	+25 + 9	+18 + 2	+11 -5	0 -16	-9 -25	-25 -41	25	+68 +43	+59 +34	+51 +26	+42 +17	+34 + 9	+27 + 2	+15 -10	0 -25	-9 -34	-25 -50	-50 -75	39	0 -39	-25 -64	-50 -89	-80 -119	62	0 -62	-50 -112	-80 -142	-120 -182	-170 -232	100	0 -100	160	0 -160	
50// 60// 65// 80//	19	-5 -24						+51 +32	+39 +20	+30 +11	+21 + 2	+12 -7	0 -19	-10 -29	-30 -49	30	+83 +53 +89 +59	+71 +41 +73 +43	+62 +32	+50 +20	+41 +11	+32 + 2	+18 -12	0 -30	-10 -40	-30 -60	-60 -90	46	0 -46	-30 -76	-60 -106	-100 -146	74	0 -74	-60 -134	-100 -174	-140 -214 -150 -224	-190 -264 -200 -274	120	0 -120	190	0 -190	
80// 100// 100// 120//	22	-6 -28						+59 +37	+45 +23	+35 +13	+25 + 3	+13 -9	0 -22	-12 -34	-36 -58	35	+106 +71 +114 +79	+86 +51 +89 +54	+72 +37	+58 +23	+48 +13	+38 + 3	+20 -15	0 -35	-12 -47	-36 -71	-72 -107	54	0 -54	-36 -90	-72 -126	-120 -174	87	0 -87	-72 -159	-120 -207	-170 -257 -180 -267	-220 -307 -240 -327	140	0 -140	220	0 -220	
120// 140// 140// 160// 160// 180//	25	-8 -33						+68 +43	+52 +27	+40 +15	+28 + 3	+14 -11	0 -25	-14 -39	-43 -68	40	+132 +92 +140 +100 +148 +108	+103 +63 +105 +65 +108 +68	+83 +43	+67 +27	+55 +15	+43 + 3	+22 -18	0 -40	-14 -54	-43 -83	-85 -125	63	0 -63	-43 -106	-85 -148	-145 -208	100	0 -100	-85 -185	-145 -245	-200 -300 -210 -310 -230 -330	-260 -360 -280 -380 -310 -410	160	0 -160	250	0 -250	
180// 200// 200// 225// 225// 250//	29	-8 -37						+79 +50	+60 +31	+46 +17	+33 + 4	+16 -13	0 -29	-15 -44	-50 -79	46	+168 +122 +176 +130 +188 +140	+123 +77 +126 +80 +130 +84	+96 +50	+77 +31	+63 +17	+50 + 4	+25 -21	0 -46	-15 -61	-50 -96	-100 -146	72	0 -72	-50 -122	-100 -172	-170 -242	115	0 -115	-100 -215	-170 -285	-240 -355 -260 -380 -275 -495	-340 -455 -380 -495	185	0 -185	290	0 -290	
250// 280// 280// 315//	32	-9 -41						+88 +56	+66 +34	+52 +20	+36 + 4	+16 -16	0 -32	-17 -49	-56 -88	52	+210 +158 +222 +170	+146 + 94 +150 + 98	+108 +56	+86 +34	+72 +20	+56 + 4	+26 -26	0 -52	-17 -69	-56 -108	-110 -162	81	0 -81	-56 -137	-110 -191	-190 -271	130	0 -130	-110 -240	-190 -320	-300 -430 -330 -460	-480 -610 -540 -670	210	0 -210	320	0 -320	
315// 355// 355// 400//	36	-10 -46						+98 +62	+73 +37	+57 +21	+40 + 4	+18 -18	0 -36	-18 -54	-62 -98	57	+247 +190 +265 +208	+165 +108 +171 +114	+119 +62	+94 +37	+78 +21	+61 + 4	+29 -28	0 -57	-18 -75	-62 -119	-125 -182	89	0 -89	-62 -151	-125 -214	-210 -299	140	0 -140	-125 -265	-210 -350	-360 -500 -400 -540	-600 -740 -680 -820	230	0 -230	360	0 -360	
400// 450// 450// 500//	40	-10 -50						+108 +68	+80 +40	+63 +23	+45 + 4	+20 -20	0 -40	-20 -60	-68 -108	63	+295 +232 +315 +252	+189 +126 +195 +132	+131 +68	+103 +40	+86 +23	+68 + 5	+31 -32	0 -63	-20 -83	-68 -131	-135 -198	97	0 -97	-68 -165	-135 -232	-230 -327	155	0 -155	-135 -290	-230 -385	-440 -595 -480 -635	-760 -915 -840 -995	250	0 -250	400	0 -400	

Appendix G Rubber Capacity in Realation to Shaft Speed and Diameter



Appendix H Design Sheet

		Design Sheet		NO.336 INDUSTRIAL ROAD., NANKANG INDUSTRIAL ZONE, NANTOU CITY, 54012 TAIWAN, R.O.C. TEL: 886-49-2255011. FAX: 886-49-2250035 . 886-49-2255800 E-Mail: service@mail.nak.com.tw		
Customer & Division/客戶		膠料物性	NAK規範(ASTM) NAK Standard (ASTM)			
		Material	依客戶規範 Customer Standard			
		品質檢驗	NAK規範(ASTM) NAK Standard(AQL 4.0,C=0)			
Address/地址		Q.C.	依客戶規範 Customer Standard			
Contact/接洽者		設計依據 Design by	戶原樣 Customer Drawing			
			戶原圖 Customer Sample			
			AK standard			
Telephone/電話						
Customer P/N /客戶編號						
Type of Equipment /使用設備						
Application/操作環境						
☐ OEM ☐ Date Required ☐ Aftermarket						
Annual Usage		A. Shaft Dia.: _____ D. Shaft Chamfer & Angle: _____ B. Bore Dia.: _____ E. Bore Chamfer & Angle: _____ C. Max Seal OD Width: _____				
Peak Month Usage						
SHAFT 軸	Horizontal/水平	Material/材質	Finish/粗糙度	Hardness/硬度		
	Vertical/垂直					
BORE 軸孔	Material/材質	Finish/粗糙度	Hardness/硬度	Installation Direction/安裝方向		
						
MOTION	Rotating/旋轉	RPM's /轉速	Direction From Air Side/ 由空氣側觀測			
		Normal	☐ CW/順時針	☐ CCW/逆時針	☐ Bi-rotation/雙向	
作動方式	Max	Shaft Runout(TIR)/偏置量	Misalignment	Frequency of Rotation/旋轉頻率		
				☐ Continuous/連續 ☐ Intermittent/間歇		
		Reciprocating/往復	Stroke Length/行程	Cycles/Min	Special Operating Conditions 特殊操作說明	
		Oscillating/搖擺	Degrees of Arc/角度	Cycles/Min.		
FLUID	Internal/內部	Type/種類	el/高度			

Appendix I Seal Failure Analysis

	SEAL FAILURE ANALYSIS 油封失效分析		NAK	
			NO.	
			PAGE	1

CHECKLIST PART1.(檢查表-1)

 Inspect before seal removal
 失效油封未移除前實際情況檢驗

Seal Application Location 油封使用位置		Equipment Identification 設備名稱	
Batch NO. 產品批號		Seal Type/Size 油封型式/規格	
Hours of Operation 使用時數		Material Case/Rubber 材質 鐵殼/橡膠	
Failure Rate 失效數量		Complaint 改進建議	

Before removal the seal, carefully inspect the seal, the shaft and the immediate area around the leakage site. Follow this list.
在移除失效油封前請仔細依照表格檢查油封、轉軸和當時漏油的部分區域。

 Amount of Leakage
 目前漏油量

☐ Slight Leakage 輕微漏油	☐ Middle Leakage 中等漏油	☐ Heavy Leakage 嚴重漏油
--	--	---

Source of Leakage
 洩漏位置

☐ Between shaft & Seal lip 油封唇部與軸之間	☐ At Retainer Bolt Holes 護圈栓孔
☐ Between O.D. of Seal and Bore 油封外徑部分	☐ At Retainer Gasket 護圈襯墊
☐ Between Wear Sleeve & Shaft 套筒與軸之間	☐ Through Seal on Assembled Seals

 Application Environment
 使用環境

☐ Clean 乾淨	☐ Mud or Dust 泥濘多塵
-----------------------------------	---

Inspect Appearance
 檢查外觀

☐ Nicks on Bore Chamfer 孔徑槽面刻痕	☐ Seal Case Deformed 油封外殼變形
☐ Seal Loose in Bore 油封外徑鬆脫	☐ Shaft to Bore Misalignment 偏軸心
☐ Seal Lip Damage 油封唇部損壞	☐ Seal installed in incorrect Orientation 不當安裝
☐ Seal Cocked in Bore 油封外徑變形	

Rotate shaft Check for Radial & Axial Play
轉動主軸檢查軸向及徑向運轉

☐ Excessive Shaft End Play (amount)_____	
☐ Excessive Shaft Run out (amount)_____	

	SEAL FAILURE ANALYSIS 油封失效分析		NAK	
			NO.	
			PAGE	2

CHECKLIST PART2.(檢查表-2)

Inspect after seal removal 失效油封拆下後檢測

Clean the removed seal in a mild solvent, Do not attempt to scrape away carbon, etc.
將油封用中性溶劑清洗，不要企圖將表面微粒刮除。

Primary Lip Area 主唇部

☐ Normal Wear 一般磨耗	☐ Inverted Lip Due to Poor Installation 唇部翻出	☐ Softening or Swelling 唇部浸潤
☐ No Wear 無磨耗	☐ Nick, scratches or Cuts at Lip Contact Area 唇尖接觸面有刮痕	☐ Coked Oil on Lip 唇部油品焦化
☐ Excessive Wear 嚴重磨耗	☐ Hardened and Cracked Rubber 橡膠硬化及破損	☐ Eccentric Wear 偏心磨耗

Seal outside Diameter 油封外徑

☐ Normal 正常	☐ Severe Axial Scratches 嚴重軸向刮傷
☐ Peeled Rubber 外圍橡膠剝落	☐ Hardened Rubber 橡膠硬化
☐ Cracks or Cuts 傷口破損	

Spring and Spring Groove Area 彈簧部

☐ Spring Normal & In Place 正常	☐ More Than One Spring 不只一條彈簧
☐ Spring Missing 彈簧遺失	☐ Separated Spring 彈簧斷開
☐ Spring Corroded 彈簧鏽蝕	

Make the Following Measurement

Seal Inside Diameter 內徑尺寸		Seal Radial Force 唇壓	
Seal Outside Diameter 外徑尺寸		Spring Diameter 彈簧尺寸	

Primary Lip Wear Band Width 接觸面磨耗寬度 Min. () Max. ()

Inspect the Housing Bore Area 油腔部分檢測

☐ Bore Chamfer Damaged 外徑凹槽損壞	☐ Flaws or Voids in Housing 油腔裂縫
☐ Tool Withdrawal Marks in Bore 孔徑刮痕	☐ Bore Surface Scratched or galled 內面刮傷
☐ Measure Bore Diameter 油腔孔徑()	

Inspect the Shaft in the Seal Contact Area 軸部與油封接觸面檢測

☐ Shaft Surface Corroded 軸面鏽蝕	☐ Seal Wear Path in Wrong Location 磨耗路徑錯誤
☐ Scratched at Lip Contact Area 接觸面磨耗	☐ Discoloration on Shaft Surface 軸面污點
☐ Coked Lubricant 油品焦化	☐ Shaft Chamfer Damaged 軸導角面損傷
☐ Measure Shaft Diameter 軸 徑:()	☐ Measure Wear Path Width 磨耗面寬()

Remove Shaft From the Application for Further Inspection 軸部拆下檢測

Measure Surface Roughness:()RA 軸部表面粗糙度	Measure Depth of Wear Path:() 磨損深度
Measure Shaft Lead:()Deg 軸端導角	Measure Shaft Hardness:()HRC 軸部硬度
Check for Proper Shaft Material 軸部材質	

Appendix J Thermal Expansion Coefficient

	Thermal Expansion Coefficient				NAK
					NO.
					1
Linear Coefficient of Thermal Expansion α (°C) ⁻¹					
M e n t a l	$\alpha \times 10^6$		M e n t a l	$\alpha \times 10^6$	
Steel (1020)	11.7		Aluminum (1100)	23.6	
Steel (1040)	11.3		Aluminum (2040)	22.9	
Steel (4140)	12.3		Cooper (C11000)	17.0	
Steel (43400)	12.3		Cooper (C17200)	0.128	
Stainless (304)	17.2		Titanium	8.6	
Stainless (316)	15.9		Molybdenum	4.9	
Stainless (405)	10.8		Gold	14.2	
Stainless (440A)	10.2		Platinum	9.1	
Iron (G1800)	11.4		Silver	19.7	
Linear Coefficient of Thermal Expansion α (°C) ⁻¹					
Polymer	$\alpha \times 10^4$		Polymer	$\alpha \times 10^4$	
Butadiene-acrylonitrile	235		Polyester	100-180	
Styrene-butadiene	220		Polyetheretherketone	72-85	
Silicone	270		Polyethylene terephthalate	117	
Epoxy	81~117		Polymethyl methacrylate	90-162	
Nylon	144		Polypropylene	146-180	
Phenolic	122		Polystyrene	90-150	
Polybutylene terephthalate	108–171		Polytetrafluoroethylene	126-216	
Polycarbonate	122		Polyvinyl chloride	90-180	

Appendix K Seal Installation Checklist

	Seal Installation Checklist	NAK	
		NO.	
		PAGE	1

Item	Check Points	Yes	No	Remark
1	Is the seal in good condition?			
2	Is the spring properly in place, or has it been displaced during handling?			
3	Have you carefully wiped the seal clean (so as not to damage it)?			
4	Have you made sure there are no nicks, scratches, or spiral grooves on the shaft surface?			
5	Have you pre-lubricated the seal's lip for initial break-in?			
6	Are you installing the seal with the lip facing in the right direction?			
7	Are you installing the seal at a right angle to the centerlines of the bore and shaft?			
8	Have you made sure that bore adhesives do not contaminate the shaft or seal lip?			
9	Have you taken measures to keep the lip from being damaged by passing over splines, threads, or burrs on the shaft?			
10	Have you inspected the bore to make sure there are no burrs or scratches?			
11	Have you ensured proper protection for the seal during painting or cleaning operations?			
12	Is adequate ventilation provided for internal pressure in the seal area?			
13	Have you made sure that assembly components do not rub and that any vents are not clogged?			

Appendix L NAK Material Characteristics

Fluorocarbon rubber

Recipe	material	color	Hardness	Summary
VN601	FKM	Brown	60	V-seal standard
VN611	FKM	Brown	60	For Packing
VN701	FKM	Brown	70	standard
VN702	FKM	Brown	70	For V-seal, good heat tear resistant
VN761	FKM	Brown	70	For Packing
VNC01	FKM	Brown	75	standard
VNC25	FKM	Brown	75	Standard (H16)
VN801	FKM	Brown	80	standard
VN802	FKM	Brown	80	customer required colour (B18)
VN804	FKM	Brown	80	for food application
VN812	FKM	Brown	80	GBLT-S, low temperature resistant -40°C
VN851	FKM	Brown	80	For Packing
VNB01	FKM	Brown	85	Standard
VN901	FKM	Brown	90	Standard
VK601	FKM	black	60	Standard
VK701	FKM	black	70	Standard
VKC01	FKM	black	75	Standard
VK801	FKM	black	80	Standard
VK901	FKM	black	90	Standard
VK961	FKM	black	90	For Packing
VG701	FKM	green	70	Standard
VG801	FKM	green	80	Standard
VG805	FKM	green	80	With PTFE
VGB01	FKM	green	85	Standard
VT801	FKM	grey	80	customer required colour (a09)
VT802	FKM	grey	80	Standard
VB801	FKM	blue	80	Standard

Hydrogenated NBR rubber

Recipe	material	color	Hardness	Summary
HKD01	HNBR	black	65	for transfer mould
HK701	HNBR	black	70	standard
HK702	HNBR	black	70	PEROXIDE curing
HK704	HNBR	black	70	PEROXIDE curing /high performance
HK714	HNBR	black	70	for food application
HK762	HNBR	black	70	PEROXIDE curing/ for transfer mould
HKC02	HNBR	black	75	PEROXIDE curing
HK801	HNBR	black	80	standard
HK804	HNBR	black	80	PEROXIDE curing
HKB02	HNBR	black	85	PEROXIDE curing

Silicone rubber

Recipe	material	color	Hardness	Summary
SR601	VMQ	red	60	standard
SR701	VMQ	red	70	standard
SRC01	VMQ	red	75	standard
SR801	VMQ	red	80	standard
SK701	VMQ	black	70	standard
SK801	VMQ	black	80	standard
SW601	VMQ	white	60	standard
SW602	VMQ	white	60	off-white
SWD01	VMQ	white	65	standard
SW701	VMQ	white	70	standard
SW704	VMQ	white	70	for food application
SW801	VMQ	white	80	standard
SW804	VMQ	white	80	for food application
ST601	VMQ	grey	60	for C.V.J.Boots
ST801	VMQ	grey	80	standard
SG701	VMQ	green	70	standard
SG801	VMQ	green	80	standard
SN801	VMQ	brown	80	standard
SN802	VMQ	brown	80	customer required color (B18)
SB801	VMQ	blue	80	standard
SB802	VMQ	blue	80	customer required color

Polyacrylate rubber

Recipe	material	color	Hardness	Summary
PK601	ACM	black	60	standard
PK701	ACM	black	70	standard
PK702	ACM	black	70	low temperature resistant -25°C
PKC01	ACM	black	75	standard
PKC02	ACM	black	75	low temperature resistant -35°C
PK801	ACM	black	80	standard
PN701	ACM	brown	70	standard
PN702	ACM	brown	70	For VALVE SEAL
PNC01	ACM	brown	75	standard
PB701	ACM	blue	70	standard
PBC01	ACM	blue	75	standard
PG701	ACM	green	70	standard
PG702	ACM	green	70	For VALVE SEAL
PG801	ACM	green	80	standard
PR701	ACM	red	70	standard

Fluorinated silicones rubber

Recipe	material	color	Hardness	Summary
FB751	FVMQ	blue	70	For O-ring
FGC51	FVMQ	green	75	For O-ring

Ethylene propylene rubber

Recipe	material	color	Hardness	Summary
EK462	EPDM	black	40	Packing
EKF61	EPDM	black	45	Packing
EK551	EPDM	black	50	Packing
EK561	EPDM	black	50	Packing
EK601	EPDM	black	60	standard
EK602	EPDM	black	60	Boots
EK651	EPDM	black	60	Packing
EK701	EPDM	black	70	standard
EK752	EPDM	black	70	Packing
EK801	EPDM	black	80	standard
EKC01	EPDM	black	75	Packing
EKC02	EPDM	black	75	Brake Fluid

Chloroprene rubber

Recipe	material	color	Hardness	Summary
CKF01	CR	black	45	standard
CK501	CR	black	50	Boots
CK502	CR	black	50	standard
CK601	CR	black	60	Boots
CK701	CR	black	70	standard
CK751	CR	black	70	Packing

Ethylene/Acrylic rubber

Recipe	material	color	Hardness	Summary
MK501	VAMAC	black	50	standard
MK701	VAMAC	black	70	standard
MKC01	VAMAC	black	75	standard
MN701	VAMAC	brown	70	standard

Carboxylated NBR rubber

Recipe	material	color	Hardness	Summary
XK701	XNBR	black	70	standard
XK801	XNBR	black	80	standard
XK902	XNBR	black	90	Caterprllar
XB801	XNBR	blue	80	standard
XR801	XNBR	red	80	standard

Natural rubber

Recipe	material	color	Hardness	Summary
RK601	NR	black	60	standard
RK603	NR	black	60	standard

Acrylonitrile butadiene rubber

Recipe	material	color	Hardness	Summary
NK451	NBR	black	40	Packing
NK501	NBR	black	50	standard
NK502	NBR	black	50	low friction (with graphite)
NK503	NBR	black	50	low friction (with MoS2)
NKE01	NBR	black	55	standard
NK601	NBR	black	60	standard
NK602	NBR	black	60	low friction (with graphite)
NK603	NBR	black	60	low friction (with MoS2)
NK606	NBR	black	60	high ACN%=40%
NK611	NBR	black	60	Packing
NK612	NBR	black	60	Ozone resistance
NK701	NBR	black	70	standard
NK702	NBR	black	70	low friction (with graphite)
NK703	NBR	black	70	low friction (with MoS2)
NK704	NBR	black	70	for Food grade application
NK705	NBR	black	70	high temperature resistance 125°C
NK706	NBR	black	70	high ACN%=40%
NK711	NBR	black	70	Fuel gas resistance
NK712	NBR	black	70	low temperature resistance
NK713	NBR	black	70	Ozone resistance
NK714	NBR	black	70	light black color
NK720	NBR	black	70	High performance
NK761	NBR	black	70	Packing
NK763	NBR	black	70	WS transfer molding
NKC01	NBR	black	75	standard
NKC02	NBR	black	75	low friction (with graphite 3%)
NKC03	NBR	black	75	PEROXIDE curing
NKC05	NBR	black	75	Caterpillar
NKC06	NBR	black	75	Caterpillar
NKC11	NBR	black	75	for power steering seal product
NKC25	NBR	black	75	for Absorber seal (Front)
NKC27	NBR	black	75	for Absorber seal
NKC61	NBR	black	75	Packing
NK801	NBR	black	80	standard
NK802	NBR	black	80	low friction (with graphite)
NK803	NBR	black	80	low friction (with MoS2)
NK804	NBR	black	80	for Food grade application
NK805	NBR	black	80	high temperature resistance 125°C
NK811	NBR	black	80	high ACN% = 40%

Recipe	material	color	Hardness	Summary
NK812	NBR	black	80	low temperature resistance
NK813	NBR	black	80	low friction (with MoS ₂) high ACN% = 40%
NK815	NBR	black	80	Packing
NK825	NBR	black	80	for Absorber seal
NK826	NBR	black	80	For CAR Absorber seal
NK861	NBR	black	80	Packing
NKB01	NBR	black	85	standard
NKB26	NBR	black	85	for Absorber seal
NK901	NBR	black	90	standard
NK902	NBR	black	90	low friction (with graphite)
NK903	NBR	black	90	low friction (with MoS ₂)
NK911	NBR	black	90	Packing
NKA01	NBR	black	95	standard
NBD01	NBR	blue	65	standard
NB701	NBR	blue	70	standard
NBC01	NBR	blue	75	standard
NB801	NBR	blue	80	standard
NB825	NBR	blue	80	for Absorber seal
NB851	NBR	blue	80	O-ring
NB901	NBR	blue	90	standard
NG701	NBR	green	70	standard
NGC01	NBR	green	75	OEM
NGC04	NBR	green	75	for food grade application
NG801	NBR	green	80	standard
NG803	NBR	green	80	low friction (with MoS ₂)
NGB01	NBR	green	85	standard
NR601	NBR	red	60	standard
NR602	NBR	red	60	standard
NR701	NBR	red	70	standard
NR705	NBR	red	70	high temperature application
NR706	NBR	red	70	high ACN% = 40%
NRC11	NBR	red	75	for power steering seal product
NR801	NBR	red	80	standard
NR811	NBR	red	80	high ACN% = 40%
NW701	NBR	white	70	standard
NW801	NBR	white	80	standard
NW851	NBR	white	80	O-ring
NN701	NBR	brown	70	standard
NNC01	NBR	brown	75	standard
NN801	NBR	brown	80	standard
NT612	NBR	grey	60	Ozone resistance

Recipe	material	color	Hardness	Summary
NT701	NBR	grey	70	standard
NTC01	NBR	grey	75	standard

Appendix M Fluid Compatibility Table

Material Item	NBR	EPDM	FKM	CR	ACM	FVMQ	VMQ
ASTM OIL NO. 1	⊙	△	⊙	⊙	⊙	⊙	⊙
NO. 3	⊙	△	⊙	△	⊙	⊙	⊙
ASTM REFERENCE FUEL A	⊙	△	⊙	○	○	⊙	△
B	⊙	△	⊙	△	△	⊙	△
C	○	△	⊙	△	△	○	△
D	○	△	⊙	△	△	X	△
MILK	⊙	⊙	⊙	⊙	△	⊙	⊙
ACETALDEHYDE	⊙	○	△	⊙	△	△	○
ACETAMIDE	⊙	⊙	⊙	⊙	△	⊙	○
ACETIC ACID, GLACIAL	○	○	△	△	△	△	○
HOT, HIGH PRESS	△	⊙	△	△	△	△	⊙
5%	○	⊙	⊙	⊙	△	○	⊙
ACETONE	△	⊙	△	△	△	△	△
ACETOPHENONE	△	⊙	△	△	△	△	△
ACETYLENE	⊙	⊙	⊙	○	X	X	○
AMMONIA, GAS, COLD	⊙	⊙	△	⊙	△	△	⊙
GAS, HOT	△	○	△	○	△	△	⊙
LIQUID (ANHYDROUS)	○	⊙	△	⊙	△	△	○
AMMONIUM HYDROXIDE, 3 MOLAR	⊙	⊙	○	⊙	△	⊙	⊙
CONCENTRATED	△	⊙	⊙	⊙	△	⊙	⊙
AMYL ACETATE	△	⊙	△	△	△	△	△
ANDEROL ,L-774 (DI-ESTER)	○	△	⊙	△	○	○	△
ANTIFREEZE	⊙	⊙	⊙	⊙	△	X	⊙
ANILINE	△	○	⊙	△	△	⊙	△
ANSUL ETHER 161 OR 181	⊙	⊙	△	△	△	⊙	△
AROCLOR, 1248	⊙	○	⊙	△	△	○	○
1254	△	○	⊙	△	△	○	⊙
1260	⊙	X	⊙	⊙	△	⊙	⊙
ASKAREL	○	△	⊙	△	△	○	△
AUTO. TRANSMISSION FLUID	⊙	△	⊙	○	⊙	X	△
BEER	⊙	⊙	⊙	⊙	△	⊙	⊙
BENZALDEHYDE	△	⊙	△	△	△	△	△
BENZENE	△	△	⊙	△	△	⊙	△

COMPATIBILITY RATING

⊙:SATISFACTORY

○:FAIR(USUALLY OK FOR STATIC SEAL)

⊙ : DOUBTFUL(SOMETIMES OK FOR STATIC SEAL) △:UNSATISFACTORY

X:INSUFFICIENT DATA

Material Item	NBR	EPDM	FKM	CR	ACM	FVMQ	VMQ
BENZINE	⊙	△	⊙	○	⊙	⊙	△
BENZOIC ACID	△	△	⊙	△	△	○	△
BENZOPHENONE	X	○	⊙	X	△	⊙	X
BENZYL ALCOHOL	△	○	⊙	○	△	○	X
BLEACH LIQUOR	△	⊙	⊙	△	△	○	○
BORAX	○	⊙	⊙	△	○	○	○
BORIC ACID	⊙	⊙	⊙	⊙	△	⊙	⊙
BRAKE FLUID (NON-PETROLEUM)	⊙	⊙	△	○	X	△	⊙
BROMINE	△	△	⊙	△	△	○	△
BROMOBENZENE	△	△	⊙	△	△	⊙	△
BUNKER OIL	⊙	△	⊙	△	⊙	⊙	○
BUTANE	⊙	△	⊙	⊙	⊙	⊙	△
BUTTER-ANIMAL FAT	⊙	⊙	⊙	○	⊙	⊙	○
N-BUTYL ACETATE	△	○	△	△	△	△	△
BUTYL ALCOHOL	⊙	○	⊙	⊙	△	⊙	○
BUTYL AMINE OF N-BUTYL AMINE	⊙	△	△	△	△	△	○
BUTYL CARBITOL	△	⊙	⊙	⊙	△	△	△
BUTYL CELLOSOLVE	⊙	○	△	⊙	△	△	X
BUTYRALDEHYDE	△	○	△	△	△	△	△
CARBITOL	○	○	○	○	△	○	○
CARBITOL ACETATE	△	△	⊙	△	△	X	△
CARBON DISULFIDE	△	△	⊙	△	⊙	⊙	X
CARBON TETRACHLORIDE	○	△	⊙	△	△	○	△
CARBONIC ACID	○	⊙	⊙	⊙	⊙	⊙	⊙
CASTOR OIL	⊙	○	⊙	⊙	⊙	⊙	⊙
CELLOSOLVE	△	○	△	△	△	△	△
CHASSIS GREASE	⊙	△	○	○	⊙	X	△
CHLORACETIC ACID	△	○	△	△	△	△	X
CHLORACETONE	△	⊙	⊙	○	X	X	△
CHLORODANE	○	△	⊙	⊙	X	○	△
CHLORINE, DRY	△	△	⊙	△	△	⊙	△
CHLORINE DIOXIDE	△	⊙	⊙	△	△	○	X
CHLORINE DIOXIDE, 8% CL AS NAC10 ₂ IN SOLUTION	△	△	⊙	△	△	○	X
CHLORINE TRIFLUORIDE	△	△	△	△	△	△	△
CHLORINE, WET	⊙	○	⊙	△	△	○	X

COMPATIBILITY RATING

⊙:SATISFACTORY

○:FAIR(USUALLY OK FOR STATIC SEAL)

⊙ : DOUBTFUL(SOMETIMES OK FOR STATIC SEAL) △:UNSATISFACTORY

X:INSUFFICIENT DATA

Material Item	NBR	EPDM	FKM	CR	ACM	FVMQ	VMQ
CHLOROBENZOL	△	△	⊙	△	△	X	△
CHLOROFORM	△	△	⊙	△	△	○	△
CHLOROSULPHONIC ACID	△	△	△	△	△	△	△
CHROME PLATING SOLUTIONS	△	○	⊙	△	△	○	○
CHROMIC ACID, 50%	△	○	⊙	△	△	⊙	⊙
CITRIC ACID	⊙	⊙	⊙	⊙	X	⊙	⊙
COD LIVER OIL	⊙	⊙	⊙	○	⊙	⊙	○
COFFEE	⊙	⊙	⊙	⊙	△	⊙	⊙
CORN OIL	⊙	⊙	⊙	⊙	⊙	⊙	⊙
CREOSOTE, COAL TAR	⊙	△	⊙	○	⊙	⊙	△
CREOSOTE OIL	⊙	△	⊙	○	X	X	○
CREOSYLIC ACID	△	△	⊙	△	△	○	△
CRUDE OIL	○	△	⊙	△	⊙	○	△
CYCLOHEXANE	⊙	△	⊙	⊙	○	⊙	△
CYCLOHEXNOL	⊙	△	⊙	○	X	⊙	△
DECALIN	△	△	⊙	△	X	⊙	△
DENATURED ALCOHOL	⊙	⊙	⊙	⊙	△	⊙	⊙
DIACETONE	△	⊙	△	△	△	△	△
DIBUTYLAMINE	△	△	△	⊙	△	△	⊙
DIBUTYL PHTHALATE	△	○	⊙	△	△	⊙	X
DICHLORO ANILINE	△	△	○	△	△	X	△
DICHLORO BUTANE	○	△	⊙	△	△	○	△
DIESEL OIL	⊙	△	⊙	⊙	⊙	⊙	△
DIETHYLAMINE	○	○	△	○	△	△	○
DIETHYL BENZENE	○	△	⊙	△	X	X	X
DIETHYLENE GLYCOL	⊙	⊙	⊙	⊙	△	⊙	○
DIMETHYL ETHER	△	△	△	⊙	⊙	⊙	△
DIMETHYL FORMAMIDE	△	⊙	△	X	X	X	⊙
DIMETHYL PHTHALATE	△	⊙	⊙	△	△	X	X
DIMETHYL TEREPHTHALATE	△	△	⊙	△	△	X	△
DIOCTYL PHTHALATE	△	○	○	△	△	○	⊙
DIOXANE	△	○	△	△	△	△	△
DIPHENYL	△	△	⊙	△	△	○	△
DOW CORNING-550	⊙	⊙	⊙	⊙	⊙	⊙	⊙
DOW GUARD	⊙	⊙	⊙	⊙	⊙	⊙	⊙
DOWTHERM, A	△	△	⊙	△	△	○	△

COMPATIBILITY RATING

⊙:SATISFACTORY

○:FAIR(USUALLY OK FOR STATIC SEAL)

⊙ : DOUBTFUL(SOMETIMES OF FOR STATIC SEAL) △:UNSATISFACTORY

X:INSUFFICIENT DATA

Material Item	NBR	EPDM	FKM	CR	ACM	FVMQ	VMQ
DOWTHERM, E	△	△	⊙	△	△	○	△
ELCO 28-EP LUBRICANT	⊙	△	⊙	⊙	⊙	⊙	○
EPOXY RESINS	X	⊙	△	⊙	X	X	X
ETHANE	⊙	△	⊙	○	⊙	○	△
ETHANOL	⊙	⊙	⊙	⊙	△	⊙	⊙
ETHANOL AMINE	○	○	△	○	△	△	○
ETHYL ACETATE-ORGANIC ESTER	△	○	△	△	△	△	○
ETHYL BENZENE	△	⊙	⊙	△	△	⊙	△
ETHYL CELLULOSE	○	○	△	○	△	△	○
ETHYL CHLORIDE	⊙	⊙	⊙	⊙	⊙	⊙	△
ETHYL ETHER	⊙	⊙	△	△	△	⊙	△
ETHYL FORMATE	△	○	⊙	○	X	⊙	X
ETHYL HEXANOL	⊙	⊙	⊙	⊙	△	⊙	○
ETHYL MERCAPTAN	△	⊙	△	○	X	X	⊙
ETHYLENE CHLORIDE	△	△	⊙	△	△	X	△
ETHYLENE OXIDE	△	⊙	△	△	△	X	△
FORMALDEHYDE	⊙	○	△	⊙	△	△	○
FORMIC ACID	○	⊙	△	⊙	X	X	○
FREON 12	⊙	○	⊙	⊙	X	△	△
FUEL OIL	⊙	△	⊙	○	⊙	⊙	△
FURAN (FURFURAN)	△	X	X	△	△	X	X
FURFURAL	△	○	△	△	△	X	△
FURFURYL ALCOHOL	△	○	X	△	△	△	△
FYRQUEL A60	△	○	△	△	△	△	⊙
GALLIC ACID	○	○	⊙	○	△	⊙	X
GASOLINE	⊙	△	⊙	△	△	⊙	△
GELATIN	⊙	⊙	⊙	⊙	△	⊙	⊙
GLUCOSE	⊙	⊙	⊙	⊙	X	⊙	⊙
GLYCERINE-GLYCEROL	⊙	⊙	⊙	⊙	△	⊙	⊙
N-HEPTANE	⊙	△	⊙	○	⊙	⊙	△
N-HEXALDEHYDE	△	⊙	△	⊙	X	△	○
N-HEXANE	⊙	△	⊙	○	⊙	⊙	△
HEXANOL	⊙	○	⊙	⊙	△	X	⊙
HOME HEATING OIL	⊙	△	⊙	○	⊙	X	⊙
HYDRAZINE	○	⊙	X	○	X	X	○
HYDROCYANIC ACID	○	⊙	⊙	○	△	○	⊙

COMPATIBILITY RATING

⊙:SATISFACTORY

○:FAIR(USUALLY OK FOR STATIC SEAL)

⊙ : DOUBTFUL(SOMETIMES OF FOR STATIC SEAL) △:UNSATISFACTORY

X:INSUFFICIENT DATA

Material Item	NBR	EPDM	FKM	CR	ACM	FVMQ	VMQ
HYDROCHLORIC ACID, 3 MOLAR	⦿	⊗	⊗	⦿	○	○	△
CONCENTRATED	△	⦿	⊗	△	△	⦿	△
HYDROGEN PEROXIDE	○	⊗	⊗	⊗	△	⊗	⊗
90%	△	⦿	⊗	△	△	○	○
HYDROGEN SULFIDE DRY, COLD	⊗	⊗	△	⊗	△	⦿	⦿
DRY HOT	△	⊗	△	○	△	⦿	⦿
WET, COLD	△	⊗	△	⊗	△	⦿	⦿
WET, HOT	△	⊗	△	○	△	⦿	⦿
HYDROQUINONE	⦿	△	○	△	△	○	X
HYPOID GEAR LUBE	⊗	△	⊗	○	⊗	X	○
IODINE	○	○	⊗	△	X	⊗	X
ISOCYANATE	X	X	⊗	X	X	X	X
ISO OCTANE	⊗	△	⊗	○	⊗	⊗	△
ISOPHORONE (KETONE)	△	⊗	△	△	△	△	△
ISOPAR	⊗	△	⊗	⊗	⊗	X	△
ISOPROPANOL	○	⊗	⊗	○	△	○	⊗
ISOPROPYL ACETATE	△	○	△	△	△	△	△
JP-4 (MIL-J-5624)	⊗	△	⊗	△	○	○	△
JP-5 (MIL-J-5624)	⊗	△	⊗	△	○	○	△
KEROSINE	⊗	△	⊗	○	⊗	⊗	△
LACTIC ACID, COLD	⊗	⊗	⊗	⊗	△	⊗	X
HOT	△	△	⊗	△	△	○	X
LACQUERS	△	△	△	△	△	△	△
LARD, ANIMAL FAT	⊗	○	⊗	○	⊗	⊗	○
LINOLEIC ACID	○	△	○	○	X	X	○
LINSEED OIL	⊗	⦿	⊗	⦿	⊗	⊗	⊗
LYE SOLUTIONS	○	⊗	○	○	△	○	○
MALATHION	○	△	⊗	X	X	○	△
MALEIC ACID	△	△	⊗	△	△	X	X
MERCURY	⊗	⊗	⊗	⊗	X	X	X
METER-CRESOL	△	△	⊗	⊗	△	X	△
METHANE	⊗	△	⊗	○	⊗	○	△
METHANOL	⊗	⊗	△	⊗	△	⊗	⊗
METHYL ACETATE	△	○	△	○	△	△	△
METHYLACRYLIC ACID	△	○	⦿	○	△	△	△
COMPATIBILITY RATING ⊗:SATISFACTORY ○:FAIR(USUALLY OK FOR STATIC SEAL) ⦿: DOUBTFUL(SOMETIMES OK FOR STATIC SEAL) △:UNSATISFACTORY X:INSUFFICIENT DATA							

Material Item	NBR	EPDM	FKM	CR	ACM	FVMQ	VMQ
METHYL CELLOSOLVE	⊙	○	△	⊙	△	△	△
METHYL CHLORIDE	△	⊙	⊗	△	△	○	△
METHYL ETHYL KETONE (MEK)	△	⊗	△	△	△	△	△
METHYL MERCAPTAN	X	⊗	X	X	X	X	X
MINERAL OILS	⊗	⊙	⊗	○	⊗	⊗	○
MINERAL SPIRITS	⊗	△	⊗	△	⊗	X	△
MONOVINYL ACETYLENE	⊗	⊗	⊗	○	X	X	○
MUSTARD	X	⊗	⊗	X	X	X	⊗
NAPHTHA	○	△	⊗	△	○	○	△
NAPHTHALENE	△	△	⊗	△	X	⊗	△
NAPHTHENIC ACID	○	△	⊗	△	X	⊗	△
NATURAL GAS	⊗	△	⊗	⊗	○	⊙	⊗
NEATSFOOT OIL	⊗	○	⊗	△	⊗	⊗	○
NITRIC ACID							
3 MOLAR	△	○	⊗	△	△	⊙	△
CONCENTRATED	△	△	⊗	△	△	⊙	△
RED FUMING (RFNA)	△	△	○	△	△	△	△
INHIBITED RED FUMING (IRENA)	△	△	○	△	△	△	△
NITROBENZENE	△	△	○	△	△	△	△
NITROPROPANE	△	○	△	△	△	△	△
N-OCTANE	○	△	⊗	△	△	○	△
OCTANOL	⊗	⊗	⊗	⊗	△	X	⊗
OLEIC ACID	⊙	△	○	△	△	X	△
OLEUM (FUMING SULFURIC ACID)	△	△	⊗	△	△	X	△
ORONITE 8200	○	△	⊗	⊗	X	⊗	△
OXALIC ACID	○	⊗	⊗	○	X	⊗	○
PEANUT OIL	⊗	⊙	⊗	⊙	⊗	⊗	⊗
PENTANE, 2 METHYL	⊗	△	⊗	○	⊗	⊙	△
2-4, DIMETHYL	⊗	△	⊗	○	⊗	⊙	△
3-METHYL	⊗	△	⊗	○	⊗	⊙	△
PERCHLOROETHYLENE	○	△	⊗	△	△	○	△
PETROLEUM ETHER	△	△	⊗	△	△	X	△
PHENOL	△	△	⊗	△	△	○	△
PHENYLHYDRAZINE	△	△	⊗	△	△	X	X
PINE OIL	⊗	△	⊗	△	X	⊗	△
POTASSIUM HYDROXIDE, 50%	○	⊗	△	○	△	⊙	⊙
COMPATIBILITY RATING ⊗:SATISFACTORY ○:FAIR(USUALLY OK FOR STATIC SEAL) ⊙: DOUBTFUL(SOMETIMES OF FOR STATIC SEAL) △:UNSATISFACTORY X:INSUFFICIENT DATA							

Material Item	NBR	EPDM	FKM	CR	ACM	FVMQ	VMQ
PHOSPHORIC ACID							
3 Molar	△	⊙	⊙	⊙	X	○	○
CONCENTRATED	△	○	⊙	△	X	○	⊙
PROPANE	⊙	△	⊙	○	⊙	○	△
PROPANOL	⊙	⊙	⊙	⊙	△	X	⊙
PROPYL ACETATE	△	○	△	△	△	△	△
PYDRAUL 10E, 29ELT	△	⊙	⊙	△	△	△	△
30E, 50E, 65E, 90E	△	⊙	⊙	△	△	⊙	⊙
115E	△	⊙	⊙	△	△	⊙	△
230E, 312C, 540C	△	△	⊙	△	△	△	△
PYRANOL	⊙	△	⊙	⊙	⊙	X	△
PYRIDINE	△	△	△	△	△	X	△
RAPESEED OIL	○	⊙	⊙	○	○	⊙	△
SAE10W30	⊙	△	⊙	○	⊙	X	⊙
SEA (SALT) WATER	⊙	⊙	X	○	△	⊙	⊙
SILICONE GREASES	⊙	⊙	⊙	⊙	⊙	⊙	⊙
SILVER NITRATE	○	⊙	⊙	⊙	⊙	⊙	⊙
SKELLY, SOLVENT B, C, E	⊙	△	⊙	△	X	⊙	X
SKYDROL	△	⊙	⊙	△	△	X	△
SKYDROL 500	△	⊙	△	△	△	⊙	⊙
SODIUM HYDROXIDE, 3 Molar	○	⊙	○	○	△	○	⊙
SOVASOL NO. 1,2 AND 3	⊙	△	⊙	○	○	⊙	△
NO. 73 AND 74	○	△	⊙	○	○	⊙	△
SOYBEAN OIL	⊙	⊙	⊙	⊙	⊙	⊙	⊙
STEARIC ACID	○	○	X	○	X	X	○
STODDARD SOLVENT	⊙	△	⊙	○	⊙	⊙	△
SUCROSE SOLUTIONS	⊙	⊙	⊙	○	△	⊙	⊙
SULFURIC ACID							
3 Molar	△	○	⊙	⊙	○	⊙	△
CONCENTRATED	△	△	⊙	△	△	△	△
TALL OIL	⊙	△	⊙	○	⊙	X	X
TANNIC ACID	⊙	⊙	⊙	○	△	X	○
10%	⊙	⊙	⊙	⊙	△	⊙	○
TAR, BITUMINOUS	○	△	⊙	⊙	△	⊙	○
TARTARIC ACID	⊙	○	⊙	○	X	⊙	⊙
TETRACHOROETHANE	△	△	⊙	△	△	○	X
COMPATIBILITY RATING ⊙:SATISFACTORY ○:FAIR(USUALLY OK FOR STATIC SEAL) ⊙: DOUBTFUL(SOMETIMES OF FOR STATIC SEAL) △:UNSATISFACTORY X:INSUFFICIENT DATA							

[illegible]

COMPATIBILITY RATING

<Engine Oil Guide>

- ⊙ API's Engine Oil Service Category(for automotive gasoline engine)

Gasoline Engines		
Category	Status	Service
SL	Current	For all automotive engines presently in use. Introduced July 1, 2001. SL oils are designed to provide better high-temperature deposit control and lower oil consumption. Some of these oils may also meet the latest ILSAC specification and/or qualify as Energy Conserving.
SJ	Current	For 2001 and older automotive engines.
SH	Obsolete	For 1996 and older engines. Valid when preceded by current C categories.
SG	Obsolete	For 1993 and older engines.
SF	Obsolete	For 1988 and older engines.
SE	Obsolete	For 1979 and older engines.
SD	Obsolete	For 1971 and older engines.
SC	Obsolete	For 1967 and older engines.
SB	Obsolete	For older engines. Use only when specifically recommended by the manufacturer.
SA	Obsolete	For older engines; no performance requirement. Use only when specifically recommended by the manufacturer.

Note: API intentionally omitted "SI" and "SK" from the sequence of categories. For more information about API's Engine Oil Program, call the American Petroleum Institute at 202-682-8516 or visit our website at www.api.org/eolcs. This guide is provided as a service to the motoring public courtesy of the American Petroleum Institute.

- ⊙ SAE Viscosity Grades for Engine Oils(SAE J300)

SAE viscosity grade	Maximum cranking viscosity (cP) at given temperature (°C)	Maximum pumping viscosity (cP) at given temperature	Minimum viscosity (cSt) at 100°C	Maximum viscosity (cSt) at 100°C
0W	3250 at -30	30000 at -35	3.8	
5W	3500 at -25	30000 at -30	3.8	
10W	3500 at -20	30000 at -25	4.1	
15W	3500 at -15	30000 at -20	5.6	
20W	4500 at -10	30000 at -15	5.6	
25W	6000 at -5	30000 at -10	9.3	
20			5.6	<9.3
30			9.3	<12.5
40			12.5	<16.3
50			16.3	<21.9
60			21.9	<26.1

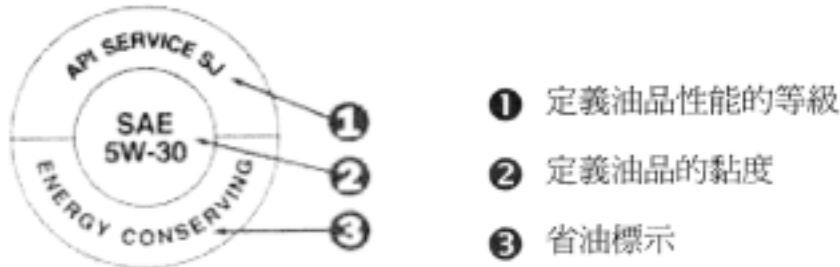
◉ Additives for Lubricating Oils

Type	Purpose
Antifoamants	Reduce foams in crankcase
Oxidation inhibitors	Prevent or control oxidation of oil, formation of varnish, sludge, and corrosive compounds; limit viscosity increase
Rust inhibitors	Prevent the formation of rust on metal surfaces by formation of surface film or neutralization of acids
Dispersants, detergents	Keep sludge, carbon, and other deposits suspended in the oil

⊙ The API Certification Mark

The API Certification Mark "Starburst" is designed to identify engine oils recommended for a specific application (such as gasoline service). An oil may be licensed to display the Starburst only if the oil satisfies the most current requirements of the International Lubricant Standardization and Approval Committee (ILSAC) minimum performance standard for this application (currently GF-3 for passenger cars). Many automobile manufacturers recommend oils that carry the API Certification Mark.

<Gear Oil>



1. **Display one of the current API service categories**
2. **Display viscosity grade.**
3. **Display the energy conservation designation of the oil.**

⊙ API Service Classification of Gear Oils

Classification	Type	Typical application
GL-1	Straight mineral oil	Automotive manual transmission (tractors and trucks), industrial gear boxes
GL-2	Usually contains fatty materials	Worm gear drives, industrial gear boxes
GL-3	Contains mild EP additives	Manual transmission and spiral bevel final drives
GL-4	Equivalent to obsolete MIL-L-2105 specification usually satisfied by 50% GL-5 additive level	Manual transmission and spiral bevel and hypoid gears where moderate service prevails
GL-5	Equivalent to obsolete MIL-L-2105D specification; primary field service recommendation of most passenger car and truck builders worldwide	Used for moderate and severe service in hypoid and all other types of gears; also may be used in manual transmission
GL-6	Same performance as Ford M2C105A/M2C154A	Typically recommended in service conditions where more protection from scoring is desired, e.g., passenger car hypoid axles with high offset

⊙ Axle and Manual Transmission Lubricant Viscosity Classification

SAE Viscosity	Max temperature for viscosity	Viscosity at 100°C (cSt)	
		Min.	Max.
Grade	150000 cP (°C)		
70W	-40	4.1	—
80W	-26	7.0	—
85W	-12	11.0	—
90W	—	13.5	< 24.0
140	—	24.0	< 41.0
250	—	41.0	—
80W90	-26	13.5	< 24.0
85W140	-12	24.0	< 41.0



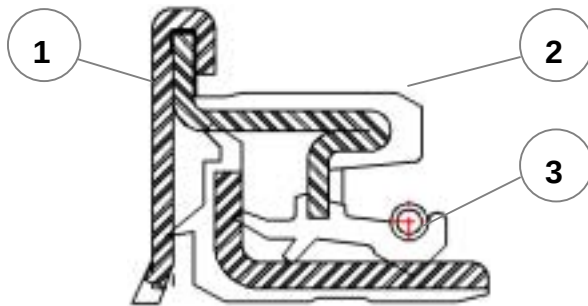
MAO SHUN
ENTERPRISE GROUP

NAK

Product Information

NAK Type : AP SEAL

Description : Unitized lip and sleeve seal



6.	
5.	
4.	
3.	Sleeve
2.	Sealing element
1.	Faceplate
NO.	Part list

1. Features

Unitized lip and sleeve seal with rubber covered O.D. combined with sleeve, spring-loaded sealing lip and additional several excluding dust lips.

2. Material

Rubber : NBR(HNBR/FKM)

70 Shore A

Case : Steel SAE 1008

Spring : Steel SAE 1070

3. Application

For use in severe muddy applications including construction equipment, agricultural machinery, track driven vehicles, and other applications where oil or grease must be held in contact with rotary shaft and bearing assemblies. The flange will allow easy installation or replacement and restrict the installation depth into the housing.

4. Operating conditions

Media : Mineral oils,
synthetic oils

Temperature : -40°C to +100°C

Surface Speed : up to 3.5 m/s

5. Parts information

5.1 Faceplate

Faceplate contacts the surrounding contamination directly. It can prevent contamination entering the sealing element that loses sealing function. It can also prevent the lubricant leaking outside that loses lubrication that may cause the temperature raise greatly inside the sealing element.



MAO SHUN
ENTERPRISE GROUP

NAK

Product Information

NAK Type : AP SEAL

Description : Unitized lip and sleeve seal

5.2 Sealing element

Sealing element can seal the inside lubricant and prevent the contamination entering the seal. The sealing element can be deigned depend on different applications e.g. high pressure, high speed, axial movement application etc.

5.3 Sleeve

If the shaft surface roughness is too high ($>1.0 \text{ Ra}$) or defects on the shaft surface, it is suggested to use a sleeve to prevent shaft wearing.

6. Advantage of AP seal

1. Sealing function is good, and it is widely used in many kinds of machinery.
2. It can prevent many kinds of cotanimiment entering inside.
3. Good wear and corrosion resistance, and the price is low.
4. Easy to install and remove.
5. It can prevent the shaft wearing.



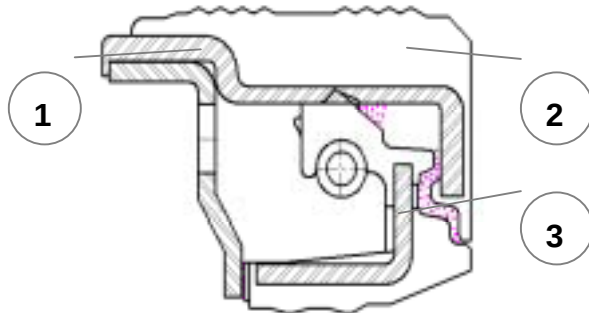
MAO SHUN
ENTERPRISE GROUP

NAK

Product Information

NAK Type : ST SEAL

Description : Hub seal



6.	
5.	
4.	
3.	Outside Seal
2.	Sealing element
1.	Faceplate
NO.	Part list

1. Features

ST seal is one kind of rotary seal, and it is combined with many components. The O.D. cover G type rubber design improve the sealing function. The sealing element design for the high run-out application. The seal is widely used muddy application.



2. Material

Rubber : NBR 70 Shore A
NBR 80 Shore A
Case : Steel SAE1008
Spring : Steel SAE1070



3. Application

The ST seal is widely used in the hub of trunk and bus etc. The seal can prevent mud entering into the seal and hub effectively. So that it can protect the hub and prolong the shaft life.

4. Operating conditions

Media : Mineral oils,
synthetic oils
Temperature : -40°C to +100°C
Surface Speed : 2040F.P.M. Max.



MAO SHUN
ENTERPRISE GROUP

NAK

Product Information

NAK Type : ST SEAL

Description : Hub seal

4. Operating conditions

Media : Mineral oils,
synthetic oils
Temperature : -40°C to +100°C
Surface Speed : 2040F.P.M. Max.

5. Parts information

- 5.1 : The O.D. cover G type rubber design ease installing into the housing.
- 5.2 : The dust lip use tortuous design that can reduce heat generation and prevent mud entering into the seal effectively.
- 5.3: The I.D. cover G type rubber design ease installing into the shaft.
- 5.4 : The new type of hydrodynamic aid desing increase pumping rate that reduce lip temperature raise, rubber wear and increase sealing function.
- 5.5 : Spring retaining lip have a perturbation design that increase heat convection.
- 5.6: The sealing element uses nanorubber that increase wear and heat resistance so that the seal can prolong the life.
- 5.7: The ST seal uses the high performance grease that can reduce temperature rise.

- 5.8: The seal outside is a flat surface so that the dirt and mud won't stick on the seal.
- 5.9: The case with a hole offers good heat transferring and lubrication.

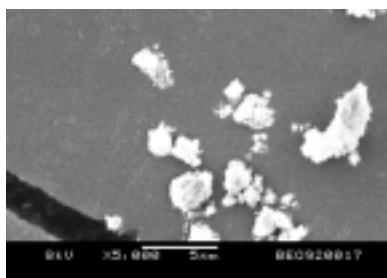
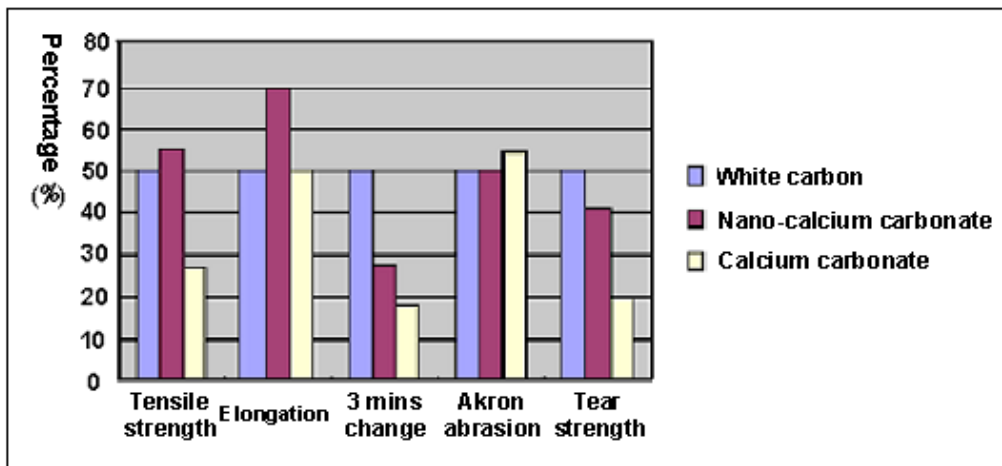
Nano Rubber Technology

Making product smaller lighter, thinner, shorter and smaller has been a global trend in the 21st century. How to make a product smaller, more portable, and easier to manipulate and maneuver has been on the minds of innovators. In recent years, small has taken on a whole new dimension. Many developers are now thinking all the way down to one-billionth of a meter the nanometer. Nano technology is the important base for many scientific fields like information science and life science; meanwhile it can also be formed into a huge industry itself. Nano technology can be used to restore the environments being ruined by human being, make new products with superior performance, highly integrated, lower lose and less resource consumption. It can be widely used in industry, agriculture, electronics, chemical engineering, textile, communication, environmental protection, people's daily life as well as pharmacy.

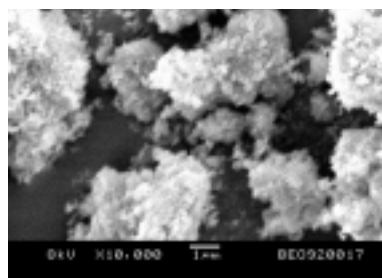
As a kind of new material, nano material will certainly cause the changes in industrial structure and create substantial riches for the new economy. For nano rubber application, it is very important to consider the dispersion of nano-sized particles in polymer base. Two dispersion methods are studied in our R&D team:

(1) Phase mixing

- Utilizing high dispersion nano-sized particle to mix with rubber, masticating by roller or internal mixer.
- Easy operation, easy to industrilization.
- The following figure shows Physical properties of inorganic nano-sized filler reinforced NBR:



(a)



(b)

Fig 1. The SEM image of Nano Calcium Carbonate,

Enlarge factor (a) × 5000 (b) × 10000

(2) sol-gel

- Raw gum is immersed in the precursor of nano-sized particle. Sol-gel reaction is carryout under fixed condition. After reaction, the nano composite material is obtained by vacuum drying.
- Different to the high temperature of traditional rubber mixing process, the mild reaction condition of sol-gel reaction is possible to produce the high performance rubber compound.
- There are three steps including hydrolysis、condensation、polymerization

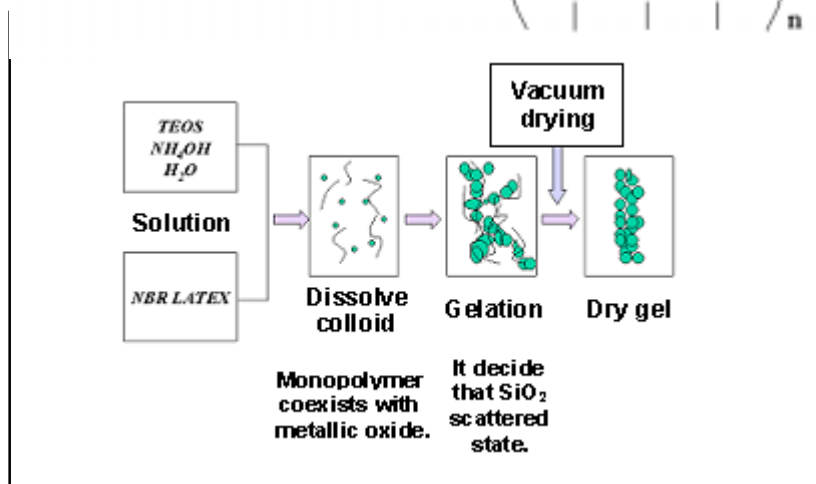
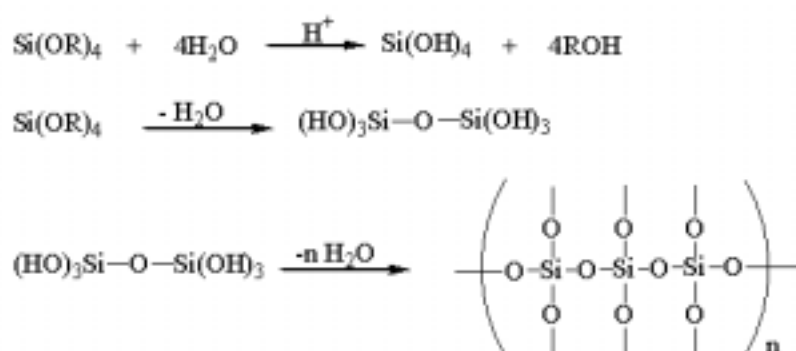


Fig 2. The process of sol-gel reaction to reinforce NBR Elastomer

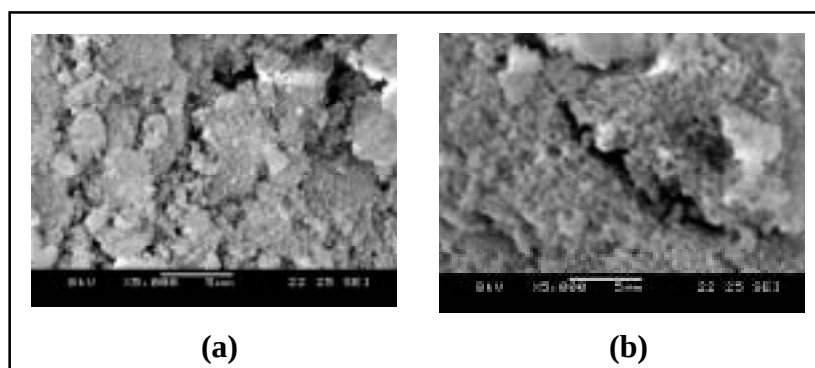


Fig. 3. SEM image of (a)Hi-Sil 255; (b) sol-gel SiO₂

It is being seen that nano technology has been applied in some fields and is marching towards industrialization. The nano rubber material has the benefit of high physical properties including:

- (a). Increase the tensile strength、Elongation、Tear strength and hardness.
- (b). The cross linking of nano sized particle, decrease the resilience of rubber composite.
- (c). The filler disperse in polymer base is nano size. Due to the smaller the particle the bigger the surface area, the ability of reinforcement is much increased.

Through the nano technology and the vertical integration of rubber industry, we hope to innovate the rubber material to brave new properties and to increase the value of our product.