Friction Estimation

Friction, either break-out, running, or both, can become troublesome in some applications. At any given time there are anomalies and difficulties in the prediction of friction. These are accentuated if one of the surfaces involved is deformable as in O-ring piston or shaft seals. An understanding of the principles may prove helpful in the solution of specific problems.

BREAK-OUT FRICTION In addition to the usual causes of friction, such as the hardness of the rubber, the type of surface, the surface finish, the squeeze on the O-ring, the amount and type of Iubrication, and the fluid pressure and temperature, the amount of break-out friction which an O-ring will develop depends on the length of time the surfaces of the metal and the rubber have been in contact.

See Figure A6-3 and Figure A6-4.

TABLE A6-1 FRICTION FACTORS (IN ORDER OF IMPORTANCE)

TO INCREASE FRICTION	FACTOR	TO DECREASE FRICTION
Increase	Unit Load (squeeze)	Decrease
Increase RMS	Surface Finish (metal)	Decrease RMS
Increase	Durometer	Decrease
Decrease	Speed of Motion	Increase
Increase	Cross Section of O-Ring	Decrease
Increase	Pressure	Decrease
Omit	Lubrication	Use
Decrease	Temperature	Increase
Decrease	Groove Width	Increase
Increase	Diameter of Bore or Rod	Decrease
Decrease	Surface Finish (O-Ring)	Increase
Stretch O-ring	Joule Effect*	Compress O-Ring
Lower Durometer of O-Ring	Coefficient of Friction#	Increase Durometer

* Refer to rotary seals.
# A minor factor and should be ignored in design work other than for ultra high speeds

The theory has been proposed and generally accepted that the increase of friction on standing is caused by the rubber O-ring flowing into the microfine grooves or surface irregularities of the mating part. As a general rule for a 70 durometer rubber against an 8 micro-inch surface, the maximum break-out friction that will develop in a system is 3 times the running friction. This ratio can be reduced by the use of a softer rubber. Table A6-1 shows some of the factors which may be used to adjust friction.

Coefficient of friction has little bearing on lubricated rubber's break-out and running friction. The other variables listed are much more important in the practical solution to problems.

RUNNING FRICTION High running friction may cause difficulty by wearing soft metal parts. Metals such as copper brass, aluminum can be rapidly worn away by a moving O-ring. This is especially true if high pressures are involved. If unexplained leakage occurs with these or other soft metals, it is good practice to check the metal dimensions for signs of wear.

The following formulas may be used for estimating the running friction of O-rings.

PISTON GROOVE	ROD GROOVE
Fc = fc x Lp	FC = fc x Lr
FH = fh x Ap	FH = fh x Ar
F = Fc + FH	F = Fc + FH

Ap = Projected area of seal for piston groove applications.
Ar = Projected area of seal for rod groove applications.

F = Total seal friction in pounds.
Fc = Total friction due to seal compression.
FH = Total friction due to hydraulic pressure on the seal.
fc = Friction due to O-ring compression obtained from Figure A6-5.
fh = Friction due to fluid pressure obtained from Figure A6-6.
Lp = Length of seal rubbing surface in inches for piston groove applications.
Lr = Length of seal rubbing surface in inches for rod groove applications.

Example:

Parker 2-214 rubbing against OD of O-ring at 1500 psi, 10% compression, 70 durometer:

Fc = 0.7 x 3.93 = 2.75
FH = 48 x 0.44 = 20.90
F = Fc + FH = 23.65 pounds

Data for the coefficients (fc and fh) are given in Figure A6-5 and Figure A6-6. Projected areas and lengths of rubbing surface are given in Table A6-2.

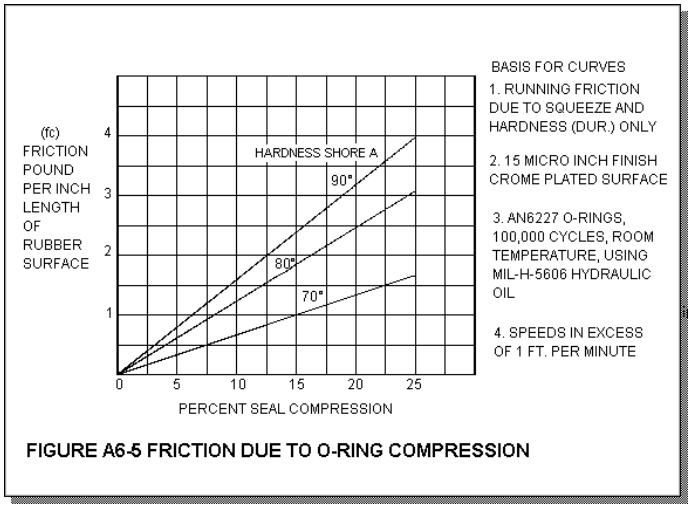

FIGURE A6-5 FRICTION DUE TO O-RING COMPRESSION

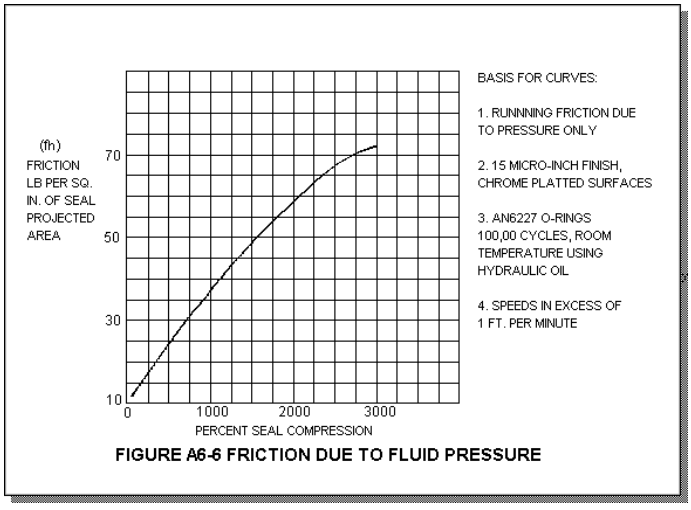

FIGURE A6-6 FRICTION DUE TO FLUID PRESSURE

TABLE A6-2 PROJECTED AREAS AND LENGTHS OF RUBBING SURFACE FOR O-RINGS

	PISTON GROOVE		ROD GROOVE	
O-RING SIZE PARKER NO	Ap SQ. IN.	Lp IN.	A SQ. IN.	Lr IN.
2-006	.03	.79	.03	.39
2-007	.04	.89	.04	.49
2-008	.05	.98	.04	.58
2-009	.05	1.08	.05	.68
2-010	.06	1.18	.05	.78
2-011	.07	1.38	.07	.98
2-012	.08	1.57	.08	1.17
2-013	.09	1.77	.09	1.37
2-014	.10	1.97	.10	1.57
2-015	.11	2.16	.11	1.76
2-016	.12	2.36	.12	1.96
2-017	.14	256	.13	2.16
2-018	.15	2.75	.14	2.35
2-019	.16	2.95	.16	2.55
2-020	.17	3.14	.17	2.75
2-021	.18	3.34	.18	2.94
2-022	.19	3.54	.19	3.14
2-023	.20	3.73	.20	3.33
2-024	.21	3.93	.21	3.53
2-025	.22	4.13	.22	3.73
2-026	.24	4.32	.23	3.92
2-027	.25	4.52	.24	4.12
2-028	.26	4.72	.26	4.32
2-110	.13	1.77	.13	1.17
2-111	.15	1.97	.15	1.37
2-112	.17	2.16	.17	1.57
2-113	.19	2.36	.18	1.76
2-114	.20	2.56	.20	1.96
2-117	.26	3.14	.25	2.55
2-118	.28	3.34	.27	2.75
2-121	.33	3.93	.32	3.33
2-122	.35	4.13	.34	3.53
2-123	.36	4.32	.36	3.73
2-124	.38	4.52	.38	3.92
2-125	.40	4.72	.40	4.12
2-126	.42	4.91	.41	4.32
2-127	.43	5.11	.43	4.51
2-128	.45	5.30	.45	4.71
2-129	.47	5.50	.47	4.90
2-130	.49	5.70	.48	5.10
2-131	.50	5.89	.50	5.30
2-132	.52	6.09	.52	5.49
2-133	.54	6.29	.54	5.69
2-134	.56	648	.55	5.59
2-135	.58	6.68	.57	6.08
2-136	.59	6.88	.59	6.28
2-137	.61	7.07	.61	6.47
2-138	.63	7.27	.63	6.67
2-139	.65	7.46	.64	6.87
2-140	.66	7.66	.66	7.07

	PISTON GROOVE		ROD GROOVE	
O-RING SIZE PARKER NO	Ap SQ. IN.	Lp IN.	A SQ. IN.	Lr IN.
2-141	.68	7.86	.68	7.26
2-142	.70	8.05	.70	7.46
2-143	.72	8.25	.71	7.65
2-144	.73	8.45	.73	7.85
2-145	.75	8.64	.75	8.05
2-146	.77	8.84	.77	8.24
2-147	.79	9.04	.78	8.44
2-148	.80	9.23	.80	8.64
2-149	.82	9.43	.82	8.83
2-210	.34	3.15	.34	2.35
2-211	.36	3.34	.36	2.54
2-212	.39	3.54	.38	2.74
2-213	.41	3.74	.41	2.94
2-214	.44	3.93	.43	3.14
2-215	.46	4.13	.46	3.33
2-216	.48	4.33	.48	3.53
2-217	.51	4.52	.50	3.72
2-218	.53	4.72	.53	3.92
2-219	.56	4.91	.55	4.12
2-220	.63	5.50	.63	4.71
2-325	1.00	5.90	.99	4.71
2-326	1.07	6.07	1.21	5.88
2-329	1 29	7.47	1.29	6.28
2-330	1.36	7.86	1.36	6.67
2-331	1.44	8.25	1.43	7.06
2-332	1.51	8.65	1.51	7.45
2-333	1.58	9.04	1.58	7.85
2-334	1.66	9.43	1.65	8.24
2-335	1.73	9.82	1.73	8.63
2-336	1.81	10.22	1.80	9.03
2-337	1.88	10.61	1.87	9.42
2-338	1.95	11.00	1.95	9.81
2-339	2.03	11 40	2.02	10.20
2-340	2.10	11.79	2.10	10.59
2-341	2.17	12.18	2.17	10.99
2-342	2.25	12.58	2.24	11.38
2-343	2.32	12.97	2.31	11.77
2-344	2.39	13.36	2.39	12.16
2-345	2.47	13.75	2.46	12.56
2-346	2.54	14.15	2.54	12.95
2-347	2.62	14.54	2.61	13.34
2-348	2.69	14.93	2.68	13.73
2-349	2.76	15.32	2.76	14.13
2-425	3.59	15.72	3.57	14.13
2-426	3.69	16.11	3.66	14.52
2-427	3.78	16.51	3.76	14.91
2-428	3.87	16.90	3.85	15.31
2-429	3.97	17.29	3.95	15.70
2-430	4.06	17.68	4.04	16.09
2-431	4.16	18.08	4.14	16.48
2-432	4.25	18.47	4.23	16.88
2-433	4.35	18.86	4.32	17.27

	PISTON GROOVE		ROD GROOVE	
O-RING SIZE PARKER NO	Ap SQ. IN.	Lp IN.	A SQ. IN.	Lr IN.
2-434	4.44	19.25	4.42	17.66
2-435	4.53	19.65	4.51	18.05
2-436	4.63	20.04	4.61	18.45
2-437	4.72	20.43	4.70	18.84
2-438	4.91	21.22	4.89	19.63
2-439	5.10	22.00	5.08	20.41
2-440	5.29	22.79	5.27	21.20
2-441	5.48	23.57	5.46	21.98
2-442	5.67	24.36	5.64	22.77
2-443	5.85	25.15	5.83	23.55
2-444	6.04	25.93	6.02	24.34
2-445	6.23	26.72	6.21	25.12
2-446	6.61	28.29	6.59	26.69
2-447	6.98	29.86	6.96	28.26
2-448	7.36	31.43	7.34	29.84
2-449	7.74	33.00	7.72	31.41
2-450	8.12	34.57	8.09	32.98
2-451	8.49	36.14	8.47	34.55
2-452	8.87	37.71	8.85	36.12
2-453	9.25	39.28	9.22	37.69
2-454	9.62	40.85	9.60	39.26
2-455	10.00	42.42	9.98	40.83
2-456	10.38	43.99	10.36	42.40
2-457	10.75	45.57	10.73	43.97
2-458	11.13	47.14	11.11	45.54
2-459	11.51	48.71	11.49	47.11
2-460	11.89	50.28	11.86	48.69