My Calculation

Engineering Calculation Sheet

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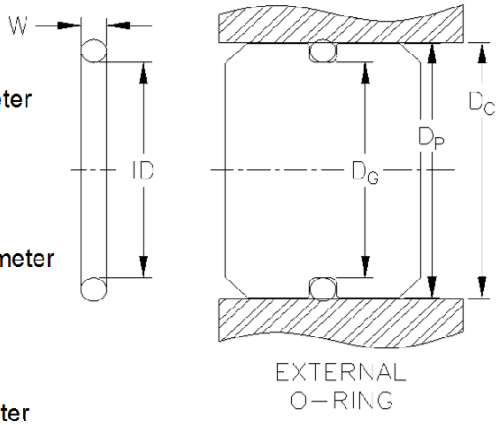
Calculation no 005

Subject External / Internal O-Ring Friction Load Estimation **Prepared By** YUDHI **Date** 24-Mar-15

This calculation was conducted in order to estimate static friction load of external/internal O-ring by using nomographic method. Parameters shall include differential pressure & O-Ring squeeze

Type: External O-Ring



D_P	13.535	±	0.005	[in]	Piston diameter
D_{P_max}	13.540 [in]				
D_{P_min}	13.530 [in]				
D_C	13.550	±	0.005	[in]	Cylinder diameter
D_{C_max}	13.555 [in]				
D_{C_min}	13.545 [in]				
D_G	13.067	±	0.005	[in]	Gland diameter
D_{G_max}	13.072 [in]				
D_{G_min}	13.062 [in]				
ID	12.475	±	0.005	[in]	O-Ring ID
$ID_{\_max}$	12.480 [in]				
$ID_{\_min}$	12.470 [in]				
W	0.275	±	0.002	[in]	O-Ring cross section
$W_{\_max}$	0.277 [in]				
$W_{\_min}$	0.273 [in]				

Stretch & Squeeze

$$\text{Maximum \% stretch} = [(D_{G\_max} - ID_{\_min}) / ID_{\_min}] \times 100$$
$$= 4.83\%$$

$$\text{Minimum \% stretch} = [(D_{G\_min} - ID_{\_max}) / ID_{\_max}] \times 100$$
$$= 4.66\%$$

$$\text{Maximum corrected \% squeeze} = \{[W_{actual\_max} - .5(D_{C\_min} - D_{G\_min})] / W_{actual\_max}\} \times 100$$
$$= 8.55\%$$

$$\text{Minimum corrected \% squeeze} = \{[W_{actual\_min} - .5(D_{C\_max} - D_{G\_min})] / W_{actual\_min}\} \times 100$$
$$= 5.29\%$$

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D_P	13.535	[in]	Nominal piston diameter	
D_C	13.550	[in]	Nominal cylinder diameter	
D_G	13.067	[in]	Nominal gland diameter	
ID	12.475	[in]	O-Ring nominal ID	
S_W	12.18	[%]	Nominal cross section squeeze	= [(W - .5(D_C - D_G)) / W] x 100

Nomograph A

ΔP	5,000	[PSI]	Differential pressure	
W	0.275	[in]	O-Ring cross section	
D_m	12.750	[in]	O-Ring mean diameter	= ID + W

A	12.0	[in^2]	Annulus area	
f_h	97	[PSI]	Friction density	
F_H	1,200	[lbf]	Friction force due to ΔP	

Nomograph B

OD	13.025	[in]	O-Ring nominal OD	= ID + 2W
S_W*	8.55	[%]	Cross section squeeze	
H_s	70	[shore A]	O-Ring shore hardness	

L_o	37	[in]	Rubbing length	
f_c	0.6	[lbf/in]	Linear friction	
F_c	24	[lbf]	Friction force due to squeeze	
F_{DYN}	1,224	[lbf]	Total dynamic force	= F_H + F_c
F_{STATIC}	3,672	[lbf]	Static friction	= 3 x F_{DYN}
P_L	721,005	[lbf]	Pressure load	= ΔP x (π/4x D_C^2)
d_{hys}	0.17	[%]	Dynamic hysteresis	= (F_{DYN} / P_L) x 100

* Cross section squeeze can be put either nominal % squeeze (S_W) or maximum corrected % squeeze.

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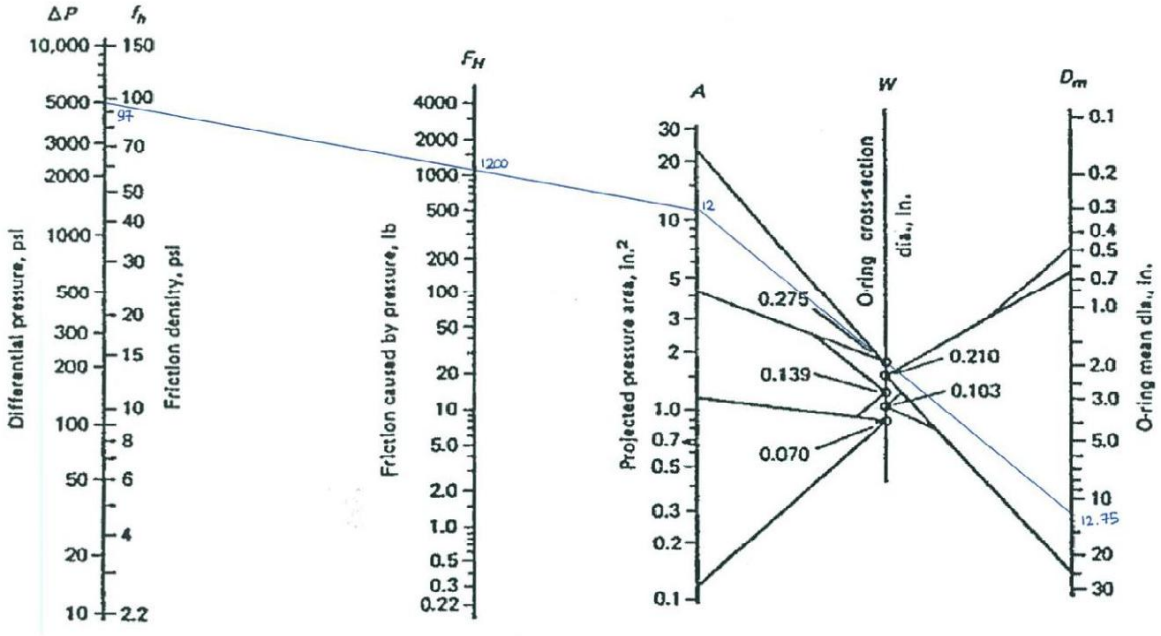
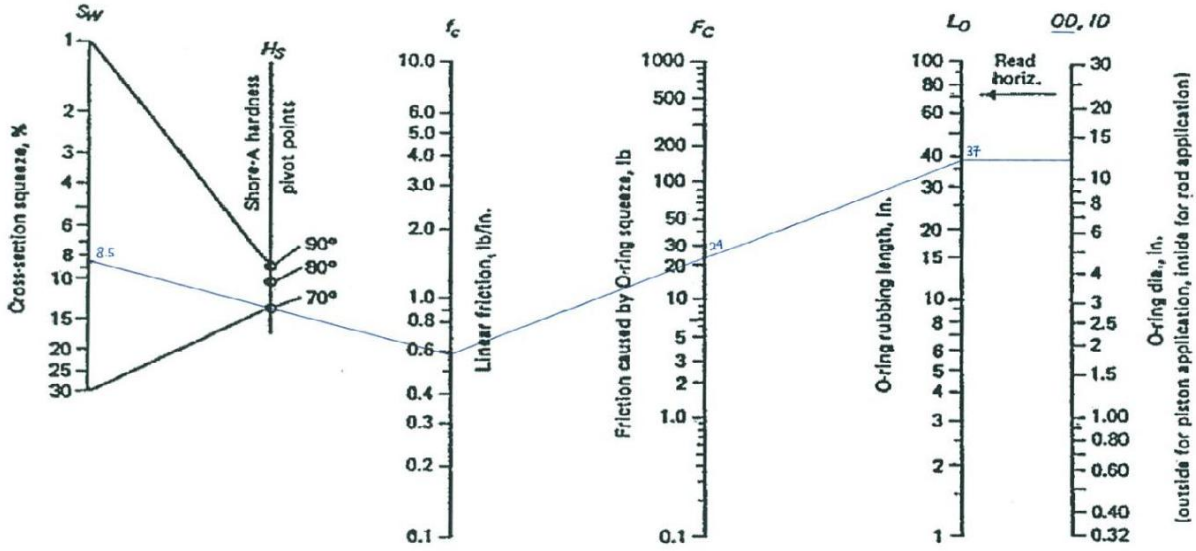
Nomograph A: O-ring friction caused by differential pressure



Nomograph B: O-ring friction caused by cross-section squeeze



Reference

Product Engineering magazine, June 1979, page 56