Investigation of Potential Distortion of UII BOP Wedge Lock Housing due to Excessive Studs Torquing

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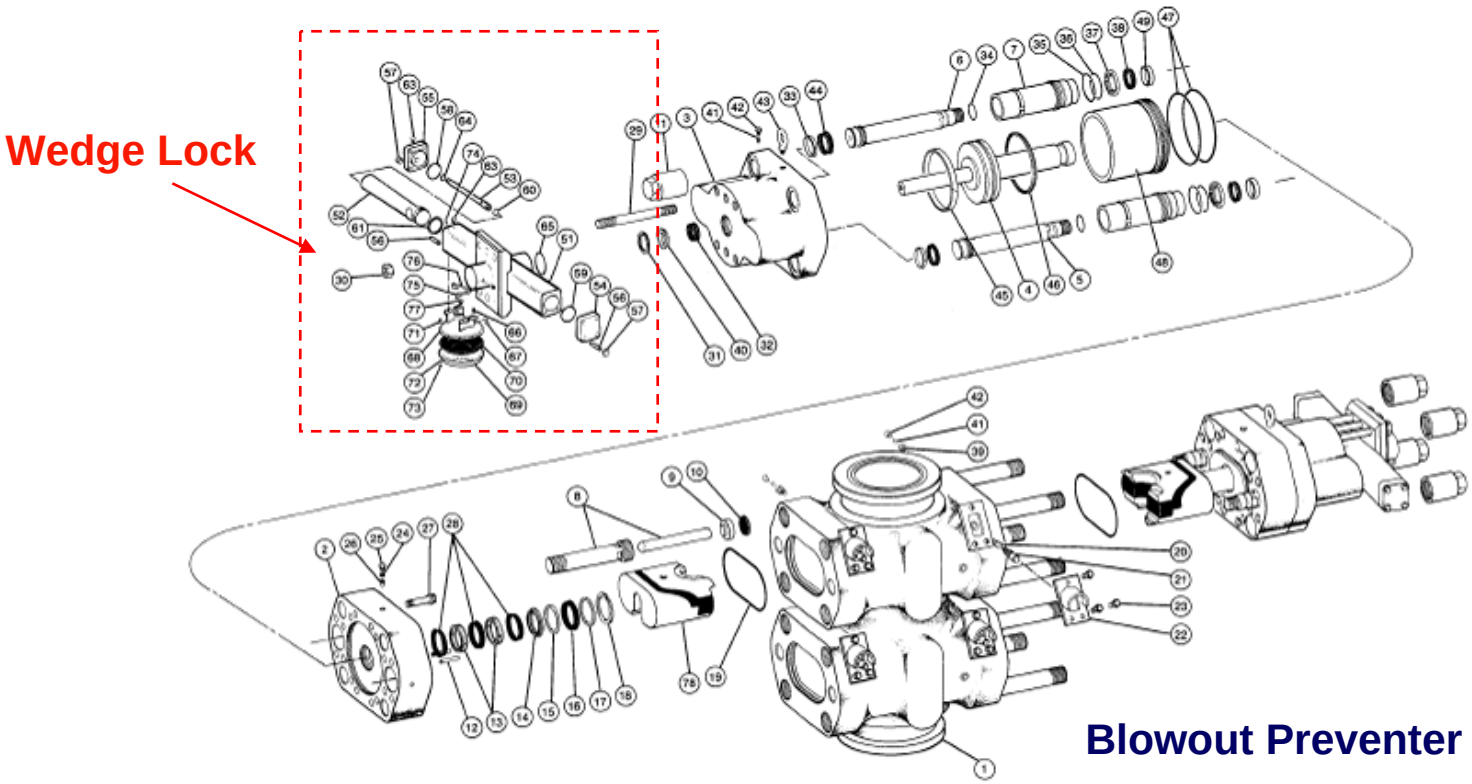
UII BOP Wedge Lock Issue with Stud Torquing

Background

- The UII BOP (Blowout Preventer) wedge locks on one of our drilling rigs had problem of jamming in the moving mechanism (piston sliding inside the cylinder) after the wedge locks had been torqued up to the BOP bonnets.



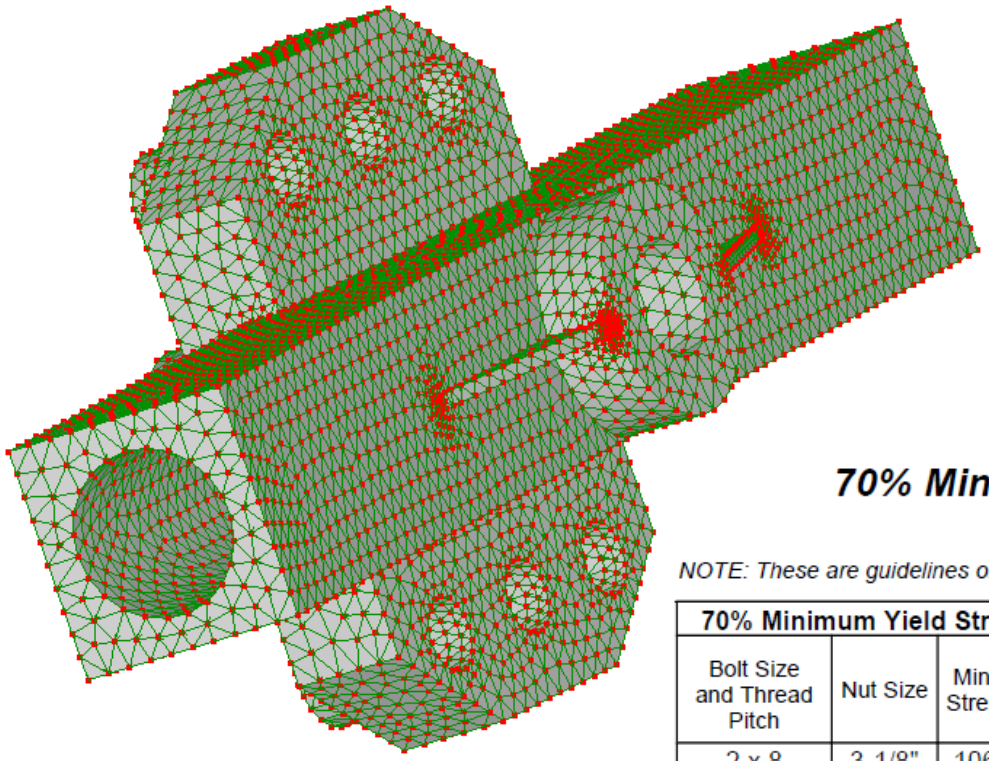
UII BOP Wedge Lock Issue with Stud Torquing

- After various attempts of troubleshooting, it was suspected that the wedge locks studs were excessively torqued causing the wedge locks housing to warp and bind the wedge piston.

Wedge Lock

- The OEM (original equipment manufacturer) doesn't specify the torque required for the 6 each 2-1/2" studs. The rig crew typically used 4500 ft-lb to torque up.
- We used finite element analysis software LISA-FET to simulate the wedge lock housing distortion to see if the 4500 ft-lb torque could cause the body to warp sufficiently to jam the piston and to determine the optimum torque to prevent such reoccurrence.

Bolt Torquing of Wedge Lock



Model of the UII BOP Wedge Lock was prepared using Freecad and meshed with LISA-FET

- **OEM doesn't specify the torque required on the 6ea 2-1/2" studs.**
- **Rig typically used 4500 ft-lb of torque with Moly lubricant.**
- **This torque could achieve tension as high as 364,000 lbs per stud.**

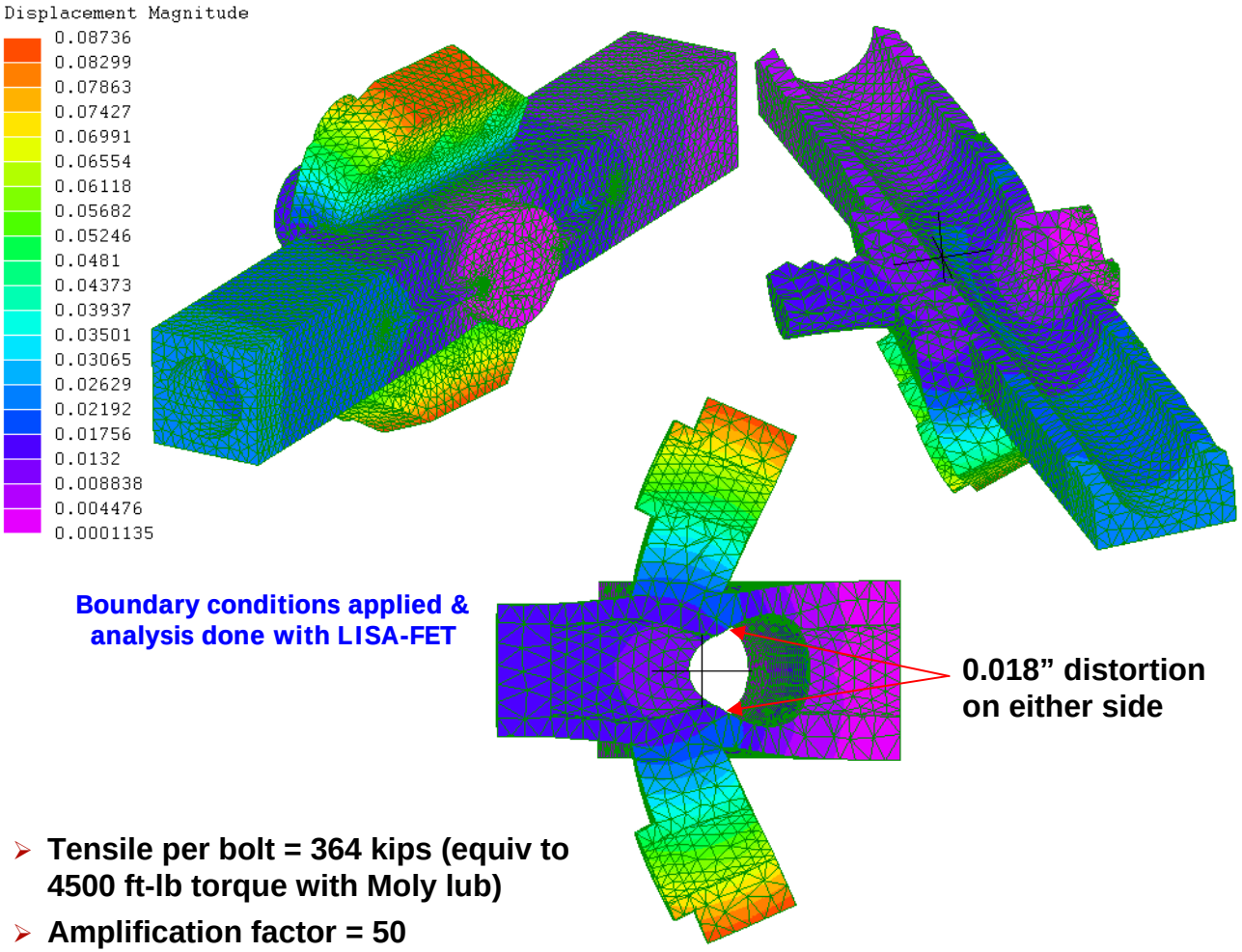
70% Minimum Yield Strenath - B7 Stud

ASTM A193 B7 Studs

NOTE: These are guidelines only - refer to manufacture specs or engineering dept

70% Minimum Yield Strength - B7 Stud				Torque For Specificed Lubricant (ft-lbs)				
Bolt Size and Thread Pitch	Nut Size	Min Yield Stress PSI	Bolt Tension (LBS)	Moly Bdenum Disulfide	Moly/Lead Oxide/Graphit (k=.085)	Copper Graph (k=.10)	Nickel Graph (k=.011)	API SA2 (k=.117)
2 x 8	3-1/8"	106,000	233,107	2331	3,302	3,885	4,274	4,546
2-1/8 x 8	3-5/16"	106,000	263,156	2796	3,961	4,660	5,126	5,452
2-1/4 x 8	3-1/2"	106,000	295,026	3319	4,702	5,532	6,085	6,472
2-3/8 x 8	3-11/16"	106,000	328,717	3904	5,530	6,506	7,156	7,612
2-1/2 x 8	3-7/8"	106,000	364,229	4553	6,450	7,588	8,347	8,878
2-3/4 x 8	4-1/4"	95,000	394,983	5431	7,694	9,052	9,957	10,590
3 x 8	4-5/8"	95,000	470,062	7051	9,989	11,752	12,927	13,749

Wedge Lock Housing Distortion for 4500 ft-lb Torque



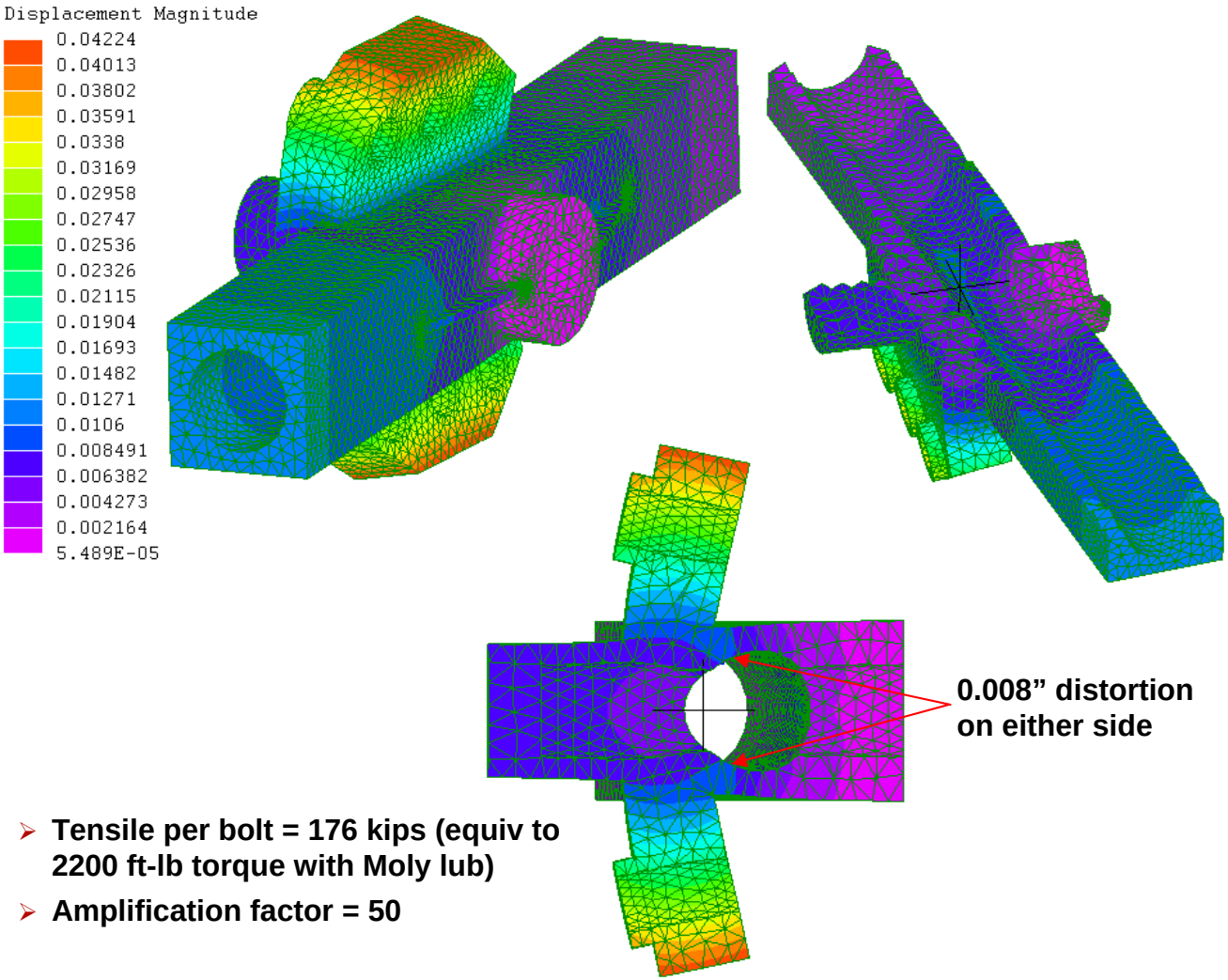
Boundary conditions applied & analysis done with LISA-FET

0.018” distortion on either side

- **Tensile per bolt = 364 kips (equiv to 4500 ft-lb torque with Moly lub)**
- **Amplification factor = 50**

- **Based on FE analysis, it shows that by torquing up the studs to 4500 ft-lb, the wedge lock housing internal bore could warp up to 0.018”, reducing the effective ID by 0.036”.**
- **We couldn’t obtain the information from OEM for the nominal clearance between wedge piston and wedge lock housing. But typically for this size of piston (5.74”), the clearance is 0.027”.**
- **This has potential of binding the wedge piston.**

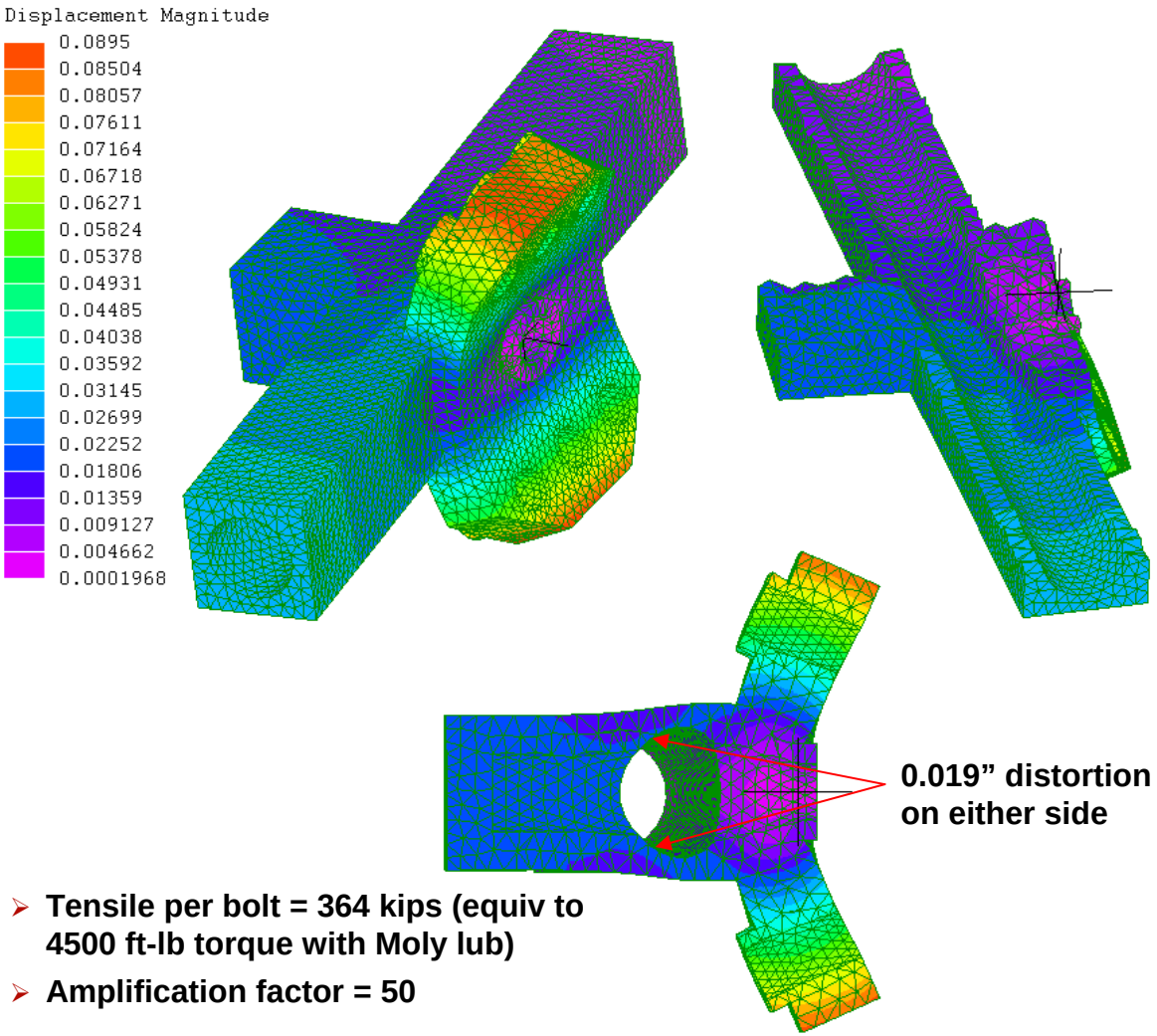
Wedge Lock Housing Distortion for 2200 ft-lb Torque



- Tensile per bolt = 176 kips (equiv to 2200 ft-lb torque with Moly lub)
- Amplification factor = 50

- FE analysis on the wedge lock assy with reduced torque on the studs to 2200 ft-lb, shows the wedge lock housing internal bore's warp is up to 0.008" and the effective ID reduced by 0.016".
- With the nominal clearance between wedge piston and wedge lock housing of 0.027", this will give better chance for the wedge piston to slide through.

Wedge Lock Housing Distortion for 4500 ft-lb Torque



- Tensile per bolt = 364 kips (equiv to 4500 ft-lb torque with Moly lub)
- Amplification factor = 50

- The newer type of wedge lock with the flange facing the bonnet is also affected by the torque on the studs. According to FE analysis, at 4500 ft-lb, the wedge lock housing internal bore warps up to 0.019" and the effective ID reduced by 0.038".
- This type of wedge lock will also benefit from reducing the stud torquing to 2200 ft-lb and the distortion will reduce to 0.009" either side.

Recommendation

- Based on the finite element analysis results with studs torquing for 4500 ft-lbs and 2200 ft-lbs, it is recommended to only torque up the wedge lock studs to 2200 ft-lbs in the future to prevent excessive distortion on the wedge lock housing.
- This analysis results were sent to the OEM and they have agreed that torquing up to 2200 ft-lbs would suffice for this application.

Piston & Cylinder Radial Clearance (appendix)

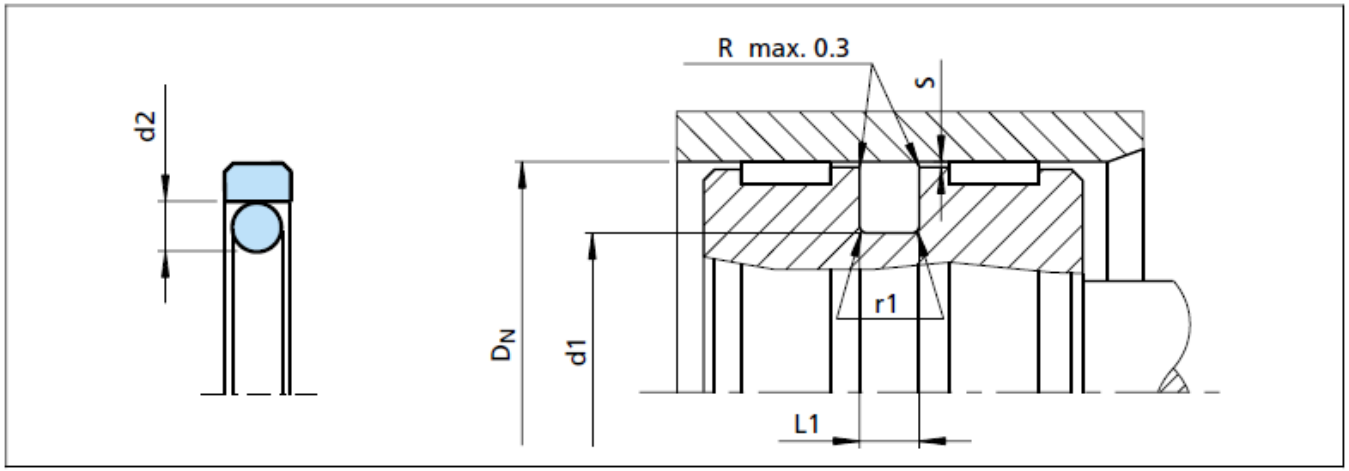


Figure 13 Installation drawing

Table IX Installation Dimension

Bore Diameter D_N H9			Groove Diameter	Groove Width	Radius	Radial Clearance S max.*			O-Ring Cross-Section
Series No. PG 44	Series No. PG 46	Series No. PG 42							
Standard Application	Light Application	Heavy Duty Application	d_1 h9	L_1 +0.2	r_1	10 MPa	20 MPa	40 MPa	d_2
8 - 14.9	15 - 39.9	-	D_N - 4.9	2.2	0.4	0.30	0.20	0.15	1.78
15 - 39.9	40 - 79.9	-	D_N - 7.5	3.2	0.6	0.40	0.25	0.15	2.62
40 - 79.9	80 - 132.9	15 - 39.9	D_N - 11.0	4.2	1.0	0.40	0.25	0.20	3.53
80 - 132.9	133 - 329.9	40 - 79.9	D_N - 15.5	6.3	1.3	0.50	0.30	0.20	5.33
133 - 329.9	330 - 669.9	80 - 132.9	D_N - 21.0	8.1	1.8	0.60	0.35	0.25	7.00
330 - 669.9	670 - 999.9	133 - 329.9	D_N - 24.5	8.1	1.8	0.60	0.35	0.25	7.00
670 - 999.9	-	330 - 669.9	D_N - 28.0	9.5	2.5	0.70	0.50	0.30	8.40
≥ 1000	≥ 1000	≥ 1000	D_N - 38.0	13.8	3.0	1.00	0.70	0.60	12.00

OD of piston ~146mm

From Trelleborg's Manual