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TEST COMPARING BEARING WEAR OF T-BIRD UNIFIED GLAND VERSUS ALUMINUM GLAND WITH WEAR RING

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Prepared for:

POTENTIAL CUSTOMERS

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1. SUMMARY

1.1. Purpose

This test is to determine the bearing wear between T-Bird Unified Gland and aluminum gland with wear ring and to find out how side loading affects the Unified Gland.

1.2. Conclusions

There was a metal-to-metal contact between gland and piston rod occurring at throat bore of aluminum gland with wear ring at tested 400,000 strokes under the radial load 556 lbs. exerted on bearing surface and a wear out was .0058". The reason for this contact is because the tolerance stacked up among wear ring thickness, gland groove depth, piston diameter and cylinder bore. Therefore, this caused the rod tilting and deflecting under side load.

With the same gland length, aluminum gland with wear ring wore much more and faster than T-Bird Unified Gland. This is because T-Bird Unified Glands bearing contact area is larger than aluminum gland contact area, reduces tolerance stack up and enhances more resistance to side load.

1.3. Recommendation

Unified Gland increases the life cycle of hydraulic & pneumatic cylinders because it reduces negative impact of side loads and prevents issues associated with stack-up tolerances.

2. EXPERIMENTAL DESIGN METHOD AND MATERIAL

As we have demonstrated side loads are detrimental to the life of hydraulic & pneumatic cylinders. It causes wear on one side of piston rod and the cylinder bore, excessive wear on one side of the gland bearing and seal failure.

In order to determine the difference of bearing wear between T-Bird Unified Gland and aluminum normal gland without wear ring, we designed a hydraulic test with a 224 lb. weight as side loading (refer to sample calculations) was subjected to both rod ends during cylinder rods moving reciprocally (figure1).

Test consisted of two equal-size cylinders; one substituted with T-Bird Unified Gland, which was tested with 400,000 strokes on the test "Test comparing bearing wear of T-Bird Unified Gland versus Aluminum gland without wear ring"(**APPENDIX – A**), named Cylinder-1 and another one using aluminum normal gland with wear ring named Cylinder-2 (figure 2). Both cylinders were mounted co-linearly on the beam with both cylinder-ends hinged and both cylinder-heads set free on supports. Two rod-ends were connected together by a linkage with stacked weights. Both cylinder-rods traverse forward and backward with the same stroke under oil pressure exerted on the surface area of pistons.

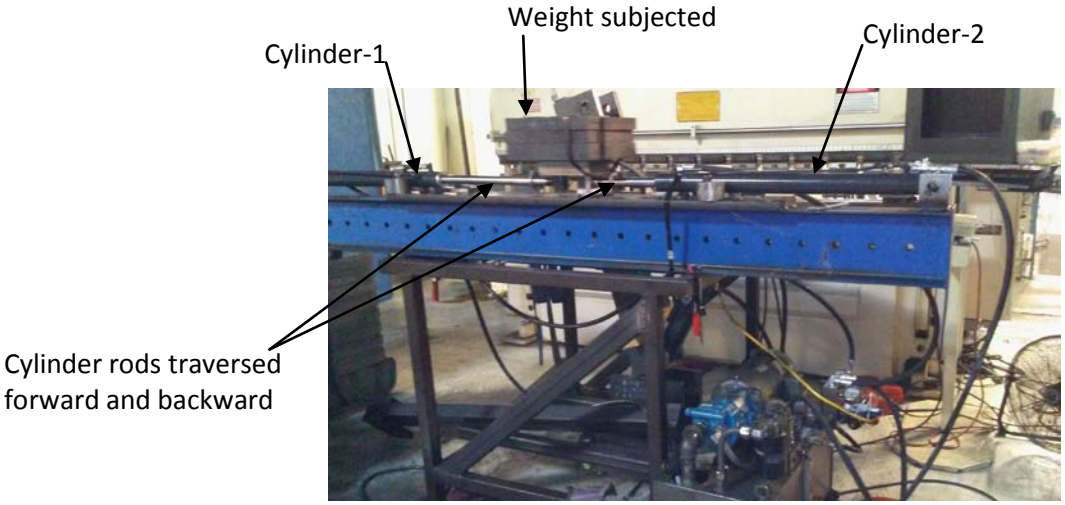


Figure 1: Experimental test model of gland bearing

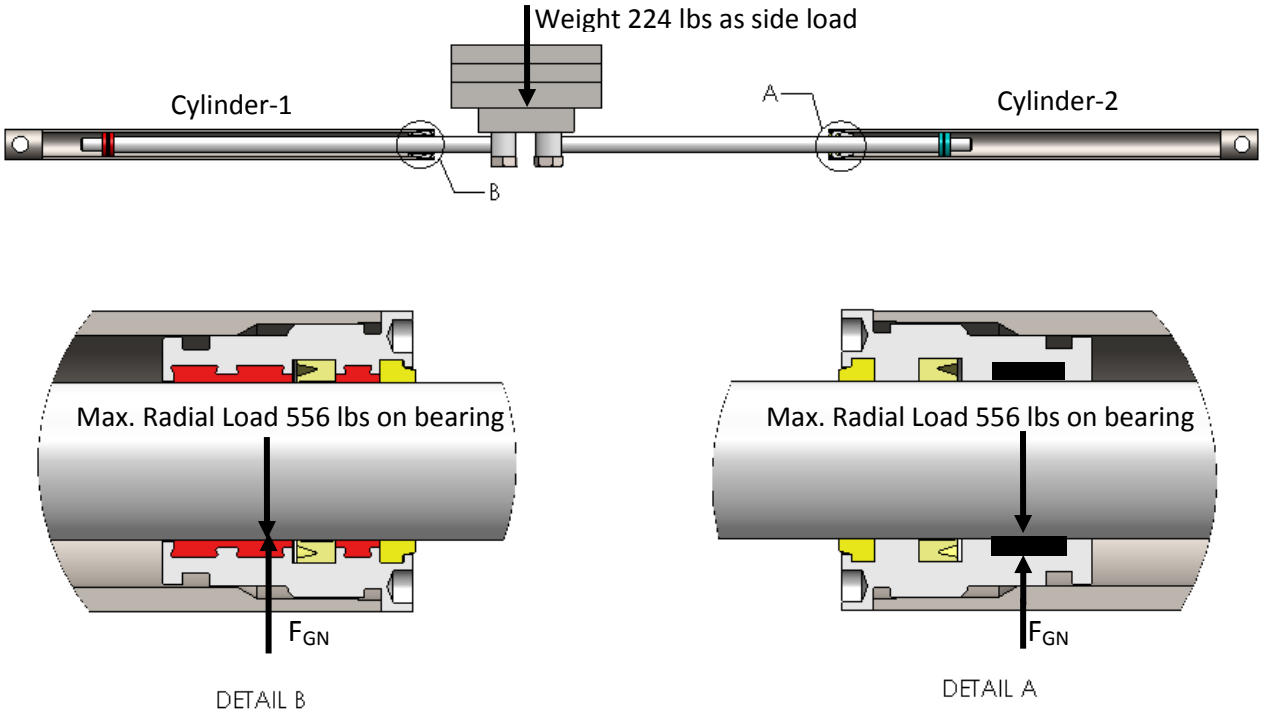


Figure 2: Simulation of testing

Test parameters: Tested cylinders' dimensions and parameters are shown in tables below.

All Dimensions Are Inches	Cylinder tube		Rod	Piston			Gland		
	Bore dia.	Length	Dia.	Dia.	Width	Type	Bore dia.	Bearing Width	Type
Cylinder-1	2.001	31.500	1.2495	1.996	1.000	unified	1.253	1.295	Unified (molded bearing with nylon 33% glass filled)
Cylinder-2	2.001	31.500	1.2495	1.996	1.000	unified	1.253	0.750	Aluminum with wear ring

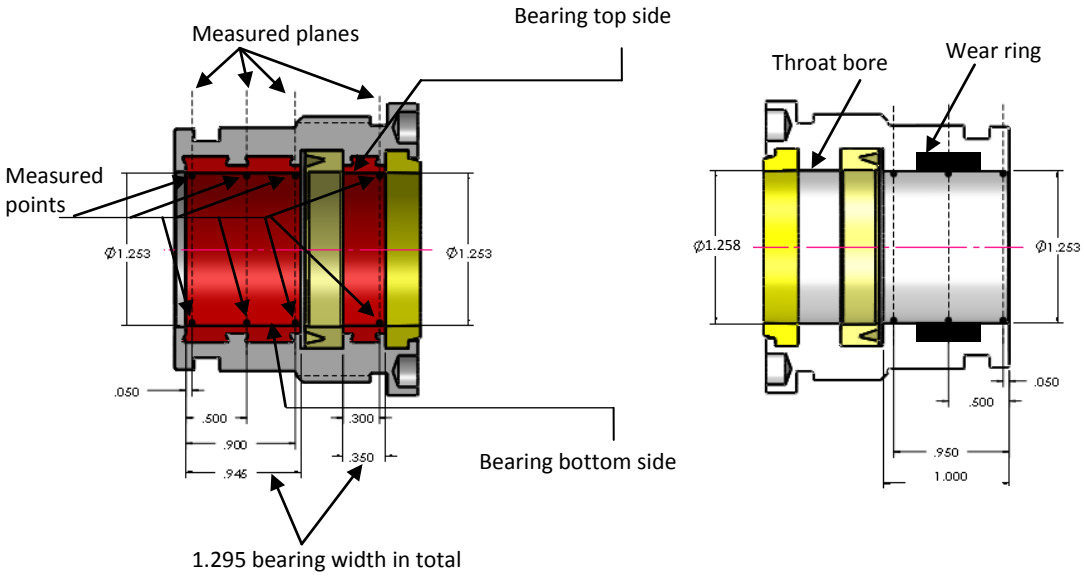
Table 1: Testing cylinder dimensions

Stroke traverse (inch)	Traverse speed (FPM)	Testing oil type	Test oil pressure (PSI)	Oil temperature	Test period of time
21	40	Coastal Eco. AW-32	4000	120^0F	Ran continuously 24 hours per 7 days until seal fail

Table 2: Testing conditions

- A method to determine a wear of gland bearing:

Under side loading condition, the gland bearing is worn on its bottom side. By measuring distances between point on bearing top and point on bearing bottom on each plane perpendicular to the gland bore center line at positions along the bearing width and thickness of wear ring before and after testing, we determined the differences between distances. These differences are gland bearing wear (figure 3).



T-Bird Unified Gland *Aluminum gland with wear ring*

Figure 3: Method to determine a wear of gland bearing

3. TEST RESULTS

After testing with 400,000 strokes, both glands were removed and check for bearing wear (figure 4). By measuring the distance between bearing top and bottom of T-Bird Unified Gland and thickness of wear ring and then subtracting the distance that was measured before testing; the differences would be determined. This is the wear out of gland bearing. Table 3 shows the bearing wear of aluminum gland with wear ring. Table 4 shows the wear of aluminum gland at throat bore. Table 5 shows the bearing wear of T-Bird Unified Gland.

Figure 4: T-Bird Unified Gland after 800,000 strokes versus Aluminum gland with wear ring after 400,000 strokes

TABLE 3: BEARING WEAR OUT OF ALUMINUM GLAND WITH WEAR RING AT 400,000 STROKES

	Measured thickness of wear ring before and after test at position along bearing width .75" wide		
.75" bearing width	0.05	0.40	0.73
At 0 strokes	1.2530	1.2530	1.2530
At 400,000 strokes	1.2539	1.2545	1.2554
Bearing wear out	0.0009	0.0015	0.0024

TABLE 4: WEAR OUT OF ALUMINUM GLAND AT THROAT BORE

	Measured distance between top and bottom of throat bore of gland
At 0 strokes	1.258
At 400,000 strokes	1.2636
Wear out	0.0056

TABLE 5: BEARING WEAR OUT OF T-BIRD UNIFIED GLAND AT 800,000 STROKES

	Measured distance between top and bottom of gland bore at position along bearing width 1.295" wide			
1.295" bearing width	0.05	0.50	0.90	1.20
At 0 strokes	1.2530	1.2530	1.2530	1.2530
At 400,000 strokes	1.2531	1.2532	1.2534	1.2536
At 800,000 strokes	1.2534	1.2536	1.2539	1.2545
Bearing wear out	0.0004	0.0006	0.0009	0.0015

Based on the bearing wear out of Table 3 and Table 5, the wear out curves diagram of T-Bird Unified Gland at 800,000 strokes versus aluminum gland with wear ring at tested 400,000 strokes is created and shown in figure 5.

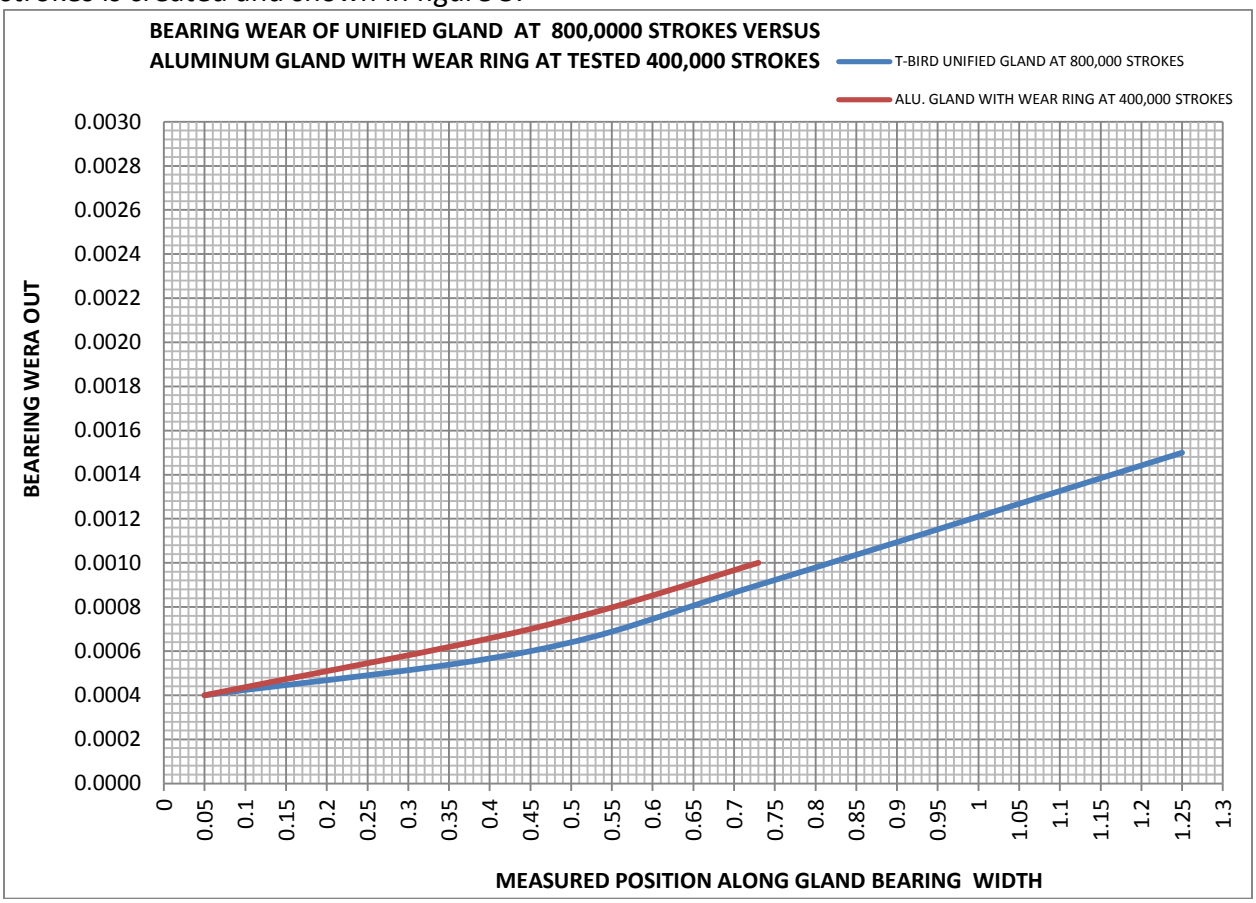


Figure 5: Wear out curves of T-Bird Unified Gland tested at 800,000 strokes versus aluminum gland with wear ring tested at 400,000 strokes.

Based on figure 5, the gland bearing wear out increased respective to the bearing width due to side load. Aluminum gland bearing wore out by .001" thick at position of 95% of its bearing width with tested 400,000 strokes; meanwhile T-Bird Unified Gland bearing only wore out by .0009" thick with tested 800,000 strokes at the same percentage of bearing width. Also Table 4 shows that throat bore of aluminum gland worn out .0056” thick with tested 400,000 strokes; meanwhile T-Bird Unified Gland bearing only wore out by .0015" thick with tested 800,000 strokes at the same measured position. This is because the T-Bird Unified Gland has a longer bearing width which in turn enhanced more resistance to side load.

4. SAMPLE CALCULATIONS

4.1. Calculation for weight

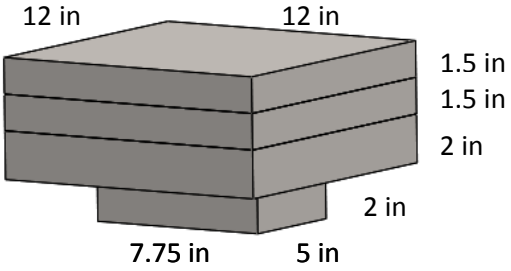


Figure 6: weight subjected to both rod ends

Weight W = [12*12*(1.5+1.5+2) + 5*7.75*2]*.28 ≈ 224 lbs

4.2. Calculation for Radial Load

Both cylinders in this test were subjected to 224 lbs. at a point on symmetric plane of two rod ends. By using a method of two force members, one rod end of each cylinder would be subjected to a half of the weight which is 112 lbs. Figure 7 shows the free-body diagram of one cylinder using T-Bird Unified Gland.

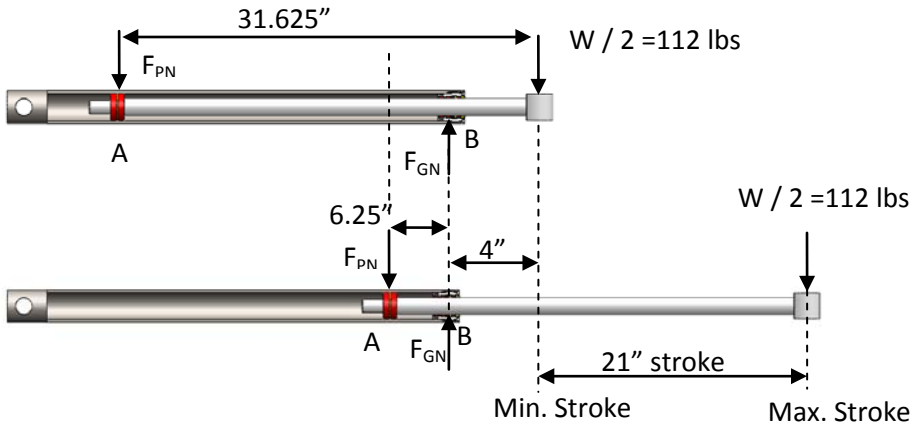


Figure 7: Free-body diagram of one cylinder using T-Bird Unified Gland.

Based on figure 7, a normal force F_{GN} reacting to the radial load exerted on the gland bearing due to side load would be maximum as the rod extends with maximum stroke.

Using two equilibrium equations to solve force F_{GN}

$$\uparrow^{+} \sum F_Y = 0$$

$$\uparrow^{+} \sum M_A = 0$$

$-F_{PN} + F_{GN} - 112(\text{lbs}) = 0$ (1)

$6.25 * F_{GN} - (6.25+4+21) * 112(\text{lbs}) = 0$ (2)

Solve eq. (2) , we have F_{GN} = 566 lbs
Substitute F_{GN} into eq. (1), we have F_{PN} = 456 lbs.

Therefore, a radial load is equal to F_{GN} but opposite direction. It is 556 lbs.

APPENDIX – A

Result of test: "Test comparing bearing wear of T-Bird Unified Gland versus Aluminum gland without wear ring (Date of release: 05/01/2018)

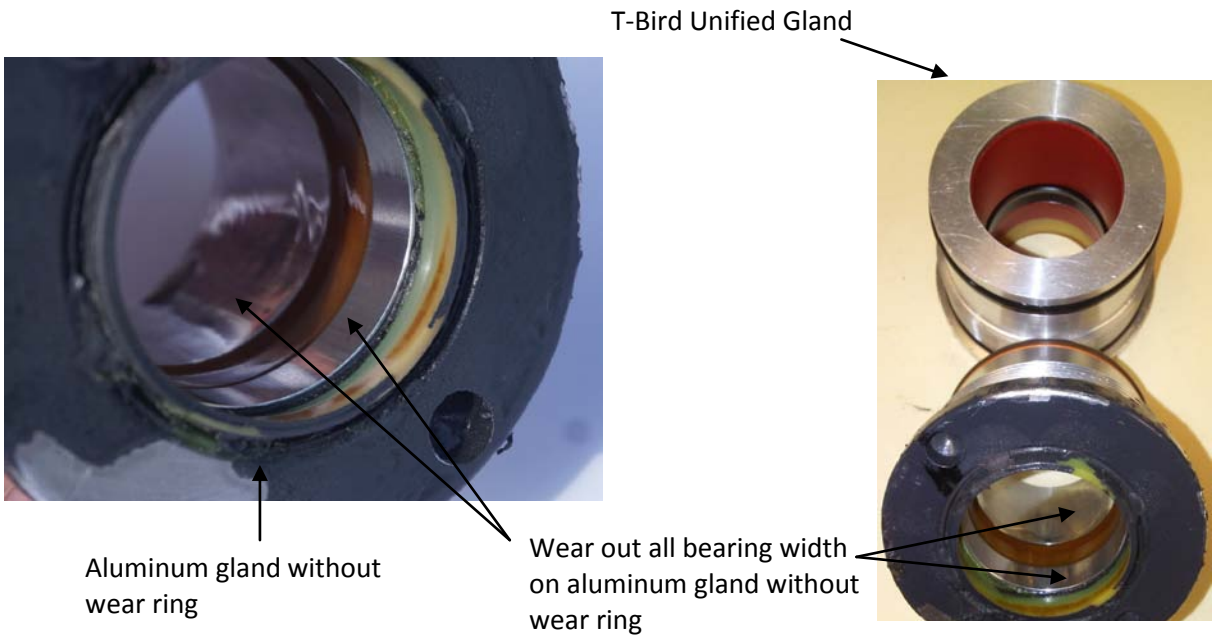


Figure 8: T-Bird Unified Gland versus Aluminum gland without wear ring after 400,000 strokes

TABLE 6: BEARING WEAR OUT OF ALUMINUM GLAND WITHOUT WEAR RING AT 400,000 STROKES

	Measured distance between top and bottom of gland bore at position along bearing width 1" wide		
1" bearing width	0.05	0.50	0.95
At 0 strokes	1.2530	1.2530	1.2530
At 400,000 strokes	1.2539	1.2545	1.2554
Bearing wear out	0.0009	0.0015	0.0024

TABLE 7: BEARING WEAR OUT OF T-BIRD UNIFIED GLAND AT 400,000 STROKES

	Measured distance between top and bottom of gland bore at position along bearing width 1.295" wide			
1.295" bearing width	0.05	0.50	0.90	1.20
At 0 strokes	1.2530	1.2530	1.2530	1.2530
At 400,000 strokes	1.2531	1.2532	1.2534	1.2536
Bearing wear out	0.0001	0.0002	0.0004	0.0006

Based on the bearing wear out of Table 6 and Table 7, the wear out curves diagram of T-Bird Unified Gland versus aluminum gland without wear ring at tested 400,000 strokes is created and shown in figure 9.

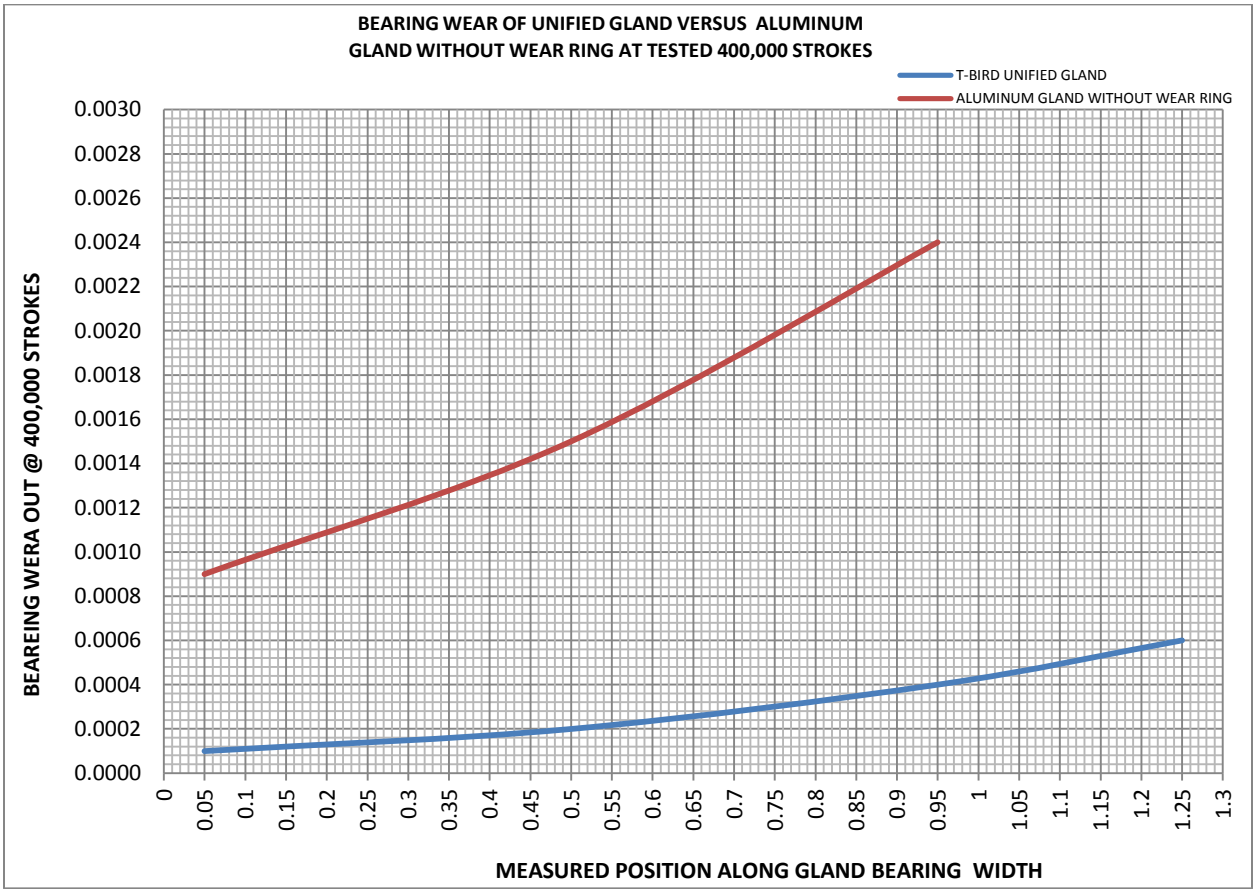


Figure 9: Wear out curves of T-Bird Unified Gland versus aluminum gland without wear ring tested at 400,000 strokes.

Based on figure 9, the gland bearing wear out increased respective to the bearing width due to side load. Aluminum gland bearing wore out by .0024" thick at position of 95% of its bearing width; meanwhile T-Bird Unified Gland bearing only wore out by .0006" thick at the same percentage of bearing width because the aluminum gland bearing width was shorter.