**GAS TURBINE ENGINE CARBON OIL SEALS COMPUTERIZED ASSEMBLY**

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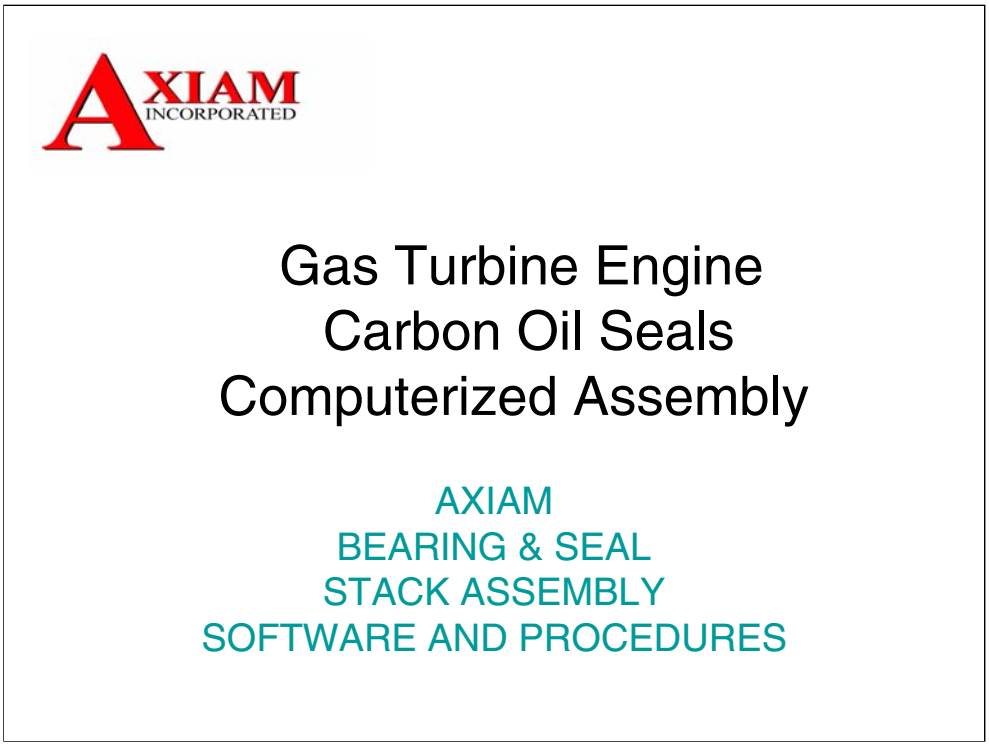
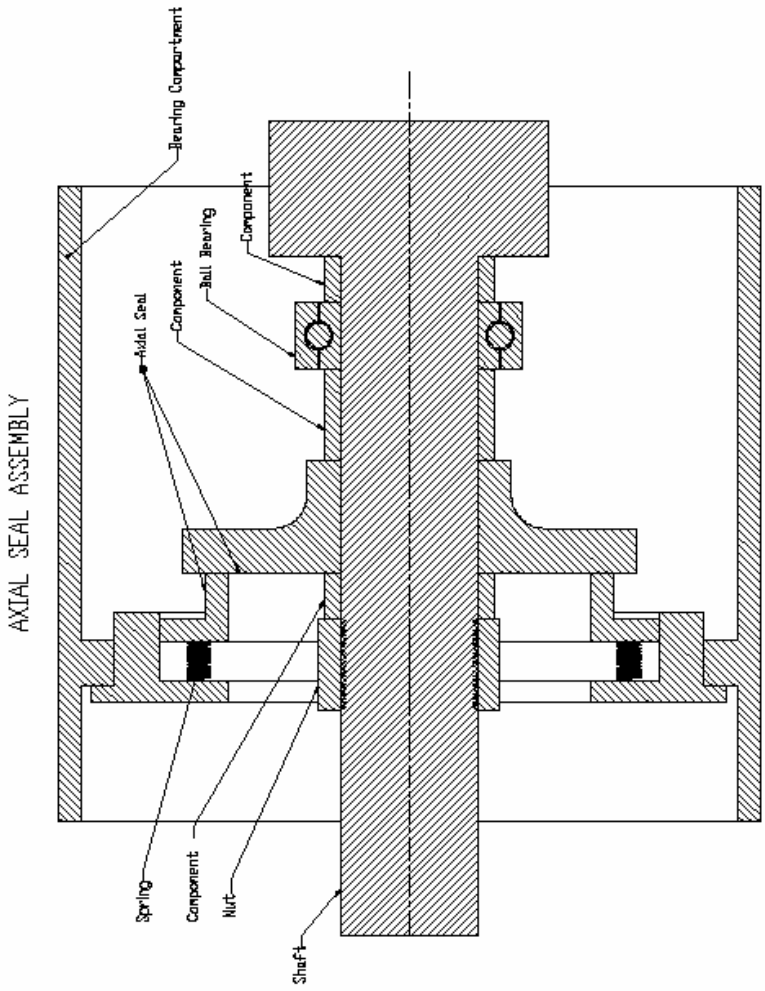


AXIAM INCORPORATED

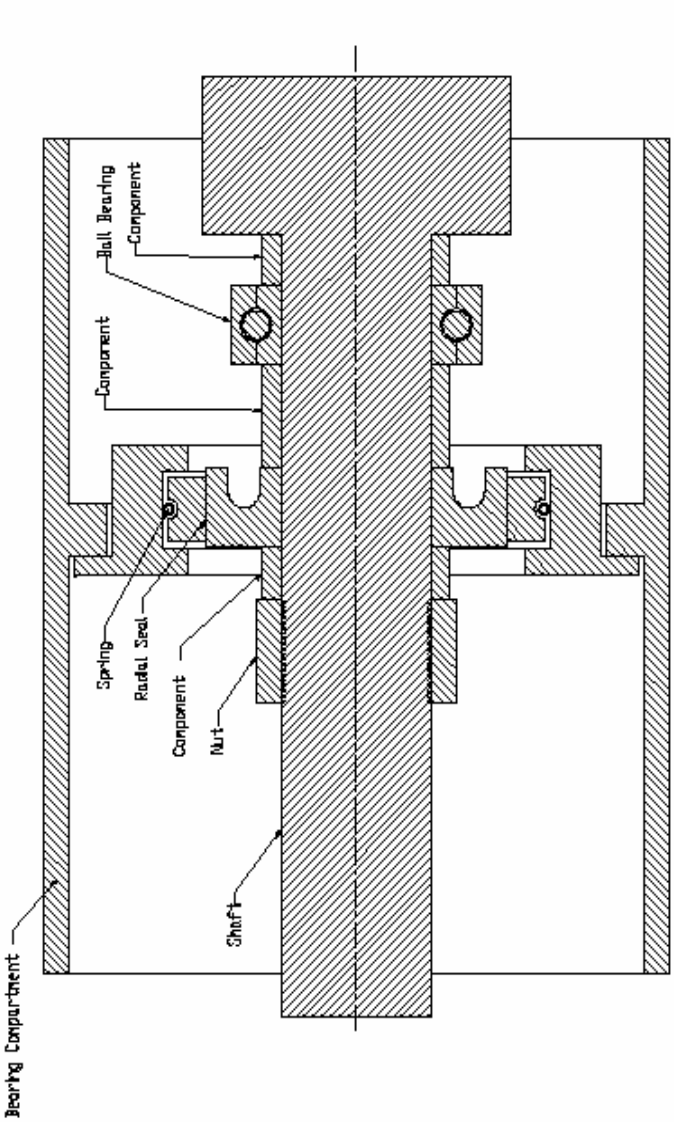
# GOALS

1) REPEATABLE ASSEMBLY PROCESS
2) ACCURATE ASSEMBLY PROCESS
3) MINIMIZE SEAL RUNOUT
4) DESIGN TO ENGINE CENTERLINE OF ROTATION, IE" BEARINGS

# Axial Seal Assembly



# Radial Seal Assembly



# GAS TURBINE SEAL LEAKS

- POTENTIAL PROBLEMS CAUSING OIL LEAKS

- 1) INCORRECT PART DATUMS
- 2) MISSING PART GEOMETRY
- 3) ENGINE VIBRATION
- 4) SEAL HYSTERESSES
- 5) INCORRECT ASSEMBLY PROCEDURES
- 6) ACCUMULATION OF TOLERANCES

# INCORRECT PART DATUMS

In a bearing compartment there are a series of parts when assembled determine the location of the bearing and seal as related to the centerline of rotation.
We see part datums that do not establish A coincident path from the bearing to the seal.

# Missing Part Geometry Controls

Part geometry controls missing on drawings:

Concentricity

Roundness

Flatness

Circumferential Waviness

# Engine Vibration

High engine vibration can cause severe oil leakage

- Case: Navy EA6B "Prowler"
- Engine: J52-408

Engine vibration level approaching 6Mils

- Low Rotor shafts breaking due to oil coking

# Seal Hysteresis

The inability of the seal to respond fast enough to the rotating element

Radial Seal: Sensitive to housing air pressure
Sensitive to seal runout ?

Axial Seal: Very sensitive to seal perpendicularity to shaft

# Incorrect Assembly Procedures

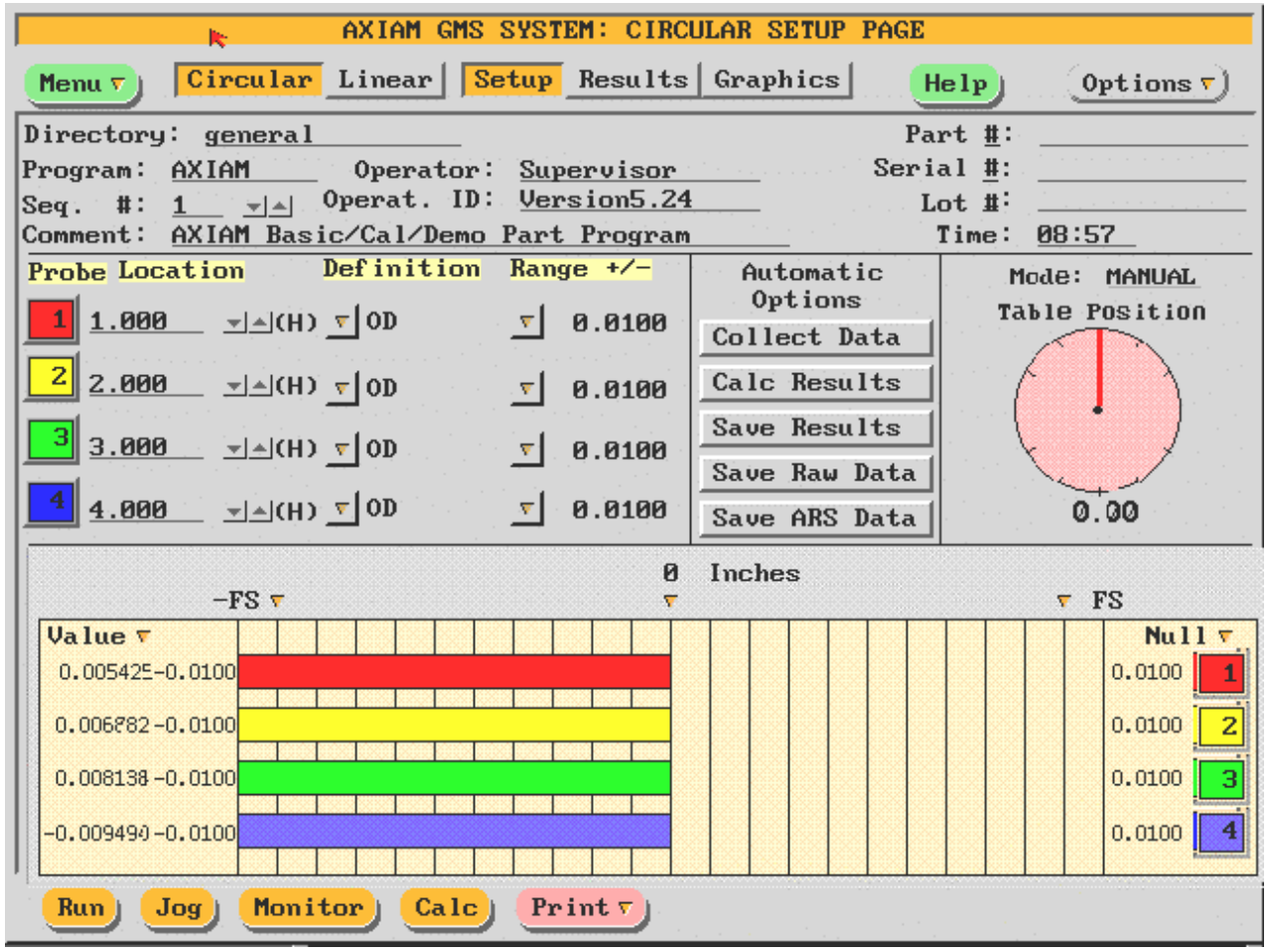
Parts not fully seated

Parts heated or cooled to incorrect temperature

Part fits are incorrect

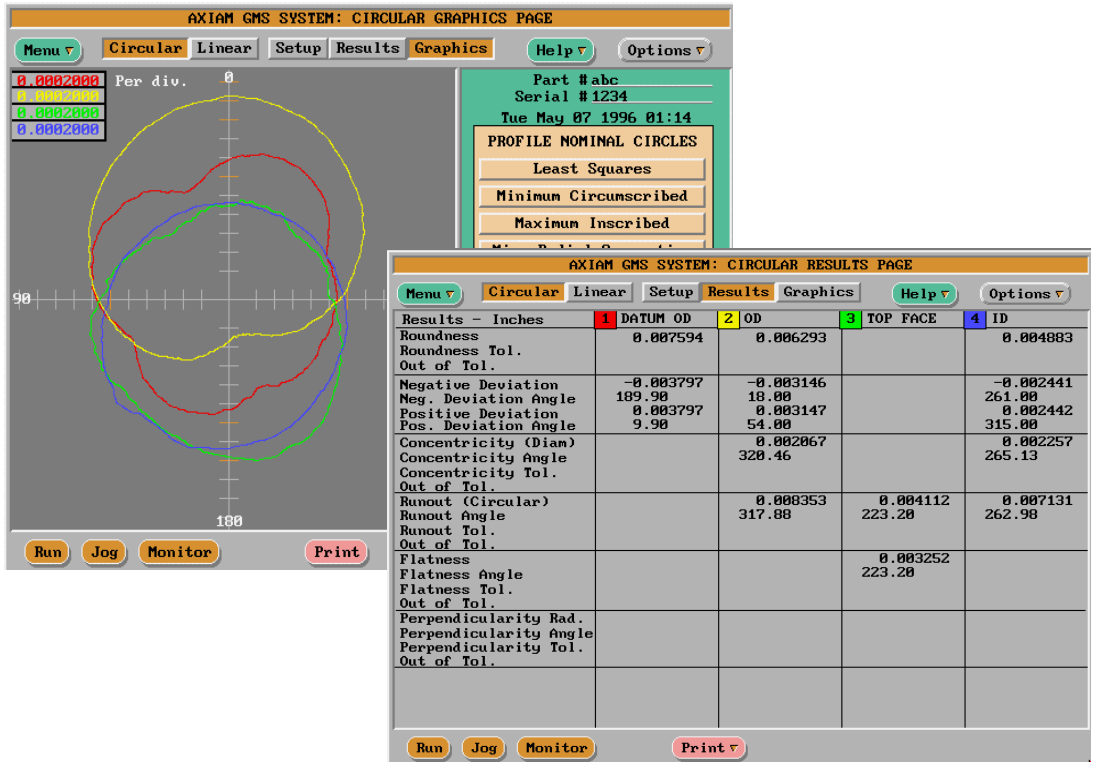
Not being aware that assembly procedures are sometimes time sensitive

# GMS-4000 Software Part Inspection Setup



# GMS-4000 Output Page

**GMS 4000™ Software Measurements**




| Results – Inches | 1 DATUM OD | 2 OD | 3 TOP FACE | 4 ID |
|---|---|---|---|---|
| Roundness | 0.007594 | 0.006293 | | 0.004883 |
| Roundness Tol. | | | | |
| Out of Tol. | | | | |
| Negative Deviation | -0.003797 | -0.003146 | | -0.002441 |
| Neg. Deviation Angle | 189.90 | 18.00 | | 261.00 |
| Positive Deviation | 0.003797 | 0.003147 | | 0.002442 |
| Pos. Deviation Angle | 9.90 | 54.00 | | 315.00 |
| Concentricity (Diam) | | 0.002067 | | 0.002257 |
| Concentricity Angle | | 320.46 | | 265.13 |
| Concentricity Tol. | | | | |
| Out of Tol. | | | | |
| Runout (Circular) | | 0.008353 | 0.004112 | 0.007131 |
| Runout Angle | | 317.88 | 223.20 | 262.98 |
| Runout Tol. | | | | |
| Out of Tol. | | | | |
| Flatness | | | 0.003252 | |
| Flatness Angle | | | 223.20 | |
| Flatness Tol. | | | | |
| Out of Tol. | | | | |
| Perpendicularity Rad. | | | | |
| Perpendicularity Angle | | | | |
| Perpendicularity Tol. | | | | |
| Out of Tol. | | | | |

# Rotor Output Sheet

Program: 8thspcr Operator: Part #: 773168
Seq. #: 1 Operator ID: Serial #: RG5695
Comment: Fwd End Up Run #: 3
Date Data Collected 11/17/98 12:34
Table rotation CW.
Date Tue Nov 17 1998 Time: 12:35

| Probe Configuration | #1 RED OD | #2 Yellow TOP FACE | #3 Green DATUM OD | #4 Blue DATUM BF |
|---|---|---|---|---|
| Height | 2.570000 | 2.670000 | 0.100000 | 0.000000 |
| Angle | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Radius | 7.750000 | 7.650000 | 7.710000 | 7.610000 |
| Range | 0.0200 | 0.0100 | 0.0200 | 0.0100 |
| Waviness Filter | 50 | 50 | 50 | 50 |
| Centering Method | LSC | LSC | LSC | LSC |
| **Results - Inches** | | | | |
| Roundness | 0.024036 | | 0.025814 | |
| Roundness Tolerance | | | | |
| Out of Tolerance | | | | |
| Negative Deviation | -0.012968 | | -0.013560 | |
| Neg. Deviation Angle | 254.34 | | 245.16 | |
| Positive Deviation | 0.011068 | | 0.012254 | |
| Pos. Deviation Angle | 337.14 | | 161.28 | |
| Eccentricity (radius) | 0.000279 | | | |
| Eccentricity Angle | 146.16 | | | |
| Eccentricity Tol. | | | | |
| Out of Tolerence | | | | |
| Runout (Circular) | 0.023888 | 0.002668 | | |
| Runout Angle | 156.60 | 329.04 | | |
| Runout Tolerance | | | | |
| Out of Tolerance | | | | |
| Flatness | | 0.002379 | | 0.002841 |
| Flatness Angle | | 329.04 | | 174.06 |
| Flatness Tolerance | | | | |
| Out of Tolerance | | | | |
| Perpendicularity Rad. | 0.000279 | | | |
| Perpendicularity Angle | 146.16 | | | |
| Perpendicularity Tol. | | | | |
| Out of Tolerance | | | | |

**Typical CMM Output**

# Alternet Results Page

## Rotor Output Sheet (cont'd)

Program: 8thspcr Operator: Part #: 773168
Seq. #: 1 Operator ID: Serial #: RG5695
Comment: Fwd End Up Run #: 3
Date Data Collected 11/17/98 12:34
:e Tue Nov 17 1998 Time: 12:35

Table rotation CW.
Results - Inches

| | PROBE | NOMINAL | ACTUAL | MIN.TOL. | MAX.TOL. | OUT TOL |
|---|---|---|---|---|---|---|
| Biplane Deviation | 2 | .000000 | .000452 | | | |
| Biplane Deviation Angle | 2 | | 37.07 | | | |
| Center Line Deviation | 1 | .000000 | .000279 | | | |
| Center Line Dev. at Angle | 1 | | 146.16 | | | |

AXIAM Bearing Stack Report

DIRECTORY
PROGRAM 25SEAL
OPERATOR
DATE STACKED 05/19/05 11:30
DATE PRINTED Thu May 19 2005

Part # SEAL25ASSY
Serial # NOINDEX
Run # 1
Time 11:30

RESULTS SECTION

| Stage | Centerline Deviation 0 | .0010 | .0020 | .0030 | .0040 | .0050 |
|---|---|---|---|---|---|---|
| BNG | + | | | | | |
| GEAR | + | | | | | |
| IBR | | + | | | | |
| SEAL | | | + | | | |

| Stage | Build Angle | Spline Tooth | Biplane Deviation Amount | Biplane Deviation Angle | Centerline Deviation Amount | Centerline Deviation Angle |
|---|---|---|---|---|---|---|
| BNG | 0 | | 0.000000 | 0.00 | 0.000250 | 180.00 |
| GEAR | 0 | | 0.000500 | 0.00 | 0.000500 | 180.00 |
| IBR | 0 | | 0.001451 | 0.00 | 0.001009 | 180.00 |
| SEAL | 0 | | 0.001917 | 0.00 | 0.002144 | 180.00 |

Greatest centerline deviation = 0.002144

INPUT SECTION

| Stage | Part Number | Serial Number | Biplane/Perp.Plane Amount | Biplane/Perp.Plane Angle | Center Line Deviation Amount | Center Line Deviation Angle |
|---|---|---|---|---|---|---|
| BNG | 4315875 | | 0.000000 | 0.00 | 0.000250 | 180.00 |
| GEAR | 4317132 | | 0.000500 | 0.00 | 0.000250 | 180.00 |
| IBR | 4322504 | | 0.001000 | 0.00 | 0.000500 | 180.00 |
| SEAL | 4314924 | | 0.000500 | 0.00 | 0.000500 | 180.00 |

| Stage | Height (in) | Radius (in) | Spline Teeth | Index | Index Angle |
|---|---|---|---|---|---|
| BNG | 0.75 | 2.85 | 0 | YES | 0.00 |
| GEAR | 0.10 | 2.85 | 0 | NO | 0.00 |
| IBR | 0.10 | 2.57 | 0 | NO | 0.00 |
| SEAL | 2.25 | 2.51 | 0 | NO | 0.00 |

AXIAM Bearing Stack Report

DIRECTORY
PROGRAM 25SEAL
OPERATOR
DATE STACKED 05/19/05 11:29
DATE PRINTED Thu May 19 2005 Time 11:29

Part # SEAL25ASSY
Serial # INDEX
Run # 1

RESULTS SECTION

| Stage | Centerline Deviation 0 | .0010 | .0020 | .0030 | .0040 | .0050 |
|---|---|---|---|---|---|---|
| BNG | + | | | | | |
| GEAR | + | | | | | |
| IBR | | + | | | | |
| SEAL | + | | | | | |

| Stage | Build Angle | Spline Tooth | Biplane Deviation Amount | Biplane Deviation Angle | Centerline Deviation Amount | Centerline Deviation Angle |
|---|---|---|---|---|---|---|
| BNG | 0 | | 0.000000 | 0.00 | 0.000250 | 180.00 |
| GEAR | 180 | | 0.000500 | 0.00 | 0.000000 | 0.00 |
| IBR | 0 | | 0.000549 | 0.00 | 0.000491 | 180.00 |
| SEAL | 180 | | 0.000036 | 0.00 | 0.000232 | 180.00 |

Greatest centerline deviation = 0.000491

INPUT SECTION

| Stage | Part Number | Serial Number | Biplane/Perp.Plane Amount | Biplane/Perp.Plane Angle | Center Line Deviation Amount | Center Line Deviation Angle |
|---|---|---|---|---|---|---|
| BNG | 4315875 | | 0.000000 | 0.00 | 0.000250 | 180.00 |
| GEAR | 4317132 | | 0.000500 | 0.00 | 0.000250 | 180.00 |
| IBR | 4322504 | | 0.001000 | 0.00 | 0.000500 | 180.00 |
| SEAL | 4314924 | | 0.000500 | 0.00 | 0.000500 | 180.00 |

| Stage | Height (in) | Radius (in) | Spline Teeth | Index | Index Angle |
|---|---|---|---|---|---|
| BNG | 0.75 | 2.85 | 0 | YES | 0.00 |
| GEAR | 0.10 | 2.85 | 0 | YES | 0.00 |
| IBR | 0.10 | 2.57 | 0 | YES | 0.00 |
| SEAL | 2.25 | 2.51 | 0 | YES | 0.00 |

# SEAL #2 MAX. ACCUMULATED TOLERANCES

| PARTS | PT, NUMBER | MAX STACK BIPLANE DEVIATION | MAX STACK CENTERLINE DEV. | MAX STACK SEAL RUNOUT |
|---|---|---|---|---|
| **# 2 SEAL** | | | Tolerance=.0005 | Tolerance= .001 |
| BEARING | 4317248 | 0.000500 | 0.000250 | 0.000500 |
| COUPLING | 4321831 | 0.001000 | 0.000517 | 0.001034 |
| SPACER | 4310500 | 0.001483 | 0.000845 | 0.001690 |
| SEAL | 4318437 | 0.001807 | 0.001408 | 0.002816 |

# AXIAM STACK # 2 SEAL

| PARTS | PT, NUMBER | BNG STACK BIPLANE DEVIATION | BNG STACK CENTERLINE DEV. | BNG STACK SEAL RUNOUT |
|---|---|---|---|---|
| **# 2 SEAL** | | | Tolerance=.0005 | Tolerance=.001 |
| BEARING | 4317248 | 0.000500 | 0.000250 | 0.000500 |
| COUPLING | 4321831 | 0.000000 | 0.000517 | 0.001034 |
| SPACER | 4310500 | 0.000500 | 0.000517 | 0.001034 |
| SEAL | 4318437 | 0.000941 | 0.000005 | 0.000010 |

# SEAL # 2.5 MAX. ACCUMULATED TOLERANCES

| PARTS | PT, NUMBER | MAX STACK BIPLANE DEVIATION | MAX STACK CENTERLINE DEV. | MAX STACK SEAL RUNOUT |
|---|---|---|---|---|
| **# 2.5 SEAL** | | | | |
| BALL BEARING | 4315875 | 0.000000 | 0.000250 | 0.000500 |
| BEVEL GEAR | 4317132 | 0.000500 | 0.000500 | 0.001000 |
| IBR DISC | 4322504 | 0.001451 | 0.001009 | 0.002018 |
| SEAL | 4314924 | 0.001917 | 0.002144 | 0.004288 |

# AXIAM STACK 2.5 SEAL

| PARTS | PT, NUMBER | BNG STACK BIPLANE DEVIATION | BNG STACK CENTERLINE DEV. | BNG STACK SEAL RUNOUT |
|---|---|---|---|---|
| **# 2.5 SEAL** | | | | |
| BEARING | 4315875 | 0.000000 | 0.000250 | 0.000500 |
| BEVEL GEAR | 4317132 | 0.000500 | 0.000000 | 0.000000 |
| IBR DISC | 4322504 | 0.000549 | 0.000491 | 0.000982 |
| SEAL | 4314924 | 0.000036 | 0.000232 | 0.000464 |

# SEAL # 3 MAX. ACCUMULATED TOLERANCES

| PARTS | PT, NUMBER | MAX STACK BIPLANE DEVIATION | MAX STACK CENTERLINE DEV. | MAX STACK SEAL RUNOUT |
|---|---|---|---|---|
| **# 3 SEAL** | | | | |
| BEARING # 3 | 4315875 | 0.000000 | 0.000250 | 0.000500 |
| GEAR | 4317132 | 0.000500 | 0.000500 | 0.001000 |
| IBR | 4322504 | 0.001456 | 0.001254 | 0.002508 |
| SEAL | 4314926 | 0.002747 | 0.001782 | 0.003564 |

# AXIAM STACK # 3.0

| PARTS | PT, NUMBER | BNG STACK BIPLANE DEVIATION | BNG STACK CENTERLINE DEV. | BNG STACK SEAL RUNOUT |
|---|---|---|---|---|
| **# 3 SEAL** | | | | |
| BEARING | 4315875 | 0.000000 | 0.000250 | 0.000500 |
| GEAR | 4317132 | 0.000500 | 0.000000 | 0.000000 |
| IBR | 4322504 | 0.000544 | 0.000246 | 0.000492 |
| SEAL | 4314926 | 0.000347 | 0.000244 | 0.000488 |

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