

# Building a Partnership

(‘Reducing Uncertainty’)

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# 1

## SKF Overview

# SKF Aerospace: Airframe & Aerostructure Bearing Units



USA, NY, Falconer  
Aeroengine bearings



Elgin, Il, USA  
Seals & PED



EU, UK, Clevdon  
Airframe bearings



USA, Ct, Colebrook,  
Balls



- 3 000 employees
- 13 production sites: France (3), US (7), UK (2), Italy (1)
- 2 Dev. centers : Europe (Valence) & US (Falconer)

The SKF Aerospace Resource Pool



EU, FR, Valenciennes,  
Aeroengine bearings



USA, SC, Ladson, VAB  
JV+Repair station



EU, FR, Lons-le-Saunier  
Airframe bearings,  
composite



USA, Md, Baltimore, Kaydon  
Seals & Rings



EU, FR, Valence  
Development Centre



USA, Mi, Dexter  
Kaydon ITI Balls



EU, IT, Villar Perosa,  
Aeroengine bearings



USA, MI, Muskegon  
Kaydon Bearings

SKF Proprietary

# USA, New York : Falconer

## SKF Aeroengine USA & Development Centre

### HISTORY

- 1903 : foundation as Gurney Ball Bearings
- 1924 : became Marlin Rockwell Corporation
- 1964 : acquisition red by TRW Bearings division
- 1986 : acquisition by AB SKF

### EXPERTISE – MAIN PRODUCTS LINES

- **Segments** : Aircraft engines and Gas Turbine, Helicopter, Nuclear, high-tech industries
- **Applications** : Main Shaft, Jet engines, Gearboxes, Wheels, Turbocharger, Accessories
- **Product lines** : Customized Precision Engineered Ball Bearings, Cylindrical, Tapered and Spherical roller bearings for Aerospace applications, ACBB, DGGB.
- **MRO** : FAA, EASA approved repair station for engine mainshaft bearings  
Level 4 remanufacturing of engine mainshaft bearings  
Level ½ repair of gearbox, accessory and mainshaft bearings

### MAJOR CUSTOMERS

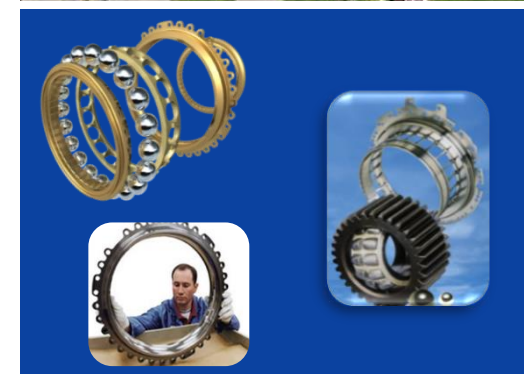
Bell, Honeywell, Sikorsky, Boeing, GE, Pratt & Whitney, Rolls-Royce.

### QUALITY CERTIFICATES

AS9100, EASA 145, 4686, NADCAP NDT, NADCAP Chemical Processing, 14 CFR Part 145 (USA), CCAR Part 145 (China)

### MORE ABOUT SKF AEROENGINE USA

- Full traceability from raw material, external components supply down to manufacturing processes & operations
- Key Technology Areas:  
Steel and Heat Treatment  
Non-steel materials: Elastomers, Thermoplastics Ceramics, Coatings,  
Tribology-Surface Engineering  
Virtual Product Development  
Verification/testing



### Key facts

- **Employees** : 510 persons
- **Managing Director** : Bob Massaro
- **Production** : 95,000 parts per year

# 2

**Challenging  
Engineering  
Opportunity**

# Bearing & Application Overview

- Customer complaint – rivets are fracturing, and raceway is brinelling
- Bearing Application – Bearing sit idle until the clutch is engaged (See Figure 1)
- Bearing Type – Deep Groove Ball Bearing, Extremely Light Series
  - Bore dia. – 85 mm
  - OD – 120 mm
  - Width – 18 mm
  - Cage – two pc. Bronze & Riveted
  - Radially loaded bearing
- This bearing was a make to print, we at that time did not ask the questions *'tell me a story of what's around the bearing'*
- By us not asking the questions, our bearing was failing and we did not understand why

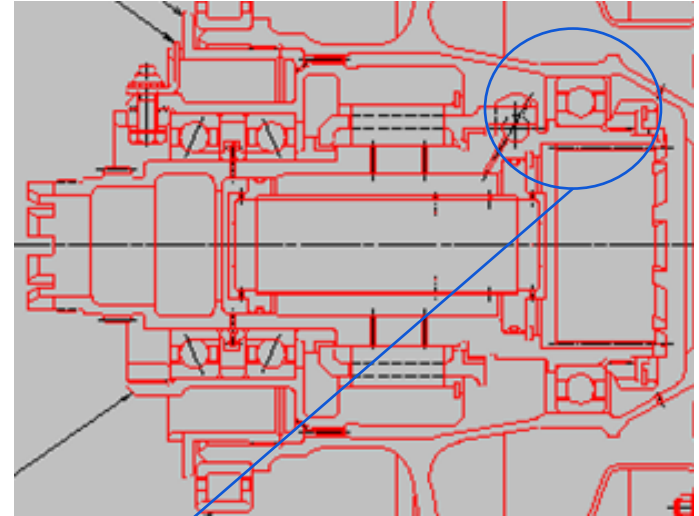
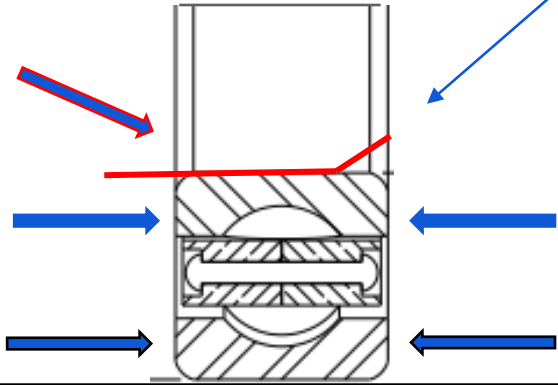


Figure 1

Shaft Geometry

Shaft Shoulder

No Housing Shoulders



Held by a Nut



# Brinelling

- False Brinelling (also known as wash boarding)

Occurs when the bearing is not running, there is no lubricant film between the rolling element and raceway. Asperity contact occurs and the vibration produces movement of the rings and rolling elements resulting in the removal of metallic particles removing the grind lines. This leads to a depression in the raceway.

- True Brinelling

A dent is produced by plastic flow of the raceway material. Remnant grinding marks are still noticeable in the complete dent.

# Action Items

- Temporary Solution – Increase rivet shank diameter
- Permanent Solution – Increase the partnership and dialog between us and the customer which included;
  - Communication and Openness
  - Sketch of the assembly
  - I.D. & O.D. fits
  - Nut Torque value
  - Set guidelines
    - No change to shaft or housing
    - Bearing bore to have complete footprint on shaft – no hang over permitted
    - No Nut Torque load changes permitted
    - New bearing to contain a one-piece machined cage
    - Minimize or eliminate brinelling opportunity
    - Weight increase must be minimal
    - Etc.

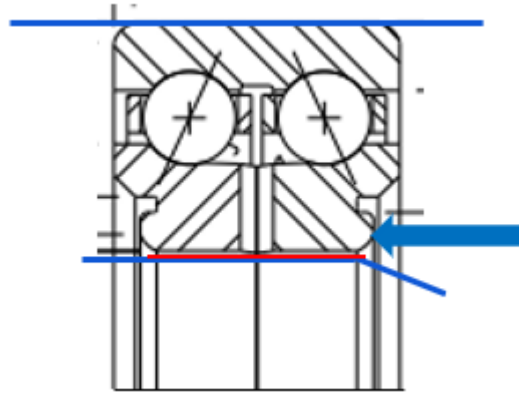
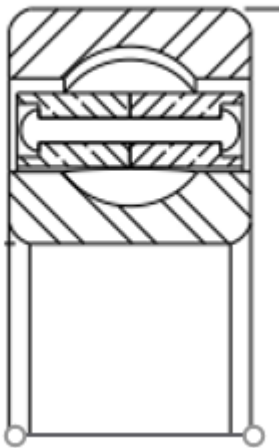


# The challenge and its achievements

- Solution – Double Row Angular Contact Ball Bearing

Inner Ring completely sits on shaft

Old Solution



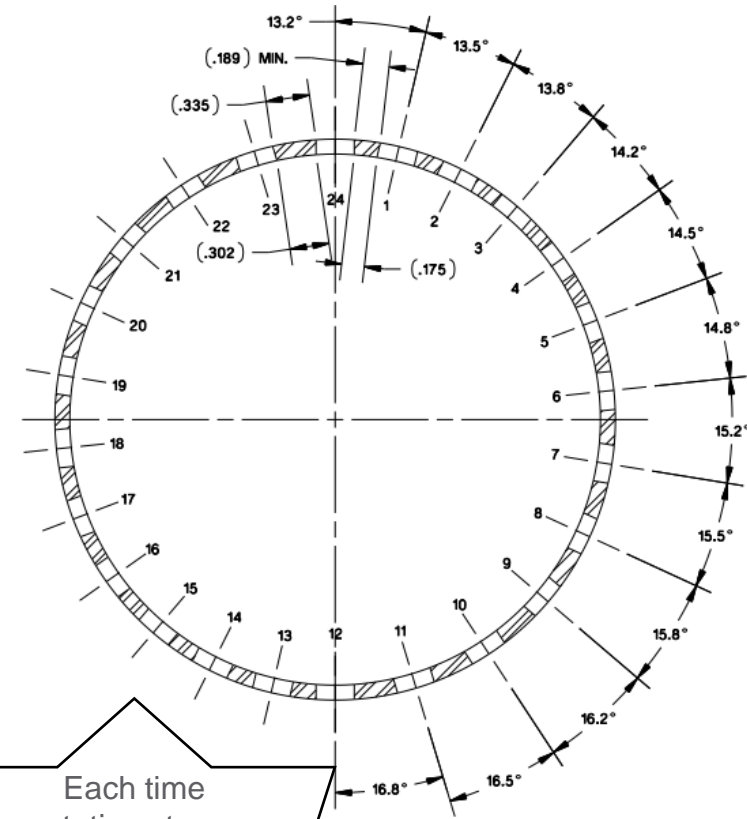
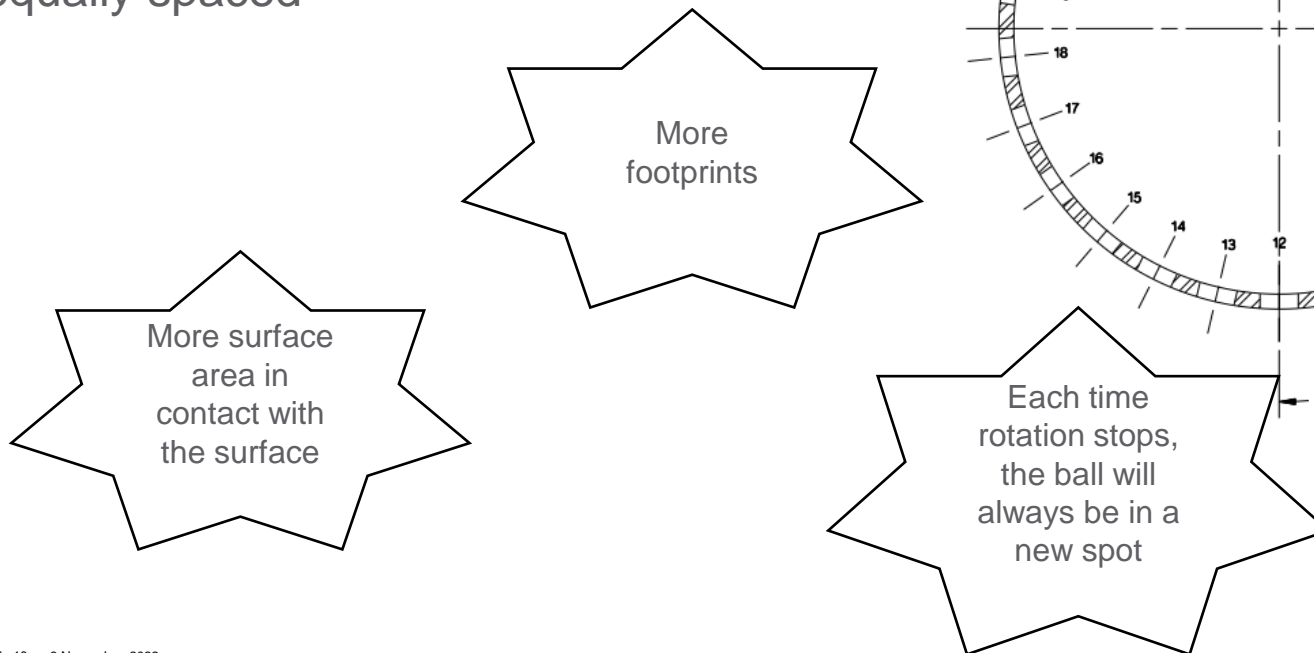
No Housing or Shaft Mods. required

No nut torque mods. required

Outer Ring is now stationary

# How to eliminate or minimize brinelling

- The new concept increased the ball quantity from 16 to 48
- Improved the contact ellipse of the ball to the raceway from 52% to 51.75%
- Cage pocket location was set to be not equally spaced



# Bearing Differences – Key Items

## Current Configuration

- Ball Qty. – 16
- Ball Dia. – 15/32”
- IRC – 0.0018” Nom.
- Raceway Curvature – 52%
- Race Depth – 22% Inner  
– 20.5%Outer
- Cage Style – 2 pc. Machined & Riveted
- \* Basic Dynamic Capacity – 7050 lbs.
- Ring Width – 0.706”
- Weight – 1.6 lbs.

## Improved Configuration

- Ball Qty. – 24 (per row)
- Ball Dia. – 9/32”
- IRC – 0.0035” Nom.
- Raceway Curvature – 51.75%
- Race Depth – 22% Inner  
– 20.5%Outer
- Cage Style – 1 pc. Machined & through pockets
- \* Basic Dynamic Capacity – 7282 lbs.
- Ring Width – 0.864”
- Weight – 1.8 lbs.

# SKF Calculation Tool Comparison

Tool	SHABERTH and PLANETSYS	SKF AeroBeast	SKF SimPro Expert	SKF BEAST
Quasi-Static Analysis	✓	✓	✓	✓
Dynamic Analysis	✗	✗	✗	✓
Flexible Bodies	Planetary	✗	✓	✓
Single Bearing	✓	✓	✓	✓
Single Shaft	✓	Future	✓	✓
Multiple Shaft	✗	✗	✓	✓
Planetary Gearbox	✓	Future	✓	✓
Press Fit and Clearance	✓	✓	✓	✓
Detailed contact analysis	✗	✗	✓	✓
Rolling element bearings	✓	✓	✓	✓
Plain bearings	✗	✓	✗	✓
Lundberg Palmgren Life	✓	✓	✗	✗
ISO Life	✗	✓	✓	✗
SKF General Bearing Life Model	✗ <small>SKF Proprietary Information</small>	✗	✓	✓

# Since Then – Design Improvements

- Swashplate Validation
- Ceramic Roller Misalignment Ability/Study
- Roller Qty. Optimization
- Roller Standardization
- Assembly – Validation that IRC is sufficient during Assembly
- Etc.

# Key Takeaway

On new or existing designs where one may have issues/concerns/ideas always have a conversation with your bearing supplier for they may have already experienced it somewhere in the world

*(‘tell me a story’)*

# Discussion

