

Article

Bearing Life Calculation and Experimental Evaluation of 6302-2RS Ball Bearing with Grease Lubricant Variations

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Abstract.

Rolling bearings are critical machine elements, but catalogue rating life and short-duration workshop observations must be interpreted separately. This study calculated the ISO 281 basic rating life of a Koyo/JTEKT 6302-2RS deep-groove ball bearing (JTEKT Corp., Kariya, Aichi Japan) and conducted a preliminary comparison of three lubrication treatments. The calculation used the current JTEKT basic dynamic load rating $C = 14.3 \text{ kN}$, an equivalent radial load $P = 98.1 \text{ N}$, and the ball-bearing exponent $p = 3$. Three bearings were used ($n = 1$ per treatment). Their seals were removed, the factory grease was cleaned out, and the specimens were either left without reapplied grease or manually filled with Cobra[®] Chassis Grease Green No. 3 or Deltalube[®] 056 General Purpose Grease EP 2; the applied grease mass was not recorded. Each specimen was tested sequentially for 30 min at 1000 rpm and 30 min at 1500 rpm under the same radial load. The corrected basic rating life was 3.097×10^{12} revolutions, equivalent to $5.162 \times 10^7 \text{ h}$ at 1000 rpm and $3.442 \times 10^7 \text{ h}$ at 1500 rpm. These very large values reflect an idealized rating-life calculation at a load far below the catalogue capacity and are not an experimentally validated service life. After cumulative testing, the recorded outer-diameter changes were 0.05 mm for the grease-free control, 0.03 mm for Cobra[®] grease, and 0.01 mm for Deltalube[®] grease; these changes are comparable with the stated caliper accuracy. At 1500 rpm, the outer-ring radial runout values were 0.30, 0.16, and 0.15 mm, respectively, while the inner-ring values were 0.09, 0.05, and 0.04 mm. Deltalube[®] grease produced the lowest observed dimensional change and runout under the present conditions, but the unreplicated, sequential test does not support statistical or long-term reliability claims.

Keywords: ball bearing; 6302-2RS; grease lubrication; basic rating life; dimensional change; radial runout

INTRODUCTION

Rolling bearings are essential machine elements in rotating systems because they support shafts, reduce friction, maintain alignment, and allow torque transmission with controlled motion. Deep-groove ball bearings are widely used in small industrial machines because of their compact geometry, availability, and capacity to carry radial load with limited axial-load contribution. The Koyo/JTEKT 6302-2RS (JTEKT Corp., Kariya, Aichi Japan) evaluated in this study is a contact-sealed deep-groove ball bearing with catalogue boundary dimensions $d \times D \times B = 15 \times 42 \times 13$ mm and a current basic dynamic load rating of 14.3 kN [1].

Bearing service life is strongly influenced by load, rotational speed, reliability level, and rolling-contact fatigue. Classical machine-design procedures and ISO-based bearing-life calculations estimate rating life from the relationship between the basic dynamic load rating and the equivalent dynamic load [2]. For ball bearings, the life exponent $p = 3$ is commonly used, which means that relatively small changes in load or operating condition can produce substantial changes in predicted bearing life [3]. ISO 281 also emphasizes that bearing-life calculation should be interpreted as a rating-life estimate rather than an absolute guarantee of field performance [4].

In practical operation, bearing performance is not determined only by theoretical load capacity. Lubrication condition, contamination, installation quality, temperature, vibration, and corrosion can accelerate premature damage even when a bearing operates below its nominal rating. Bearing-damage standards identify wear, corrosion, smearing, denting, and fatigue as common failure modes [5], [6], [7], [8]. Manufacturer guidance likewise emphasizes appropriate lubrication and contamination control [9].

Grease lubrication is often selected for sealed or semi-sealed bearings because it can be retained more readily than oil and can limit contaminant ingress. A suitable lubricant film reduces direct asperity contact, frictional heating, and corrosion [10], [11]. However, grease behaviour depends on more than nominal viscosity and dropping point; base-oil properties, thickener system, consistency, dosage, temperature, speed, churning, oil bleeding, and channeling all influence film formation and friction [12], [13], [14], [15].

Previous studies have combined remaining-life estimation, structural simulation, maintenance evaluation, and bearing-condition observation [16]–[23] [16], [17], [18], [19], [20], [21], [22], [23]. More recent rolling-bearing research shows that grease quantity and churning affect leakage, oil bleeding, and rheology [24]; initial viscosity influences churning-to-channeling behaviour [25]; viscosity, base-oil type, and thickener composition jointly affect friction torque and endurance [13]; and grease fill percentage affects film thickness in

deep-groove ball bearings [26]. These findings indicate that a higher viscosity or dropping point alone cannot establish lubricant superiority.

Accordingly, this study aims to (1) recalculate the ISO 281 basic rating life of a Koyo/JTEKT 6302-2RS bearing using traceable and unit-consistent catalogue data and (2) report preliminary descriptive observations of outer-diameter change and inner- and outer-ring radial runout for three grease treatments. The experiment is treated as an unreplicated workshop comparison rather than a statistically conclusive performance ranking.

METHODS

Research design and experimental workflow

This work used a quantitative engineering approach consisting of a catalogue-based basic rating-life calculation and a preliminary rotary experiment. Three 6302-2RS bearings were allocated to three treatments: cleaned control without reapplied grease, Cobra® grease, and Deltalube® grease ($n = 1$ bearing per treatment). The same specimen assigned to each treatment was tested sequentially at 1000 rpm for 30 min and then at 1500 rpm for 30 min under a nominal 10 kg radial load. Consequently, the 1500-rpm observations represent cumulative exposure after the preceding 1000-rpm stage. The laboratory record did not document a standardized cooling interval, intermediate cleaning, or grease reapplication between speeds; no inferential statistics were therefore applied. The main experimental inputs are summarized in Table 1.

Table 1. Bearing, specimen allocation, loading, and measurement parameters.

Parameter	Value or condition	Purpose / qualification
Bearing	Koyo/JTEKT 6302-2RS; $15 \times 42 \times 13$ mm; $C = 14.3$ kN	Calculation object and test specimen
Sample size	Three bearings; $n = 1$ per treatment	Preliminary descriptive comparison
Radial / axial load	98.1 N / 0 N	Equivalent load $P = 98.1$ N
Test sequence	1000 rpm for 30 min, then 1500 rpm for 30 min	Sequential cumulative test on each specimen
Test machine	MX-210V rotary/lathe-based setup	Rotary loading device
Bearing preparation	Seals removed; factory grease cleaned out; specimen dried and reassembled	Standardized starting condition as far as recorded
Grease dosage	Manually equalized by visual judgement; mass not weighed	Important reproducibility limitation
Caliper	INSIZE® digital caliper; 0.01 mm resolution; stated accuracy ± 0.03 mm	One recorded outer-diameter reading per stage
Dial indicator	INSIZE® dial indicator; 0.01 mm graduation; exact model/accuracy not recorded	Eight angular readings over 360°

Before lubrication treatment, the contact seals were removed and the factory grease was cleaned using diesel fuel followed by a petrol rinse; residual liquid was removed with compressed air and the bearings were air-dried. The control specimen received no grease after cleaning. Cobra[®] and Deltalube[®] greases were manually introduced after cleaning and visually equalized before reassembly, but the mass and fill percentage were not measured. The product properties in Table 2 were taken from manufacturer product information [24], [27]. Where a base-oil chemical type or viscosity test temperature was absent from the available sheet, it is reported as not stated rather than inferred.

Table 2. Lubrication treatments and manufacturer-reported grease properties.

Code	Treatment / product	NLGI / thickener	Base-oil information	Dropping point
TP	Cleaned control; no grease reapplied	Not applicable	Not applicable	Not applicable
GR1	Cobra [®] Chassis Grease Green No. 3	NLGI 3 / calcium	High-viscosity base oil; 15–25 cSt at 100 °C	102 °C
GR2	Deltalube [®] 056 General Purpose Grease EP 2	NLGI 2 / lithium complex	Chemical type not stated; 220–235 cSt; test temperature not stated	240 °C



Figure 1. Main specimens and equipment: (a) Koyo/JTEKT 6302-2RS bearing, (b) Cobra[®] Chassis Grease Green No. 3, (c) Deltalube[®] 056 General Purpose Grease EP 2, and (d) MX-210V rotary test machine.

Bearing-Life Calculation

The applied mass was converted to radial force using Equation (1), where F is force (N), m is mass (kg), and g is gravitational acceleration (9.81 m/s^2). Thus, a 10 kg indicated load corresponds to $F_r = 98.1 \text{ N}$.

$$F = m g \quad (1)$$

Because the calculation assumed radial loading only, $F_a = 0 \text{ N}$, $X = 1$, $Y = 0$, and the rotation factor $V = 1$. The equivalent dynamic load was calculated using Equation (2), giving $P = 98.1 \text{ N}$. All load terms were maintained in newtons.

$$P = (X F_r + Y F_a) V \quad (2)$$

The ISO 281 basic rating life at 90% reliability was calculated with Equation (3), where L_{10} is in revolutions, C is the basic dynamic load rating, P is the equivalent dynamic load, and $p = 3$ for ball bearings. The current JTEKT value $C = 14.3 \text{ kN} = 14,300 \text{ N}$ was used [1]. Equation (4) converts the revolution-based rating life to hours at rotational speed n in revolutions per minute.

$$L_{10} = (C / P)^p \times 10^6 \quad (3)$$

$$L_{10h} = L_{10} / (60 n) \quad (4)$$

Using $C = 14,300 \text{ N}$, $P = 98.1 \text{ N}$, and $p = 3$ gives $L_{10} = 3.097 \times 10^{12}$ revolutions. Because P is less than 1% of C , the resulting hour values are extremely large idealized fatigue-rating estimates. They should not be interpreted as an experimentally validated service life or a maintenance replacement interval.

Table 3. Corrected basic rating-life calculation for the Koyo/JTEKT 6302-2RS under a 98.1 N radial load.

Speed (rpm)	C (N)	P (N)	p (-)	L_{10} (rev)	L_{10} (h)
1000	14,300	98.1	3	3.097×10^{12}	5.162×10^7
1500	14,300	98.1	3	3.097×10^{12}	3.442×10^7

Rotary Testing, Dimensional Measurement, And Radial-Runout Measurement

After preparation, one bearing was assigned to each treatment. Each specimen was mounted on the MX-210V setup and tested first at 1000 rpm for 30 min and then at 1500 rpm for 30 min under the nominal 98.1 N radial load. The original record does not document a controlled cooling period, cleaning, or

grease replenishment between stages. Therefore, the second-stage data combine the effects of the 1000-rpm and 1500-rpm exposures. The bearing preparation, loading arrangement, and eight-sector inspection scheme are shown in Figure 2.

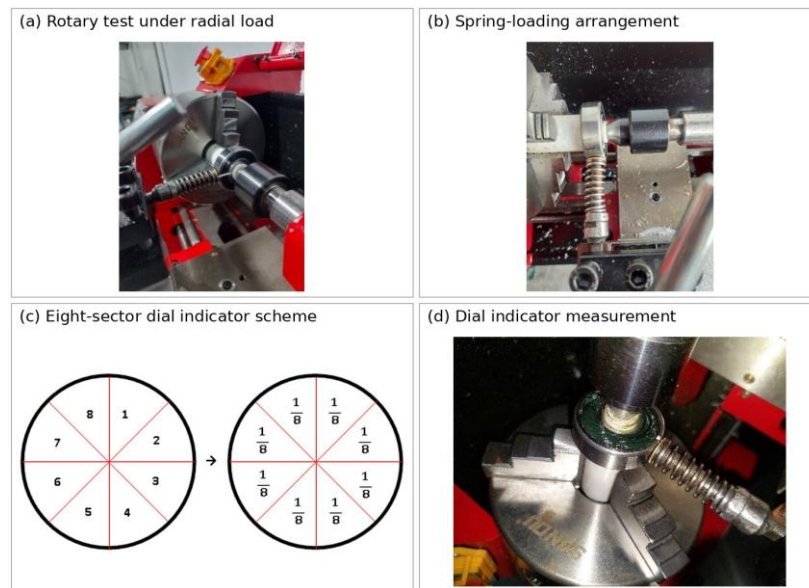


Figure 2. Rotary testing and measurement setup: (a) rotary test under radial load, (b) spring-loading arrangement, (c) eight-sector inspection scheme, and (d) dial-indicator radial-runout measurement.

Outer diameter was recorded with an INSIZE[®] digital caliper before testing, after the 1000-rpm stage, and after the 1500-rpm stage. The caliper resolution was 0.01 mm and the stated accuracy was ± 0.03 mm. The laboratory sheet contains one reading per specimen and stage and does not document repeated readings or the exact circumferential measurement line; measurement uncertainty is therefore at least the stated instrument accuracy. Dimensional change was calculated as $\Delta D = D_{\text{initial}} - D_{\text{final}}$. The original sheet also listed values of 13.50–13.68 mm as “thickness”; because the catalogue boundary width is $B = 13$ mm and the measured feature was not defined, those values were excluded and ΔB was not calculated.

The dial indicator was used to measure relative radial runout rather than flatness. The bearing was supported on the turned mandrel/fixture, the indicator probe was oriented normal to the selected cylindrical inner- or outer-ring surface, and the initial 0° sector was used as the zero reference. Readings were recorded at eight 45° sectors over 0° – 360° with a 0.01 mm graduation. For each ring, radial runout was calculated conventionally as $R = x_{\text{max}} - x_{\text{min}}$. Inner- and outer-ring runout are reported separately; the former “combined maximum loss” obtained by adding two unrelated maxima was removed because it lacks a direct geometric definition.

RESULTS AND DISCUSSION

Theoretical Bearing-Life Result

The corrected calculation in Table 3 gives a basic rating life of 3.097×10^{12} revolutions. Converting this value to operating time gives 5.162×10^7 h at 1000 rpm and 3.442×10^7 h at 1500 rpm. The reduction in hour-based life with increasing speed is purely the result of consuming the same calculated revolution capacity more rapidly. The magnitude is dominated by the very low equivalent load relative to $C = 14.3$ kN and should be understood as an idealized ISO 281 rating-life result, not a forecast of actual workshop life.

Recorded Outer-Diameter Change After Rotary Testing

Table 4 reports the recorded outer diameter before and after each sequential speed stage. The term dimensional change is used instead of wear because the caliper method does not identify the underlying wear mechanism and the observed changes must be considered relative to the instrument accuracy.

Table 4. Recorded outer-diameter change during sequential rotary testing (one reading per specimen and stage)

Stage (rpm)	Treatment with grease	D_initial (mm)	D_final (mm)	Stage ΔD (mm)	Cumulative ΔD (mm)
1000	Cleaned control	42.00	41.97	0.03	0.03
1000	Cobra®	42.00	41.98	0.02	0.02
1000	Deltalube®	42.00	41.99	0.01	0.01
1500	Cleaned control	41.97	41.95	0.02	0.05
1500	Cobra®	41.98	41.97	0.01	0.03
1500	Deltalube®	41.99	41.99	0.00	0.01

After the 1000-rpm stage, the recorded outer-diameter changes were 0.03 mm for the cleaned control, 0.02 mm for Cobra® grease, and 0.01 mm for Deltalube® grease. During the subsequent 1500-rpm stage, the incremental changes were 0.02, 0.01, and 0.00 mm, respectively, producing cumulative changes of 0.05, 0.03, and 0.01 mm. Thus, Deltalube® grease produced the smallest recorded change in this test sequence.

These differences require cautious interpretation. The caliper accuracy was ± 0.03 mm, only one reading was recorded at each stage, and the exact measurement location was not documented. The 0.01–0.03 mm changes for the greased specimens are therefore within or comparable to the stated instrument accuracy, while even the 0.05 mm control change remains based on a single sequential specimen. The data provide preliminary descriptive observations and do not establish a statistically significant wear reduction.

Radial-Runout Response

Table 5 reports inner- and outer-ring radial runout calculated as the maximum-minus-minimum dial-indicator reading. Figure 3 presents the two ring measurements separately; no combined-deviation parameter is used.

Table 5. Inner- and outer-ring radial runout from eight-sector dial-indicator measurements.

Speed (rpm)	Treatment with grease	Inner-ring runout (mm)	Outer-ring runout (mm)
1000	Cleaned control	0.04	0.20
1000	Cobra®	0.05	0.12
1000	Deltalube®	0.04	0.08
1500	Cleaned control	0.09	0.30
1500	Cobra®	0.05	0.16
1500	Deltalube®	0.04	0.15

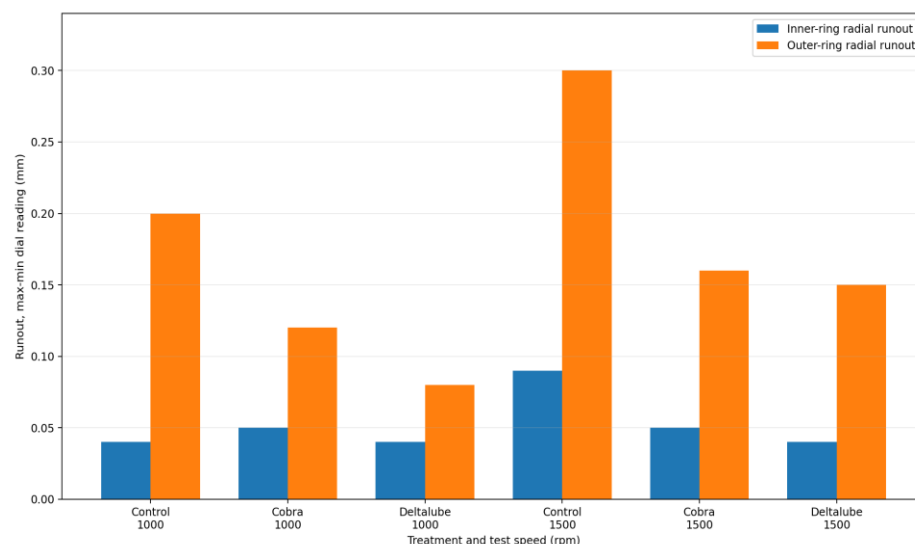


Figure 3. Inner- and outer-ring radial runout calculated as the maximum-minus-minimum dial-indicator reading for each treatment and speed

At 1000 rpm, outer-ring runout was 0.20 mm for the cleaned control, 0.12 mm for Cobra® grease, and 0.08 mm for Deltalube® grease; inner-ring values were 0.04, 0.05, and 0.04 mm. At 1500 rpm, outer-ring runout increased to 0.30, 0.16, and 0.15 mm, while inner-ring runout was 0.09, 0.05, and 0.04 mm. Under the present fixture and sequence, the two greased specimens showed lower outer-ring runout than the control, and the Deltalube® specimen produced the lowest or joint-lowest observed values.

The observed ordering cannot be attributed solely to the higher viscosity and dropping point of Deltalube® grease. Grease quantity and churning can alter leakage, oil bleeding, heat generation, and rheology [28]; initial viscosity affects channeling behaviour and grease transport by the cage [25]; and excessive

viscosity can increase friction torque under some operating conditions [13]. Grease fill percentage also influences film thickness and starvation in deep-groove ball bearings [26]. Because grease mass, operating temperature, friction torque, and film thickness were not measured here, the present data only show an association between treatment and the recorded geometric response.

Maintenance Implication and Limitations

For maintenance practice, the results support controlling lubricant identity, dosage, cleanliness, and application procedure rather than selecting grease from viscosity or dropping point alone. Within this unreplicated test, the Deltalube[®]-treated specimen produced the lowest observed cumulative outer-diameter change and the lowest outer-ring runout. This result is useful for generating a hypothesis for a controlled follow-up experiment, but it does not establish a universally superior grease or demonstrate improved service reliability.

The main limitations are $n = 1$ per treatment, sequential rather than randomized speed stages, unmeasured grease mass and fill percentage, no documented cooling or reapplication interval, one caliper reading per stage, incomplete instrument-model records, and no temperature, torque, vibration, microscopy, or long-duration fatigue measurements. The reported 13.50–13.68 mm “thickness” data were excluded because they conflict with the 13 mm catalogue width and the measured feature was not documented. Future work should use independent replicated specimens for each speed-treatment combination, gravimetrically controlled grease fill, randomized test order, calibrated instruments with repeated readings and uncertainty analysis, temperature and torque monitoring, and microscopic surface characterization.

CONCLUSION

Using the current JTEKT basic dynamic load rating $C = 14.3$ kN, equivalent load $P = 98.1$ N, and $p = 3$, the corrected ISO 281 basic rating life of the 6302-2RS bearing is 3.097×10^{12} revolutions, corresponding to 5.162×10^7 h at 1000 rpm and 3.442×10^7 h at 1500 rpm. These values are idealized catalogue rating-life estimates under a very low load and are not experimentally validated service-life predictions. In the sequential workshop test, cumulative recorded outer-diameter change was 0.05 mm for the cleaned control, 0.03 mm for Cobra[®] grease, and 0.01 mm for Deltalube[®] grease. At 1500 rpm, outer-ring radial runout was 0.30, 0.16, and 0.15 mm, respectively, and inner-ring runout was 0.09, 0.05, and 0.04 mm. Thus, the Deltalube[®]-treated specimen produced the lowest observed dimensional change and radial runout under the present conditions. Because only one specimen was used per treatment and grease dosage and measurement replication were uncontrolled, these findings are preliminary descriptive observations and require replicated, instrumented

testing before any lubricant-performance or reliability recommendation is generalized.

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