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Methods of test for petroleum and its products —

Part 168: Determination of rolling bearing performance of lubicating grease
(Identical with IP 168:2003)

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British Standards

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Summary of pages

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Determination of rolling bearing performance of lubricating grease

This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations.

1. INTRODUCTION

1.1 A rolling bearing performance test rig has been developed for general application to the dynamic evaluation of lubricating greases. The rig is of robust, simple construction. Two test bearings, each radially loaded only, can be used simultaneously, and controlled heating of the test bearing is provided.

2. SCOPE

2.1. The method may be used to evaluate a lubricating grease with respect to its ability to lubricate rolling bearings under specified operating conditions and to assess the stability of the grease with respect to physical changes, excess oil separation, and leakage.

3. SUMMARY OF METHOD

3.1. The grease is tested in a previously run-in rolling bearing for a nominal time of 500 h under selected conditions of applied radial force (1334 N max) with or without applied heat (177°C max) (but see Annex B) and at a speed of up to 1047 rad/s (10,000 rev/min).

The performance of the grease is evaluated by assessing bearing cage wear and the physical changes of the grease.

4. SIGNIFICANCE AND USE

4.1. This method is used to evaluate the ability of a grease to provide adequate lubrication for extended periods of rolling bearings operating under light load at various speeds and temperatures. It is used for specification purposes.

5. APPARATUS

5.1. *Test Rig* – a power operated rig (Fig. 1) as described in Annex A, A1–4, mounted on a heavy base, preferably of cast iron, to ensure rigidity.

5.2. *Test Bearing Assembly* – of the form and dimensions shown in Fig. 2.

5.3. *Cage Float Measuring Fixture* – as described in Annex A, A5.

5.4. *Test Bearing* – as described in Annex A, A5.

NOTE 1: In order to comply with the procedure for assessing the confidence level of the test results (Section 10) it is necessary to carry a minimum stock of six test bearings.

6. MATERIALS

6.1. *Cleaning Solvent* – petroleum spirit 60/80, conforming to the IP Specification, see Appendix B.

6.2. *Anti-fretting Grease* – any proprietary material may be used.

6.3. *Grease* – a known satisfactory grease for running-in the test bearing.

7. PREPARATION OF APPARATUS

7.1. Make these preparations under clean conditions.

7.2. Assemble the following parts for each end of the rig:

7.2.1. Test bearings – See Annex A.

For this test either a new bearing or a bearing from a previous test may be used provided it is still within the limits of cage float. When a previously used bearing is employed, certain parts of the procedure listed below may be omitted. A new bearing must be run-in for 50 hours before the test, using a known satisfactory grease at a speed of 733 rad/s (7000 rev/min) under a load of 1334 N without applied heat. If the mean cage float increase during this running-in period exceeds 0.125 mm the bearing should be rejected.

7.2.2. front and rear covers with their securing bolts;

7.2.3. housing ring;

7.2.4. shaft adaptor;

7.2.5. clamping cup, washer and bolt;

7.2.6. air spinner.

7.3. Wash the bearing by lightly spinning it in successive quantities of cleaning solvent until clean and free from grease or rust preventive. Do not spin in a dry state.

7.4. When the bearing is clean and dry, number the crowns of the eight waves of the cage 1–8 clockwise on one side of the cage [Note 2].

NOTE 2: If the bearing is supported in the lower half of the cage float measuring fixture, the number can be marked on the cage. If an electric pencil is used electrical contact direct with the cage must be obtained through the measuring fixture.

7.5. Make and record repeatable measurement of cage float for the eight numbered positions of the cage, using the measuring fixture as follows:

Place the bearing centralizing ring over the back clamping plate and insert the adaptor sleeve. Place the washed and numbered bearing in position and fit the outside clamping ring with the numbers on the face coinciding with those on the respective cage pockets.

Secure the assembly with the clamping nut and remove the centralizing ring. Place the assembly on the bracket stud and clamp it securely in position with the locknut.

The apparatus is now ready for measuring the radial float of the cage across two diametrically opposite pockets. Proceed as follows:

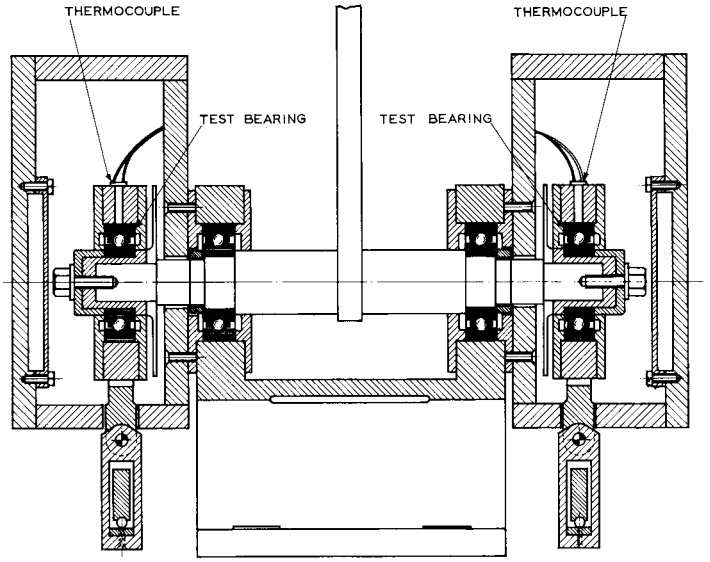


Fig. 1. Test rig.

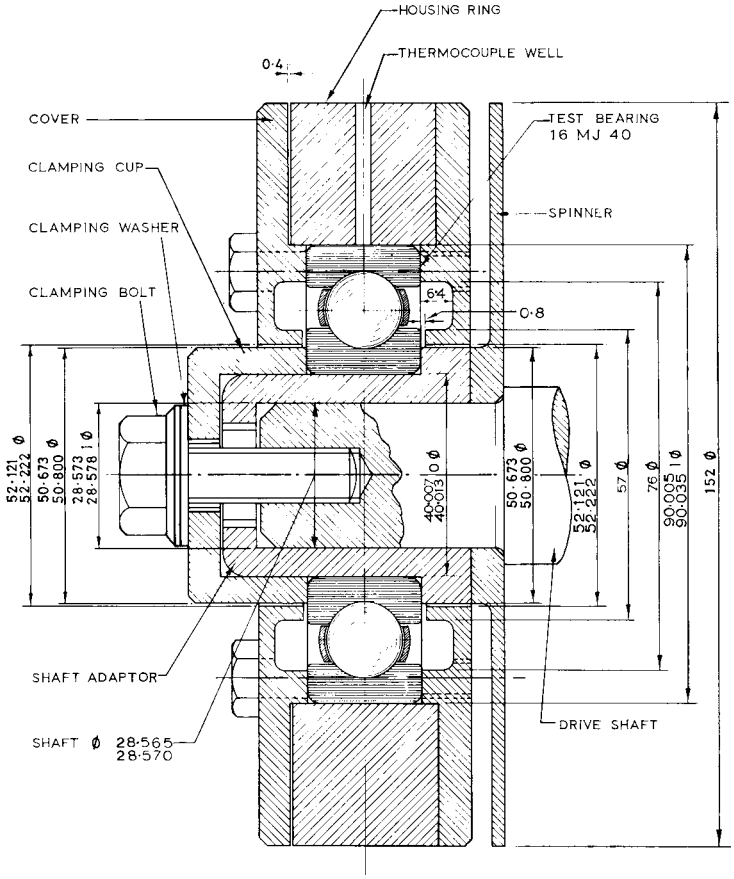


Fig. 2. Test bearing assembly.

7.5.1. Ensure that the centre line of the cage pockets to be measured is in line with the anvil of the clock indicator.

7.5.2. Remove the lever pin and gently lower the lever.

7.5.3. Set the clock indicator to zero.

7.5.4. Lift the lever so that it is not in contact with the bearing and read the cage float (0.01 mm) registered on the clock indicator. Raise and lower the lever several times until a repeatable reading is obtained.

7.5.5. Refit the lever pin, loosen the locknut, and turn the bearing assembly in an anti-clockwise direction until the next numbered pocket is in line

with the indicator anvil. Tighten the locknut and repeat the operation.

Reject any bearing which has a float measurement outside the range 0.38 to 0.76 mm in any position.

7.6. Examine all the rig parts closely (Sections 7.2.3. to 7.2.6.), and carefully remove any stains, deposits, and burrs. Thoroughly wash the parts in cleaning solvent and polish clean with a non-fraying cloth.

7.7 Wash the bearing again as described in Section 7.3., and when dry fit it on to the shaft adaptor (which has been lightly smeared with the test grease) and push it home against the shoulder of the adaptor. Weigh this assembly and firmly pack the test grease into the bearing from both sides, using a clean metal spatula and smoothing the grease flat and flush with the bearing faces. Reweigh the assembly and adjust the weight of the grease in the bearing to equal that of 30 ± 1 ml of the test grease. Record the final weight of the assembly and that of the two covers, make all weighings to the nearest 0.1 g. If the density of the grease is not known, it shall be determined using a pyknometer method, e.g. as detailed in IP 190, or BS 4699.

The weight in grams is given by w = density $\times 30 \pm 1$ ml.

NOTE 3: Alternatively the test bearing can be fitted after packing with grease and adjusting to the correct weight.

7.8. Slide the housing ring over the bearing, place the front and rear covers into position into the housing ring, and secure the whole with the cover screws or nuts and bolts. Fit the air spinner to the shaft.

7.9. Wipe the end of the rig spindle clean and apply to it a thin film of anti-fretting grease. Fit the test bearing housing assembly on to the spindle, place the clamping cup in position, and tighten with the clamping bolt and washer.

7.10. Assemble the loading arrangement, gently apply the specified loads and turn the rig shaft two or three revolutions by hand to ensure freedom.

7.11. Check the radial run-out of the test bearing with a dial indicator. The radial run-out must not exceed 0.0125 mm.

7.12. Place the test bearing temperature recording thermocouple into position in the housing ring, ensuring that the hot junction bead is in contact with the outer race of the bearing.

8. PROCEDURE

8.1. Make up to six tests in accordance with Section 10.

8.2. *No Applied Heating.*

8.2.1. Using the oven retaining pins, fit the mesh guard with the bottom flap in the horizontal position. The ovens are not fitted hence the test bearing is fully exposed to the air.

8.2.2. Start the rig. For tests of up to and including 733 rad/s (7000 rev/min) the speed shall be obtained in 30 sec. Speeds of greater than 733 rad/s (7000 rev/min) and up to 1047 rad/s (10,000 rev/min) shall be reached as quickly as possible within a maximum time of 15 min. Tolerance on any specified speed shall be $\pm 5\%$.

8.2.3. Record ambient and bearing temperatures so that the bearing peak temperature, the difference between peak and ambient temperature, and the settled (running) temperature can be reported.

8.2.4. Run the rig continuously for the first 50 hours of test. Stop and restart the rig as convenient after the first 50 hours, but it *must* be stopped and allowed to cool down to normal ambient temperature at least once a week during the remainder of the specified test duration (500 hours total).

8.2.5. Do not remove the bearing housing covers or slacken their bolts, or remove the applied load, during the test.

8.3. *With Applied Heating.*

8.3.1. Proceed as in Section 8.2. except as follows. The oven, with the vents open, is fitted in place of the mesh guard before the rig is started. When the bearing temperature has reached its peak and started to fall or after 24 hours of running, whichever is the earlier, close the oven vents and fit the mesh guard over the oven with the bottom flap in the vertical position. Switch on the heaters and adjust the control to maintain the specified temperature. The 500 hours running time starts when the heaters are switched on.

NOTE 4: After stopping for the weekly cool-down periods, restarts should be carried out with particular attention to the applied heating so that the specified bearing temperature is not exceeded. In the event of high peak temperatures after restarting, heat should not be re-applied until the bearing temperature has fallen below that specified.

8.4. *Dismantling the Rig after Test.*

8.4.1. Release the load. Unscrew the clamping bolt, remove with the clamping cup and washer, and withdraw the test bearing and housing from the spindle as a whole with a suitable extractor.

8.4.2. Unbolt the front and rear covers and remove them from the housing ring. Remove all grease and oil excepting that which is contained in the cover grooves and bores. Slide the bearing out of the housing ring on the shaft adaptor. Weigh the bearing assembly and covers together with the remaining grease.

9. INSPECTION AND REPORT

9.1. *Grease Loss Rating* – Subtract the weight obtained in 8.4.2 from the original weight of the grease assembly, obtained in 7.7, and calculate the grease loss as a percentage of the weight of the original grease pack.

Grease loss rating is as follows:

Rating	Grease weight loss as a % of the original grease pack
1	Less than 7.0%
2	From 7.0% to 17.5%
3	From 17.6% to 35.0%
4	Greater than 35.0%

9.2. *Used Grease Rating* – Determine by comparison with the unused grease the extent to which the used grease has changed, as follows:

9.2.1. *Softening or Hardening* – Estimate by touch the softening or hardening of the grease contained in the covers and rates as follows:

Rating	
(1)	Unchanged or slight change
(2)	Marked softening or hardening

9.2.2. Report other marked changes, e.g. colour and/or texture.

9.3. *Lubricating Rating* – Examine the bearing and rate it for lubrication quality as follows:

Rating
(1) Bearing surfaces greasy or oily.
(2) Bearing discoloured and/or showing lacquer or hardened grease.
(3) Bearing dry and/or traces of metal particles discernible in the grease.

9.4. *Cage Wear Rating* – Measure and record cage float for the eight numbered positions of the cage and calculate the increases using the original measurements made under Section 7.5 as follows:

Rating	Mean cage float increase, mm
(1)	to 0.05
(2)	greater than 0.05 to 0.10
(3)	greater than 0.10 to 0.15
(4)	greater than 0.15 to 0.20
(5)	greater than 0.20

9.5. *Reporting* – Report the results in the form shown in the Test Report, Annex C [Note 5], as the Rolling Bearing Performance Test, IP 168.

NOTE 5: This is the minimum information required. Any other pertinent observations should be reported.

10. PRECISION

10.1 As it is impracticable to specify the precision of this method by the procedures given in Appendix E the confidence level of the test results should be assessed as given below.

The object of testing a grease by this method will usually be to see if the grease meets some specified level of performance which will be based on the assessments described in Section 9. Several tests should be carried out and each should be classified as meeting or failing to meet the specified level.

10.1.1. Use the following procedure for assessing the performance of greases (see Note 6).

NOTE 6: When agreed betweeen parties, a single test may run using just one pair of bearings.

10.1.1.1. If at any time two results which fail to meet the specified level have occured, stop testing. This grease then fails to meet requirements.

10.1.1.2 If after four tests only three have met the specified level or performance, carry out two further tests; if these final two meet the specified level, the grease meets requirements.

10.1.1.3 If after four tests there have been four results which have met the specified level of performance, the grease satisfies the requirements.

Tests need not be done consecutively, though four tests should be completed before the final two, if required, are started.

10.1.2. If the procedure described in Section 10.1.1. has been followed, a grease which just fails to meet the required level of performance will have a one in eight chance of being accepted by the test. A good grease, in this context, will have at least a 7 in 8 chance of being accepted by this test.

This confidence level has been confirmed by co-operative tests using the procedure described in Section 9.1.1. at 60°C and 1047 rad/s (10,000 rev/min), 121°C and 733 rad/s (7000 rev/min), 150°C and 524 rad/s (5000 rev/min), and 177°C and 419 rad/s (4000 rev/min).

If it is desired to use test temperatures or spindle speeds intermediate to these combinations but within the maximum temperature of 177°C and maximum speed of 1047 rad/s (10,000 rev/min), then the product of the temperature in °C and the speed shall not exceed 73,000 (where the speed is in rad/s) or 700,000 (where the speed is in rev/min).

ANNEX A

A1. *Rolling Bearing Test Rig* – a power operated test rig consisting of a belt driven shaft, mounted on pedestals so that a test rolling bearing can be set in a housing at each end. A stirrup is fitted to pins, set diametrically at each side of the housing, and the base of the stirrup is connected to a lever. At the end of the lever arm a carrier for weights is attached to a tension spring. The weights are of the disk type such that forces of between 226 and 1334 N can be applied to the bearing. Forces must be normal to machine spindle axis.

For operating with applied heat, small air ovens, electrically heated and temperature controlled, are provided.

The rig incorporates the following:

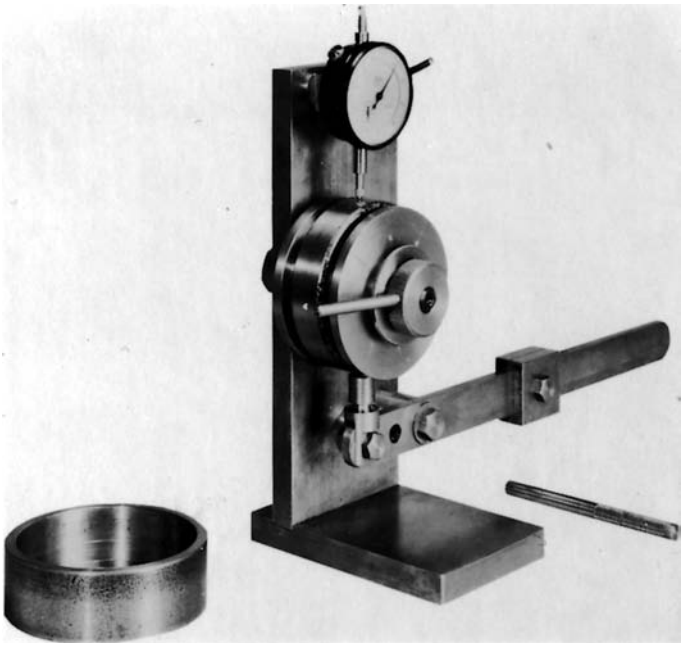
A2. *Electric Motor* – any suitable type may be used fitted with a variable speed drive capable of driving up to shaft speeds of 1047 rad/s (10,000 rev/min). The belt drive to the shaft should be endless.

A3. *Oven* – of heat resistant insulating material, internal dimensions $254 \times 127 \times 216$ mm, fitted to enclose bearing and stirrup. The oven shall be equipped with a suitable heater (1200 W minimum) fitted on the oven wall opposite the bearing housing. Temperature control must be by means of a thermocouple on the bearing outer ring. An aperture is provided for the arm of the stirrup to pass through the base of the oven to the lever attachment. A dual purpose mesh guard is supplied to give protection against burns from the outer surfaces of the oven during heated tests and to guard the rotating parts of the rig when the oven is not fitted.

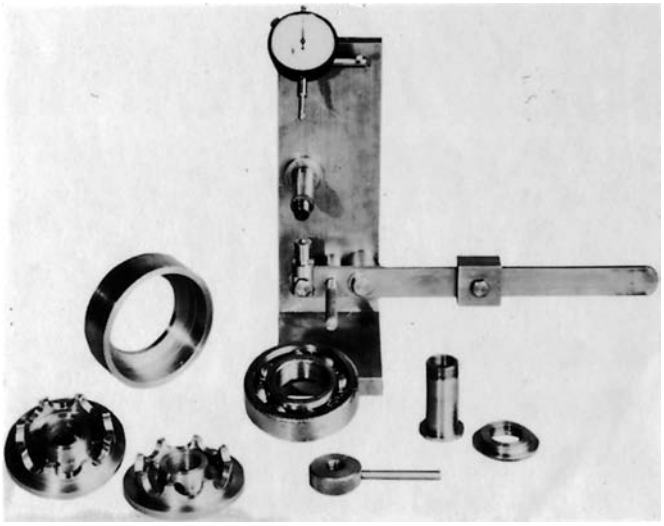
A4. *Thermocouple and Temperature Indicator* – suitable for indicating bearing temperatures up to 200°C and the thermocouple located in the hole provided in the housing such that the hot junction is in contact with the outer ring of the bearing.

The ambient temperature shall be measured at a point 300 mm above the centre of the test shaft.

A5. *Ancillary Equipment.*



(a) Assembled ready for use



(b) Exploded view showing the various parts

Fig. 3. Cage float measuring fixture.

A5.1. *Cage Float Measuring Fixture*[1] – as illustrated in Fig. 3 (*a*) and (*b*).

A5.2. *Test Bearings* – conforming to the following specification:

Type: 8-ball, single row, deep groove.

6308, $40 \times 90 \times 23$ mm, Group 3 fit. The standard 6308 bearing will be satisfactory for tests carried out at temperatures up to 120°C. The special test bearings, designated 16MJ40[1] or 16MJ40JW[1] will be satisfactory for tests carried out at temperatures up to 200°C.

Cage: pressed steel, centred on the balls. Shall allow measurement of the cage float using the cage float measuring fixtures (A5.1).

Cage float (radial): 0.38 to 0.76 mm, variation between maximum and minimum pockets to 0.2 mm max.

[1]The names of suppliers may be obtained on application to the Institute of Petroleum.

ANNEX B

ADDITIONAL RECOMMENDATIONS

B1. Hardened surfaces should be used on all rotating parts to minimize bruising or any damage to seatings of clamping faces. The rig components must be tempered to be dimensionally stable for tests carried out at 150°C, 177°C or higher temperatures.

B2. Flats may be ground on the shaft to hold it while tightening or loosening the bearing locking bolts but the preferred method is to use a special clamp on the shaft. The central hole in the locking caps must be threaded to provide for easy removal.

B3. To reduce belt slipping, the rig shaft at the point where the belt is passed around it should be parallel and the driving pulley should be crowned to give a diameter difference: maximum diameter ratio of 0.02.

ANNEX C

ROLLING BEARING PERFORMANCE TEST LUBRICATING GREASE

IP 168/93

Test Report

Test Reference .....
Grease Description or Ref. .....

Conditions of Test
- Speed of rad/s .....
- Speed in rev/min .....
- Radial Force .....
- Temperature Condition .....
- Duration (h) .....
- Grease Charge to Bearing 30 ± 1 ml. (None in covers.)

Bearing Designation .....

Summary of Observed Temperature Operating Conditions
- (1) Bearing Peak °C .....
- (2) Bearing Settled °C (for unheated tests only) — min ..... max ..... mean .....
- (3) Hours to reach settled temperature
- (4) Ambient °C, — min ..... max ..... mean .....
- (5) Difference between (2) and (4), mean (for unheated tests only)

Grease Weight Loss Rating .....

Used Grease Rating
- (i) Softening or Hardening .....
- (ii) Other Changes (remarks only) .....

Lubrication Rating .....

Cage Wear Rating .....

Remarks .....
.....
.....
.....

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