Bearing designs
Bearing testing

Extract from the Railway technical handbook, volume 1, chapter 4, page 99 to 105
Bearing testing

The key for long-term reliability and performance of railway rolling stock is rigorous testing. SKF axlebox bearings and units are tested in the Railway Test Centre at the SKF Business and Technology Park in Nieuwegein, the Netherlands. In this centre, complete axleboxes with surrounding parts such as bogie frame interfaces are tested as well as bearing units and components such as seals and cages. This facility complies with the accreditation criteria for test laboratories according to ISO/IEC 17025 (→ page 23). Further test rigs are located at the development centres and production units [22, 23].

There are different testing standards and requirements such as European EN and American AAR, to be fulfilled as well as national requirements in many European countries, China and Russia and requirements by individual customers.

For safety and long-term reliability, rigorous testing procedures are applied before introducing new axlebox bearing designs for different speeds and axleloads.

The EN 12082 standard is an important tool for manufacturers of bearings, bogies and rolling stock as well as railway operators. It provides details on principles, methods and equipment to test assembled axleboxes in test rigs along with criteria for acceptance. This standard describes two main types of testing, rig performance and field testing.
Seal testing

Water spray test
The water spray test is mentioned in the European Standard EN 12082 as a watertightness test, and in UIC 515-5 as well as other specifications. The test principle consists of water that is sprayed with a sprinkler device between the back of the sealed unit mounted on a dummy shaft and a simulated wheel. These tests are conducted under different operating conditions such as bearing speeds, angle of water spray flow, etc.

Arizona dust test
The test rig is based on a simulation of dust entry into the axlebox bearing under operating condition. The Arizona dust is a standard test medium for this application.

Seal friction test
The SKF seal friction test is a tool to evaluate wear, friction torque and sealing capability under severe operating conditions. The test rig consists of four different test machines.
Grease testing

The minimum requirements for greases for axlebox applications are mentioned in the European Standard EN 12081. This standard is focused on lithium soap grease, NLGI grade 2 (National Lubricating Grease Institute). The standard reflects very much the use of a grease with mineral base oil having a viscosity of 100 mm²/s at 40 °C, which is most commonly used. However, the standard does not restrict the use of other greases for more demanding applications. For example, bearing units for high-speed applications can be lubricated using greases with lower base oil viscosity.

V2F grease test

The SKF V2F grease testing machine monitors the mechanical stability of the grease. Under dynamic conditions, leakage could occur because in the case of non-mechanically stable greases, the thickener structure would break and consequently the grease will become liquid and run out from the housing. The SKF V2F grease testing machine consists of an SKF W4A railway axlebox with labyrinth seal fitted with two spherical roller bearings 229 750/C3. During the testing, a 50 kg hammer falls every second on the axlebox to simulate dynamic shocks. The results of this V2F test correlate very much with practical field experience. This SKF V2F test is mentioned in EN 14865 as a method to test mechanical stability of axlebox grease for vehicle speeds up to 200 km/h [24].
Quasi-static performance testing

The EN 12082 quasi-static test involves two axleboxes mounted on a test rig and subjected to repeated loading cycles that reflect accurately the operating conditions of the intended application. For bearings, performance is gauged by monitoring the operating temperature throughout the test. The values of absolute and relative temperatures have to remain within certain limits. After the test, bearings and grease have to be examined and findings are documented.

For railway vehicles with a speed limit up to 200 km/h, the test rig has to be run for an equivalent service distance of 600 000 km. Above this speed, the test distance is increased to 800 000 km. For less demanding conditions and for minor changes in proven designs, shorter distances are recommended. If particular conditions for similar rolling bearings, grease or axlebox housings are altered, a reduced test regime can be sufficient, as long as the overall performance is predictable and stable. Unless otherwise agreed, the cumulative distance covered in this case is 100 000 up to 200 000 km.

The SKF R3 railway bearing test rig has evolved through considerable experience in evaluating railway bearing performance. The rig design complies with EN 12082 requirements. This test machine, including the electronic control unit, is produced by SKF and several institutes and customers are using this SKF technology for axlebox bearing validation testing. The rig consists of a shaft with two support bearings that are mounted inboard. The axlebox bearings are fitted on both ends of the shaft. Actuators provide radial and axial forces. After a “running in” phase with speed increased in steps, the rig repeats identical cycles at maximum speed. Typically, such tests involve two hours of rotation in each direction, separated by a short stop. Fans directed at the axleboxes give a similar cooling effect as that experienced during actual operation. Performance is monitored by measuring temperature in a minimum of three positions. Normally, these measurements take place above the load zone of each bearing row in contact with the outer ring and above the scanning zone of the infrared temperature scanners, known as hot box detectors, along the track (page 48). The maximum temperature of the bearing in the load zone and hot box detection zone is monitored. After the running in phase the temperature difference of the two tested axlebox bearings is recorded. During the test, the temperature has to be inside the specific limits, otherwise the test has to be stopped. No defect in lubrication, and no bearing defects like spalling, breakage or seal failures shall occur. SKF operates a battery of several R3 test rigs in the SKF Railway Test Centre located at the SKF Business and Technology Park in Nieuwegein, the Netherlands.
**Test rig principle of the EN 12082**

The axlebox bearings are mounted on both ends of the shaft. Actuators provide radial and axial forces. Fans on both sides simulate the wind cooling while travelling.

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**Graphical presentation of test cycles that are described in detail in EN 12082**

- **Key**
  1. speed variation
  2. pre-test
  3. performance test
  4. detail of one test cycle
  5. radial force
  6. axial force variation (force at pre-test as agreed ...)
  7. detail of time history of axial force (enlarged time scale)
**Dynamic testing**

Beyond the quasi-static performance testing, the behaviour of new bearing and axlebox designs is evaluated under more realistic operating conditions. SKF has developed a sophisticated test rig called THISBE (test rig for high-speed bearings) which can simulate dynamic load conditions (→ chapter 3). Here, the bearing and axlebox are fitted in a part of an actual bogie frame, including the suspension system with springs and dampers. The load and speed spectra can be taken directly from field recordings or from specifications from customers or institutes.
Field testing
This second step of the EN 12082 performance testing is usually done after the rig testing. For main line vehicles with a speed limit up to 200 km/h, the rig and field tests should last the equivalent of two years, or 600 000 km. Above this speed, the distance is increased to 1 million km. The number of axleboxes tested must be agreed between customer and supplier. During the test period and the inspection afterwards, no defect in lubrication, or bearing defects like spalling, breakage or seal failures shall occur.
The Power of Knowledge Engineering

Drawing on five areas of competence and application-specific expertise amassed over more than 100 years, SKF brings innovative solutions to OEMs and production facilities in every major industry worldwide. These five competence areas include bearings and units, seals, lubrication systems, mechatronics (combining mechanics and electronics into intelligent systems), and a wide range of services, from 3-D computer modelling to advanced condition monitoring and reliability and asset management systems. A global presence provides SKF customers uniform quality standards and worldwide product availability.

References