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THE LATEST STANDARDS OF ROLLING BEARING TESTING

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Abstract: *The wide use of rolling bearings requires a high level of control. Bearing damage can lead to serious consequences such as equipment failure, loss of control, human injury, increased maintenance costs, and issues with quality control. To reduce these risks, it is crucial to have bearings thoroughly tested and confirmed for their properties and accuracy before they are introduced to the market and put into use. In Serbia, this is achieved through the engagement of two accredited laboratories specializing in rolling bearing testing. These laboratories adhere to standards and regulations mandated by the state. By performing measurements and assessing permitted deviations for specific properties, they ascertain whether a bearing can effectively fulfill its intended function. The standards and methods for rolling bearing testing used in the LIMES laboratory (Laboratory for testing machine elements and systems) are presented in this paper.*

Keywords: standards, rolling bearings, measuring, tolerances, hardness, vibrations

1. INTRODUCTION

Standards have significant importance because they bring social, economic and technological benefits. For example, the whole planet benefits from standards that help protect the environment, such as standards for air and water quality, soil, gas emissions, and radiation. Also, standards related to traffic safety, machinery, tools, and similar areas contribute to the overall quality of life. In the field of economy and technology, standards enable a presence in global markets and a broader product offering, facilitat trade between countries, accelerate the penetration and application of innovations (particularly standards in terms of terminology, compliance, and safety), ensure product and service compliance with standards ensures their quality, safety, reliability etc.

1.1 History of standardization

Today's standardization is considered to be based on industrial standardization related to the middle of the 19th century and the development of the railway industry. The primary goal was to produce individual parts independently at different places and enable assembly at a third location without the need for subsequent processing or modification. The production of weaponry, firefighting equipment, machine tools, and later automobiles played a significant role in the development of industrial standardization.

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In the beginning, standardization was developed within individual factories, and then it extended to related factories within the same industrial sector. Following that, standards were introduced that were valid at the state or regional level. These days, every developed nation has its own bodies where members are representatives from manufacturers, consumers, and scientific institutions. Finally, in order to harmonize standards at the global level, ISO was founded.

2. ISO (International Organization for Standardization)

ISO (International Organization for Standardization) is an independent, non-governmental international organization with a membership of 169 national standards bodies. ISO was founded on February 23, 1947. Up to date, it has published 24987 international standards, covering almost all aspects of technology, management, and manufacturing [1]. It has 824 technical committees (TCs) and subcommittees (SCs) to oversee standards development. The organization develops and publishes standardization in all technical and nontechnical fields, except for electrical and electronic engineering, which is handled by the IEC.

3. ISS

The Institute for Standardization of Serbia (ISS) is the sole national body for standardization in the Republic of Serbia. The founder of the Institute is the Government of the Republic of Serbia. ISS issues Serbian standards, which are indicated by a designation that begins with the abbreviation “SRPS”, followed by a sequence of numbers and letters that precisely identify the standard.
For example, in the case of the "SRPS ISO 1132-2:2017" standard, the meaning of the parts of the designation is as follows: "SRPS" indicates that it's a Serbian standard; "ISO" indicates that it's based on an international standard by the International Organization for Standardization; "1132-2" is the specific identifier for this standard within the ISO series; and "2017" represents the year when the standard was adopted or published.

4. BEARING

A bearing is machine element used in the shafts and axles to transfer the load to the housing and ensure that moving parts are accurately positioned in relation to stationary ones. In a bearing, the connection between moving and stationary parts of a structure is achieved, namely, between parts rotating at different angular speeds. Relatively moving surfaces can exhibit either roll or slide against each other, leading to the classification into rolling bearings and sliding bearings.
In the case of sliding bearings, the moving surface slides along the stationary surface of the bearing's housing. To reduce friction, lubricant is introduced between the surfaces, and the bearing housing is typically made from materials with a low coefficient of friction.
Rolling bearings enable rolling friction to predominate during the relative motion of the working surfaces by inserting rolling elements, such as rollers or balls, between the stationary and moving surfaces.

4.1 The importance of bearing control

Depending on the nature of the damage and the intended function, bearing damage in mechanical systems can lead to a variety of dangerous consequences. Numerous machines and equipment depend significantly on their bearings, which might fail and cause a number of operational and safety issues. Potential dangers resulting from bearing damage include:

- Equipment failure: Damage to the bearings may result in total failure of the machinery (unexpected standstill, lost output, and expenses).
- Loss of control: In certain situations, such as in vehicles or airplanes, bearing damage can lead to unwanted vibrations and loss of control that can cause accidents and injuries.

- Fire and explosion: High friction resulting from damaged bearings can produce heat, which can lead to an explosion or fire, particularly in areas where flammable materials are present.
- Human injury: When bearing failure occurs, equipment may move unexpectedly and violently, injuring people around it.
- Increased maintenance costs: Frequent bearing damage can increase maintenance and repair costs, reducing the profitability and reliability of the machinery.
- Issues with quality control: Damage to bearings during precise manufacturing can compromise the accuracy and quality of the items produced, resulting in potential recalls and product issues.
- Etc.

This is why stringent bearing control is essential. In this paper, the focus will be on testing rolling bearings.

In order to protect the country's economy, it is essential to pay attention to the quality of the bearings that are introduced to the market and put into use. For that purpose, the Republic of Serbia has adopted „Rulebook on technical and other requirements for rolling bearings" [8] and some standards that prescribe the conditions that the bearing must fulfill. Compliance with the conditions specified in those documents is determined in certified laboratories.
In the Republic of Serbia, there are two certified laboratories for rolling bearing testing. One of them is located within the rolling bearing factory FKL in Temerin. The second one is laboratory LIMES (Laboratory for testing machine elements and systems), located at the Faculty of Mechanical Engineering in Belgrade (Fig. 1).

Figure 1. Laboratory LIMES (Laboratory for testing machine elements and systems)

This paper will present standards and methods used in certified laboratory LIMES.
The standards adopted by ISS that are used for rolling bearing control in LIMES are:

- Tolerances and radial clearance: SRPS ISO 1132-2:2017
- Hardness: SRPS ISO 6508-1:2017
- Vibrations:
    - SRPS ISO 15242-1:2018
    - SRPS ISO 15242-2:2018
    - SRPS ISO 15242-3:2018

5. Tolerance - SRPS ISO 1132-1:2016, SRPS ISO 1132-2:2017

The "SRPS ISO 1132-1:2016" standard was adopted on December 23, 2016, replacing the "SRPS ISO 1132-1:2015" standard. This standard is identical to ISO 1132-1:2000, Rolling bearings – Tolerances –Part 1: Terms and definitions.

The "SRPS ISO 1132-2:2017" standard was published on June 26, 2017. and replaced the "SRPS M.C3.800:1965". This standard is identical to ISO 1132-2:2000, Rolling bearings – Tolerances – Part 2: Measuring and gauging principles and methods.

The preparation for tolerance testing involves several steps. First, it is necessary to bring the measuring equipment, the reference standard (etalon), and the part being tested to room temperature (the recommended value is 20°C). Then, it is necessary to remove the anti-corrosion agent from the bearing surfaces to eliminate the possibility that the lubricant and a sealing or protective ring adversely affect the accuracy of the measurement, which is conducted on open bearings.
After the measurement, the bearing should be protected from corrosion.

5.1 Measurement principle of bore and outside diameter

Measuring devices for bore and outside diameter testing are different, but the principle of measurement is the same. This method can be applied to all types of rolling bearings. The first step is to zero the measuring indicator using an etalon. After the rolling bearing is positioned, the smallest and largest bore and outside diameter are measured in several radial planes. Based on these values, the average diameter, diameter deviation, and diameter variation are determined. Allowable tolerances are standardized, and based on them, it is determined that the diameters (bore or outside diameter) of the given rolling bearing are within allowed limits.

5.2 Measurement principle of radial clearance

The bearing is mounted on a mandrel. Then, the indicator is positioned toward the outer surface of the outer ring, in the direction of the centre of the rolling path. The mandrel rotates the inner ring. Radial load is applied, and it is possible to read the value of radial clearance on the scale.

6. Hardnes - SRPS EN ISO 6508-1:2017

The "SRPS EN ISO 6508-1:2017" standard was adopted on April 30, 2018, replacing the "SRPS EN ISO 6508-1:2016" standard. This standard is identical with EN ISO 6508-1:2016, Metallic materials – Rockwell hardness test –Part 1: Test method.

The measurement principle of the Rockwell method involves applying an initial (preload) force to indent the indenter. Then, an additional force is applied, and upon its termination, the force value returns to the initial value. Afterward, the depth of the indentation is measured. Many digital devices measure the depth, but they only display the hardness value.
To calculate hardness using the Rockwell method, in addition to the difference between the initial and final indentation depth (h), it is necessary to determine two more constants that depend on the scale (N and S) and apply the following formula:

$$\mathrm{HR} = N - \frac{h}{S} \tag{1}$$

The indenter can be in the form of a diamond cone or ball made of a tungsten carbide alloy. In LIMES, the HRC (Rockwell C) scale is used. In that case, the indenter type is diamond cone, the initial force (F_0) is 98.07 N, the total force (F) is 1.471 kN, the scale constant (S) is 0.002 mm, the full-scale

constant (*N*) is 100, and the hardness range is from 20 HRC to 70 HRC, although the values below 35 HRC are unreliable. The formula for calculating HRC hardness is:

$$\mathrm{HRC} = 100 - \frac{h}{0.002} \tag{2}$$

Although there are many approximate conversion tables, there is no reliable way to accurately convert hardness measured on one scale to another (HB or HV) or to tensile strength.

7. Vibration

7.1 SRPS ISO 15242-1:2018

The "SRPS ISO 15242-1:2018" standard was adopted on March 26, 2018. and replaced the "SRPS ISO 15242-1:2016 " standard. This standard is identical to ISO 15242-1:2015, Rolling bearings – Measuring methods for vibration – Part 1: Fundamentals.

According to this standard, to determine the vibrations of a rotating rolling bearing, a measuring transducer is placed at a specific location on one of the bearing rings or on a device connected to one of the rings. The standard prescribes that the quantity to be measured is the speed of vibrations. The bearing under the determined load rotates at a constant frequency of rotation, and the signal from the measuring transducer is monitored. In the vast majority of cases, the outer ring is stationary and the inner ring is movable (although rare cases may have the opposite configuration).
The conditions required for vibration measurement depend on whether the bearings are pre-lubricated or not. If the bearings are previously lubricated, they are measured in the delivered condition. Previously unlubricated bearings should be thoroughly cleaned and lubricated with fine-filtered oil. Afterward, it is necessary to run-in the bearing in order to achieve a homogeneous distribution of the lubricant.
There are three scales on the vibration measuring device for three frequency ranges. Permitted values for each range can be found in the Rulebook on technical and other requirements for rolling bearings [8].

7.2 SRPS ISO 15242-2:2018

The "SRPS ISO 15242-2:2018" standard was adopted on March 26, 2018, replacing the "SRPS ISO 15242-2:2016" standard. This standard is identical to ISO 15242-2:2015, Rolling bearings – Measuring methods for vibration – Part 2: Radial ball bearings with cylindrical bore and outside surface.

As the title suggests, this part of the standard provides a detailed discussion of radial ball bearings. During the testing of these bearings, the rotation frequency should be 1800 min^{-1} (30 s^{-1}), with a specified tolerance range. Additionally, an axial load is applied to the bearing; first on one side of the stationary ring, and then the measurement is repeated with the load on the other side. Except in the case of single-row angular contact ball bearings. For their testing, the axial force acts in the direction of receiving the axial load of the bearing. Before measuring, it is necessary to position the measuring transducer on the outer surface of the stationary ring in the plane that is in the middle of the rolling contact path of the stationary ring.

7.3 SRPS ISO 15242-3:2018

The "SRPS ISO 15242-3:2018" standard was adopted on March 26, 2018, replacing the "SRPS ISO 15242-3:2016" standard. This standard is identical to ISO 15242-3:2017, Rolling bearings – Measuring methods for vibration – Part 3: Radial spherical and tapered roller bearings with cylindrical bore and outside surface.

This document refers to double-row radial cylindrical roller bearings and to single-row and double-row radial tapered roller bearings. The rotation frequency for measurements should be 900 min^{-1} (15 s^{-1}), and the measurement time should be at least 1 second.
Vibrations of double-row cylindrical roller bearings and tapered roller bearings are measured using a similar approach as that for radial ball bearings. However, for single-row radial tapered-rolled bearings, a specific loading force is applied in the direction of receiving the axial load.
When conducting measurements, it is necessary to position the measuring transducer on the outer surface of the stationary ring in the plane that is in the middle of the rolling contact path of the stationary ring.

8. CONCLUSION

Considering the widespread use of rolling bearings, it is evident that their control is of great importance. Some of the potential dangers that can result from bearing damage are equipment failure, loss of control, human injury, increased maintenance costs, issues with quality control, etc. Therefore, it is necessary that a laboratory confirm the accuracy defined by order demand and provide technical documentation of the bearing before it is introduced to the market and put into use. In the Republic of Serbia, there are two accredited laboratories for testing rolling bearings. They use standards and regulations mandated by the State. On the basis of measurements and the permitted deviations of certain values, they determine whether the bearing can properly perform its function and/or corresponds to the customer order or prescribed technical documentation. This cooperation between the State and laboratories is crucial for safeguarding the country's economy by ensuring the quality and reliability of imported bearings used in various industries.

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