

# Brinell Hardness Testing

## DESCRIPTION OF TECHNIQUE

Brinell hardness testing was one of the earliest techniques developed for measuring the hardness of metal. The test is a two-step process. First, an impression is made on the surface of the test piece using a 10-mm diameter spherical (ball-shaped) indenter at a set load. The average diameter of the impression is then measured under low magnification, typically about 20X. The Brinell hardness number is calculated by dividing the test force (kgf) by the surface area of the impression ( $\text{mm}^2$ ). A range of indenter size and loading combinations can be used, allowing both soft and hard materials to be tested using a single method. Brinell hardness numbers can be used to correlate to tensile strength for some metals and alloys, and standardized conversions are available for translating results to other hardness scales.

Of the common indentation hardness testing techniques, Brinell testing produces the largest impression on the test specimen, typically 2 - 6 mm in diameter. The large impression is beneficial for materials with inhomogeneous or coarse-grained microstructures, such as castings, because any local variation in the microstructure is averaged by the large test area. However, the large indentation requires a large test specimen, which limits the types of samples that can be tested.

Originally, indenters were made from steel ball bearings. To accommodate testing of harder materials without risk of damage or deformation to the ball with repeated use, a tungsten carbide ball became the standard indenter. For clarity, HBS or HBW are often listed after the numeric hardness value to indicate that measurements were made using a steel indenter or tungsten carbide indenter, respectively.

## ANALYTICAL INFORMATION

To provide accurate and repeatable results, testing methods should be governed by a recognized standardized procedure. Brinell hardness testing standards include ASTM E10 and ISO 6506-1.

The Brinell hardness test has three varying parameters: indenter size, test force, and dwell time. Most commonly, a 10-mm diameter ball indenter, 3000-kgf test force, and 10 - 15 second dwell time are used. These conditions are ideal for testing materials such as cast iron, and carbon and alloy steel. Other test parameters, such as a 500-kgf test force, are commonly used for testing thin samples or softer materials, such as aluminum.

For expressing Brinell hardness test results, the designation HB, without any additional information, indicates that a 10-mm tungsten carbide ball was used with a 3000-kgf test force and 10 - 15 second dwell time. If alternate conditions are used for testing, the test parameter should be specified behind the reported hardness value. For example, a hardness designation of “300 HBW 5/250/20” indicates that a hardness value of 300 was obtained in a test using a 5-mm tungsten carbide indenter, a 250-kgf test force, and a 20-second dwell time.

Most Common Test Conditions and Recommended Hardness Range					
Brinell Hardness Scale	Ball Diameter, MM	Force Diameter Ratio	Normal Value of Test Force N   Kgf	Recommended Hardness Range HBW	Materials Tested
HBW10/3000	10	30	29420   3000	95.5 to 650	Steel Cast Iron
HBW10/500	10	5	4903   500	15.9 to 109	Aluminum Magnesium

## TYPICAL APPLICATIONS

- Large Samples, such as:
  - Castings
  - Plates
  - Structural Beams
  - Pump Housings
- Heat treatment verification for metals and alloys

## SAMPLE REQUIREMENTS

An ideal specimen for Brinell testing would be at least 1 in. square with and flat and parallel faces, although measurements can also be made on curved surfaces. Irregularly-shaped samples will may need to be cut to accommodate testing.

In general, for a steel sample measured under standard conditions (10-mm indenter, 3000-kgf test force) each test indentation would require a test surface area of approximately 1 in.<sup>2</sup>. Typically the average of three to five is used to confirm a hardness value, making the minimum surface area requirement roughly 3-5 in.<sup>2</sup>

For samples where excessive size prevents testing on a laboratory instrument or for samples with a complex geometry where cutting is not feasible, a portable comparative Brinell testing may be considered. Portable hardness testing instruments bring the tester to the sample and can provide useful hardness data for most components were Brinell hardness testing is compatible with the sample material and component size.