



BUEHLER MICROMET 5103 MICROINDENTATION
HARDNESS TESTER

“The Punk”

Operating Instructions

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Introduction

The microindentation hardness tester includes Vickers and Knoop indenters, as well as an automated measurement and calculation system, allowing you to precisely and easily measure the microindentation hardness of a variety of materials.

Microindentation hardness testers produce an indentation by pushing a diamond into the sample at a controlled rate under a known load. The dimensions of the indentation are measured, and a hardness number is calculated based on the indentation dimensions.

Safety and Sample Preparation

Safety Hazards and Precautions

It's possible (although admittedly difficult) to get your hand caught between the indenter and sample. Keep hand clear of indenter while testing.

Sample Preparation

Microhardness testers make very small indentations (tens of microns in length). In order for the edges of these to be clearly discerned, the surface must be cleaned and polished to remove any surface imperfections and scratches that would interfere with the indentation or its measurements. Microhardness samples are typically encapsulated in plastic using the mounting press, and ground and polished to a finish suitable for microhardness testing.

Background

NOTE: The following text is taken directly or adapted from the *Introduction to Hardness Testing* section of *ASM Handbook, Volume 8 Mechanical Testing and Evaluation*.

The term hardness, as it is used in industry, may be defined as the ability of a material to resist permanent indentation or deformation when in contact with an indenter under load. Generally a hardness test consists of pressing an indenter of known geometry and mechanical properties into the test material. The hardness of the material is quantified using one of a variety of scales that directly or indirectly indicate the contact pressure involved in deforming the test surface. Since the indenter is pressed into the material during testing, hardness is also viewed as the ability of a material to resist compressive loads. However, do not mistake hardness for compressive strength, since it is a result of many different material properties, some of which involve the way in which the material was manufactured. While hardness tests are not always exactly repeatable, the average of a series of tests should provide an accurate reading for any given material.

There are four primary types of indentation hardness testing: Brinell, Rockwell, Vickers, and Knoop. The Brinell and Rockwell tests are considered macroindentation hardness tests – they create a sizable indentation in the material, and test over a greater area. The Vickers and Knoop tests are considered microindentation hardness tests – their indentations are hardly noticeable, and are generally analyzed through a microscope. In the Brinell, Vickers, and Knoop tests, hardness value is the load supported by unit area of the indentation, expressed in kilograms per square millimeter (kgf/mm²). In the Rockwell tests, the depth of indentation at a prescribed load is determined and converted to a hardness number (without measurement units), which is inversely related to the depth.

Durometer is another common type of hardness test. The durometer is a hand-sized instrument that measures the indentation hardness of rubber and plastic products. The tester is manually applied to the test specimen, and the hardness reading is observed on a dial or digital indicator. Durometer hardness is the resistance of the material being tested to the penetration of the indenter as the result of a variable force applied to the indenter by a spring. An infinitely hard material would yield a durometer hardness of 100, because there would be zero penetration. Durometer selection depends on the material being tested. Several types of durometers are available, and durometer hardness testing is described in ASTM D 2240, “Standard Test Method for Rubber Property—Durometer Hardness.”

The importance of material hardness is very industry dependent. In general, high hardness corresponds to high strength and low ductility. Each of these features can be considered both an advantage and a disadvantage. It may be desirable to have a hard material, such as diamond, that will resist surface scratches. On the other hand, very hard materials generally fracture easily and without deformation, and may perform poorly under impact loads. Further, harder materials are generally much more difficult to machine. Thus, from structural design or manufacturing standpoints, materials with low hardness may be preferred.

Microindentation Hardness Testing – Vickers Hardness

The Vickers hardness test was developed as a way of testing microindentation hardness of *any* material on the same scale. In the Vickers test, a square-pyramidal shaped diamond (Figure 1) is pressed against a material at a pre-determined force. The force is applied over 10-15 seconds, and then released. To calculate the hardness, the average length of the diagonals of the indent's base is measured. This average length is used with the applied force to calculate the Vickers hardness number.

While the Vickers test may be used as both a macroindentation and a microindentation hardness test, it is more frequently used for the latter. *More information about this can be found in the ASM Handbooks Online, Volume 8 → Macroindentation Hardness.*

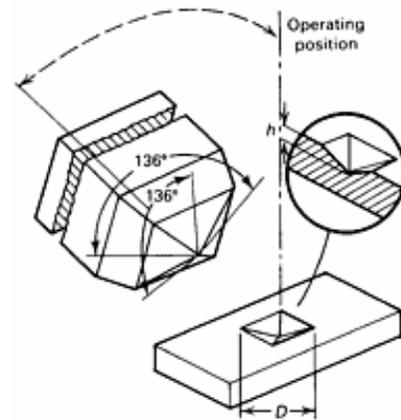


Figure 1. Diagram of a Vickers Hardness Test. Photo from ASM Handbooks Online, Volume 8.

Microindentation Hardness Testing – Knoop Hardness

The Knoop hardness test is very similar to the Vickers hardness test. Vickers and Knoop tests are typically performed on the same machine but with different indenters. The Knoop hardness indenter is a rhombohedral diamond (an elongated diamond), as shown in Figure 2. Measurement is taken as the long diagonal of the hardness indentation, and that distance is used to calculate the *projected* area of the indentation.

A significant advantage of Knoop hardness testing is the ability to test very thin or very brittle samples. A hard, brittle material under identical applied forces is less likely to crack during Knoop testing than it would be during Vickers testing. Further, if the specimen has a steep hardness gradient, the Knoop test will more accurately determine hardness at the test location, and indentations can be made closer together, allowing for more accurate calculation of the hardness gradient. The Knoop test leaves a shallow indentation, making Knoop ideal for testing the hardness of exterior coatings on materials. Drawbacks to Knoop testing include (1) hardness numbers that vary with applied test loads and (2) more difficult conversion to other hardness scales.

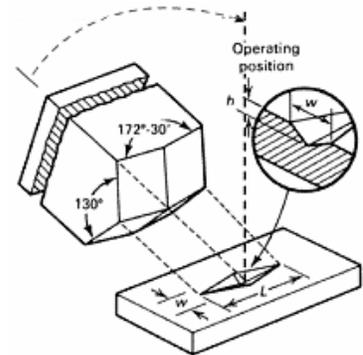


Figure 2. A diagram of a Knoop Hardness Test. Photo from ASM Handbooks Online, Volume 8.

References

- ASM Handbook Online, Volume 8 → Hardness Testing
- Askeland: Sections 6.7 for hardness testing
- ASTM E18, E38



Operation

Getting Started

1. Turn on the Punk with the power switch located on the right side near the back.
2. *Lower sample stage* to ensure that the objective lenses do not contact the sample surface. Use the large rotating knob on the front, lower right of the machine base.
3. *Insert sample:* Place the sample on round base with the test piece facing up. Use the knurled knob to fix the sample against the horizontal bars. If your sample is small, you may need to use a spacer under the sample. Ensure that the region you wish to test is visible.
4. *Find a test area:* Rotate the microscope objective lens turret so the lower-magnification lens (x10) clicks into place above the sample. The solid and open 'sun' buttons on the screen will increase and decrease the intensity of the light, respectively. Use the micrometers to center the sample under the lens, and focus with the large rotating knob on the right.
5. Once you have identified a good looking region for testing, you may wish to refocus at a higher magnification. To refocus, carefully rotate the microscope lens turret past the indenter to the higher magnification (40x) lens on the left. Watch to make sure that both the indenter and the lens clear the sample! Use the focusing knob to refocus the image at the higher magnification, and use the x-y stage micrometers to select an area that is free of imperfections.
6. *Choose a weight:* Rotate the indicator knob on the top right hand side until the correct weight is towards you. 500 g is reasonable for most metals. Lower loads may be used for thin or brittle samples.

The Hardness Test

7. Rotate the lens turret to position the indenter over your sample. Press the big 'start' button on the touch screen. Once depressed, the start button will flash throughout the duration of the test (approximately 30 seconds). When it has stopped flashing, the indentation is complete. Rotate the turret back to the high-magnification lens. You should see your indentation! If necessary, refocus to ensure that all the indentation edges are clearly visible.
8. *Check hardness type:* If you see a square indentation, you are using a Vickers indenter. Ensure the large letters on the touch screen read 'HV' for Vickers measurements and

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calculations. If you see an indentation shaped like an elongated diamond, you are using a Knoop indenter. Ensure the screen says 'HK' for Knoop measurements and calculations. Use the 'HK/HV' button to switch between Knoop and Vickers.

- 9.** *Zero the reading:* The knobs on the eyepiece control the black lines you see superimposed on the sample. The left-hand knob moves both lines; the right-hand knob only moves one of the lines. The instrument senses the position of the lines and calculates the size of the indentation (and therefore the hardness). Start by zeroing the reading: position both lines together so the smallest possible sliver of light is visible between them, and press 'zero' on the screen.
- 10.** *Measure indentation:* For Knoop indentations, you will measure the longer diagonal of the indentation. For Vickers indentations, you will measure both diagonals of the indentation. To take a measurement, use the eyepiece knobs to position a black line at each end of the indentation. The inside of the line should just touch the point of the indentation. When you are satisfied with their positions, press the 'read' button. For Knoop testing, the hardness (HK) will come up. For Vickers testing, rotate the eyepiece 90 degrees (until it is against the stop), reposition the lines to measure the length of the specimen in the other direction, and press read. The electronics will average the lengths and calculate the Vickers hardness (HV).
- 11.** Repeat as necessary to test different regions or to obtain an average value. Be careful not to place an indentation too close to previous indentations.
- 12.** To shut down the machine, simply remove your sample, and turn the power off.