

Microhardness testing refers to a hardness testing process using considerably lighter loads and smaller indentations, when compared to typical Rockwell scale hardness testing. Microhardness is generally employed in testing specimens that are too thin or physically too small to be accommodated by “standard” testers.

A microhardness test is performed using a “Vickers” or “Knoop” indenter, which are constructed from precisely ground industrial diamonds. The indentation is formed using a load of 1 to 1000 grams, dependent on the specimen and user requirements. The dimensions of the indent are such that accurate hardness determinations require the use of a specially configured microscope.

The microscope is equipped with a “filar micrometer or filar eyepiece [which is] an eyepiece equipped with a fiducial line in its focal plane, that is movable by means of a calibrated micrometer screw in order to make an accurate measurement of its length.” (ASTM E175, Vol. 14.02).

This may be more simply described as a viewing lens having highly defined vertical and horizontal graduations (μ mm) which are typically projected on to a viewing screen. Measurement is then accomplished by indexing the indent with the projected graduations, which employs an integral micrometer arrangement for accurate positioning and measurement of the impression.

The relationships of the surface area of the indent, indenter configuration, force applied to the indenter and the mean diagonal of the indent are used to mathematically derive a hardness value.

ASTM E384 (Vol. 03.01) *Standard Test Method for Microhardness of Materials* defines a microhardness test as “... a microindentation hardness test using a calibrated machine to force a diamond indenter of specific geometry, under a test load of 1 to 1000 gf, into the surface of the test material and to measure the diagonal or diagonals optically.”

ASTM E92 (Vol. 03.01) *Standard Test Method for Vickers Hardness of Metallic Materials* allows for a wider range of applied forces and accommodates spherical, cylindrical, convex and concave specimen surfaces.

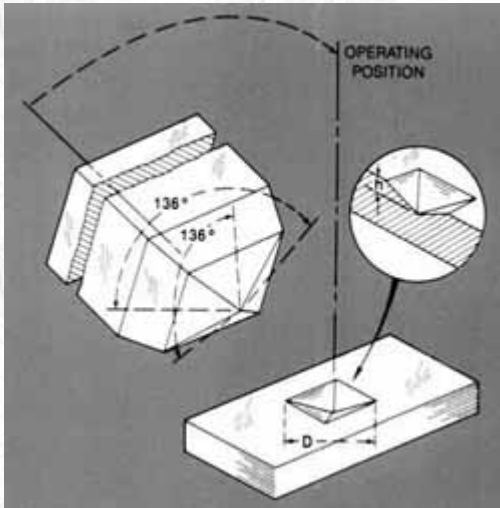
Application

The microhardness testing of materials allows for the determination of the hardness of small or thin specimens and small areas of larger specimens. Microhardness testing is commonly used to determine characteristics of thin sheets, foils, fine wire, epoxies, paints, etc. and is often employed in R&D applications where a material's microstructure is of interest.

Microhardness is especially useful in determining hardness variations caused by hardening, quenching, plating, fabrication, welding or annealing, bonding, etc. Microhardness testing can be accurately employed using loads as slight as 1 gram, somewhat less and considerably more in certain situations.

Photographic equipment, which enhances the image of the indentation, is widely used to determine the characteristics of specimen's microstructure in and around the area of the indentation.

Vickers Scale



ASTM E92 (Vol. 03.01) *Standard Test Method for Vickers Hardness of Metallic Materials* describes the Vickers microhardness test as “... a number related to the applied load and the surface area of the permanent impression made by a square-based pyramidal diamond indenter having included face angles of 136° ... all four faces of the indenter shall be equally inclined to the axis of the indenter (within ± 30 min) and meet at a sharp point, that is, the line of the junction between opposite faces shall not be more than 0.001 mm in length ...”

The Vickers hardness number, reported as HV, is the ratio of the force applied to the indenter (kgf) to the surface area (mm^2) of the indentation:

$$\text{By formula } HV = \frac{2P \sin \frac{\theta}{2}}{D^2}$$

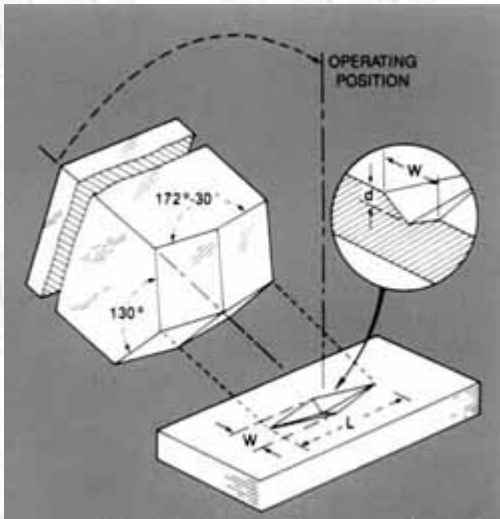
Where:

P = applied load (kgf)

D = mean diagonal of the indentation (mm)

θ = angle between opposite faces of the diamond = 136°

Knoop Scale



ASTM E384 (Vol. 03.01) *Standard Test Method for Microhardness of Materials* describes the Knoop hardness test as "... the number obtained by dividing the applied load in kilograms-force by the projected area of the indentation in square millimeters, computed from the measurement of the long diagonal of the indentation ... [formed by] a highly polished, pointed, rhombic based, pyramidal diamond with included longitudinal edge angles of 172° 30 min (± 5 min) and 130° 0 min ... the four faces of the indenter shall be equally inclined to the axis of the indenter (within ± 30 min) and shall meet at a sharp point. The line of the junction between opposite faces (offset) shall not be more than 1.0 µm ..."

The Knoop hardness number, reported as HK, is the ratio of the force applied to the indenter, P (kgf) to the unrecovered projected area, A (mm²), of the indentation.

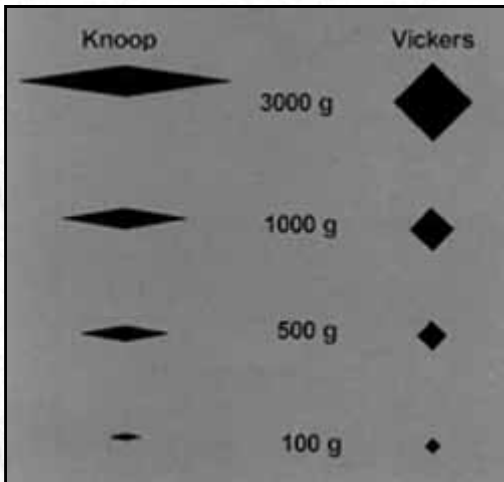
$$\text{By formula } HK = \frac{P}{A} = \frac{P}{CL^2}$$

Where:

- P = applied load (kgf)
- A = the unrecovered projected area of indentation (mm²)
- L = measured length of long diagonal (mm)
- C = 0.07028 = constant of indenter relating projected area of the indentation to the square of the length of the long diagonal

Knoop v. Vickers

In the most general of terms, for a given load and material, a Vickers indenter may penetrate approximately twice as much and the diagonal dimension may be approximately 1/3 of that achieved by a Knoop indenter. The conclusion drawn is that the Vickers test is less sensitive to certain "surface conditions" than the Knoop test.



While this is true in the most general of terms, each test has specific advantages dependent on the material, "surface condition" and the specimen configuration, i.e., a Vickers test allows for a wider range of applied forces as well as corrections for spherical, cylindrical, convex and concave surfaces. The microhardness of a specimen, when the desired results are not well defined or predetermined, are most often arrived at empirically.

Shown at the left is a relative comparison of indents formed with various loads on a given material.

Credits:

- Author & Images (edited and modified for presentation):
- Wilson-Shore Instruments, Division of Instron Corporation, Canton, MA