



INSTRON WILSON ROCKWELL SERIES 2000 HARDNESS
TESTER

“Stanley”

Operating Instructions

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Introduction

The Instron Series 2000 Rockwell Hardness Tester is a state-of-the-art, load-cell style hardness tester that features a closed loop electronic control system, fast and easy operation, and automatic conversions of hardness scales and hardness values.

Safety and Sample Preparation

Safety Hazards and Precautions

Stanley (the Rockwell hardness tester) is a relatively safe machine. Try to resist hardness testing your body parts or the body parts of bystanders. Always wear eye protection when using the Rockwell hardness tester.

Sample Preparation

Specimen Geometry. Avoid irregular shapes. Hardness test specimens should have parallel top and bottom surfaces.

- *Cylindrical specimens* are fine, but you'll need to add a cylindrical correction factor to your readings; the machine can be set up to do this automatically.
- *Tubular specimens* may be tested as long as the tube diameter, wall thickness, and hardness are sufficient to prevent the tube from springing or crushing during the test.
- *Curved plates* should be tested with the convex side down (against the anvil) to prevent elastic deformation and spring back of the plate.

Surface Condition. The testing surface should be clean and relatively smooth. Thanks to the automatic application of the 10 kgf "minor load" prior to the test load, thin surface layers (oxide, lacquer, etc.) and light machining marks will not dramatically affect the results of hardness tests on the regular (non-superficial) scales.

Thickness. Hardness indentations create a region of deformed material around the visible indentation, and depending on the material, this deformed region may be rather large. If your test specimen is too thin, you may become a victim of the "Anvil Effect." The Anvil Effect is an erroneously high hardness reading that results from the plastically deformed region around your hardness indentation actually running into the hard support anvil. A general rule-of-thumb for test specimen thickness is 10x the indentation depth. Of course, the Rockwell hardness test doesn't provide the user with indentation depth information, so this is a worthless rule-of-thumb. Better approaches are to use the Hardness vs. Minimum Thickness Chart 55 (see poster) as a guide for minimum thickness or to perform a hardness test and examine the bottom surface of your specimen for any signs of deformation.

Background

NOTE: The following text is 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.

Macroindentation Hardness Testing – Rockwell Hardness Testing

Rockwell hardness testing differs from Brinell testing in that the Rockwell hardness number is based on the difference of indenter depth from two load applications. Initially a minor load is applied, and a zero datum is established. A major load is then applied for a specified period of time, causing an additional penetration depth beyond the zero datum point previously established by the minor load. After the specified dwell time for the major load, it is removed while still keeping the minor load applied. As shown in Figure 1, the resulting Rockwell number represents the difference in depth from the zero datum position as a result of the application of the major load. The entire procedure requires only 5 to 10 s.

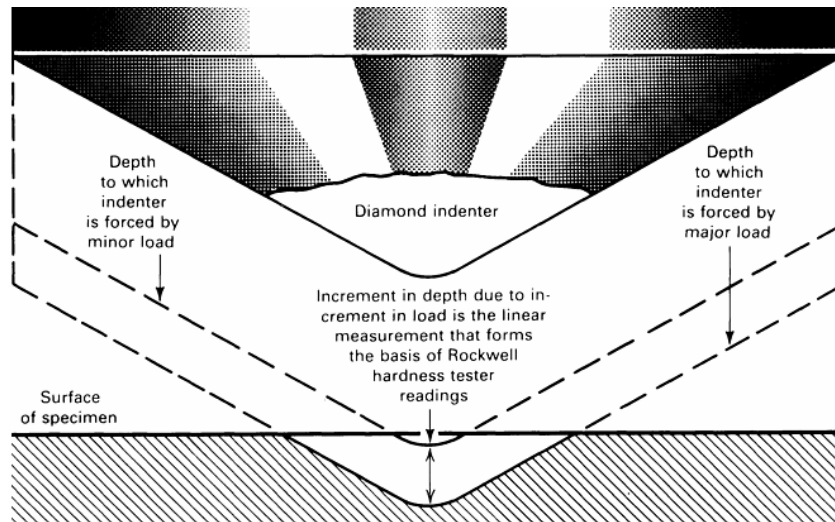


Figure 1. A diagram of the Rockwell hardness test. Photo from ASM Handbooks Online, Volume 8.

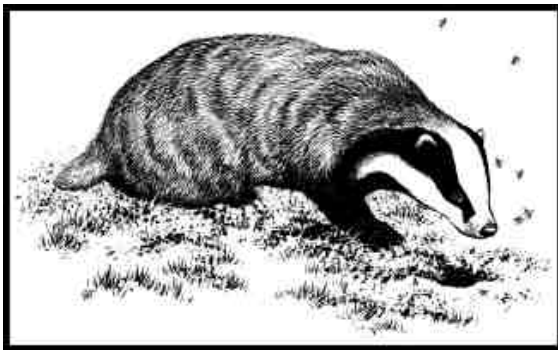
One interesting aspect of the Rockwell hardness test is the multitude of scales by which hardness is measured (Figure 2). Over time, many different types of indenters have been used for Rockwell tests on many different types of materials. While it is slightly convenient that different tools have been developed for a broad range of purposes, each indenter demands its own unique scale. *For information on the appropriate indenter to use for a specific material, consult the ASM Handbook Online, Volume 8 for hardness testing.*

Since the Rockwell test uses its own scale, it is best used as a relative measurement between materials. However, to get a sense of how Rockwell values compare to those of other hardness tests, you may consult Figure 2 or reference hardness conversion tables. A reference table that compares Rockwell to Vickers, Brinell, and Knoop hardness is posted in the materials science lab (AC 413).

Macroindentation Hardness Testing - Durometer Hardness Testing

While Rockwell tests work very well on metals, other hardness tests that are much better suited for non-metal materials. One such test is the durometer test, which is commonly used for polymeric materials. In the durometer test, hardness is based on the force required to create a dent of a specific depth. The durometer test is probably the easiest of the hardness tests – simply press the durometer into the material until its bottom surface is flush with the surface of the material. Wait three seconds to accommodate the viscoelastic response of the polymer, and then read the hardness directly from the durometer scale. That’s it!

There are many different durometer scales, but the Shore A and Shore D scales span a non-overlapping range of hardness that works excellently in conjunction with the Rockwell tests (Figure 2), and also happen to be the two that we have in the lab. Use the type A durometer for softer materials, and the type D durometer for harder materials. Since there is really no need for a token diagram in this section, please accept this graphical illustration of a badger instead.



Badger illustration from <http://www.mammal.org.uk/badger.jpg>

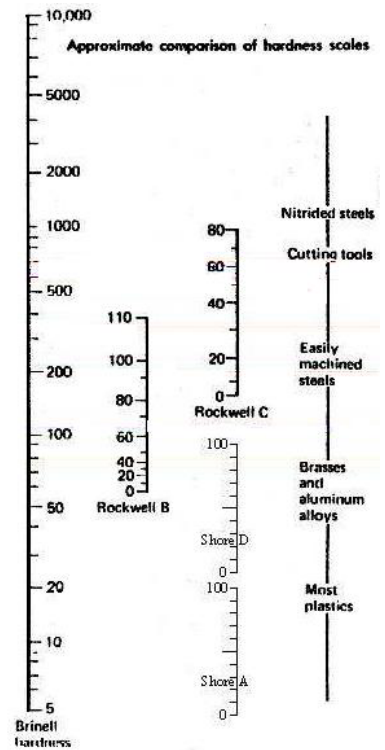


Figure 2. A Comparison between three of the most common macroindentation hardness tests. Image adopted from: http://lennon.pub.csufresno.edu/~dtm24/IT283/hardness_2.html

References

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

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Operation

1. Turn on the machine by pressing the power button on the control console.
2. Select a scale by pressing the arrow button next to scale on the display. Consult the Rockwell Hardness poster or Rockwell Scale Application Guide (see below) for the appropriate scale.
3. Select an anvil (the supporting piece) appropriate for your specimen geometry.
4. Check if your indenter tip is the proper one for the selected scale. If necessary, change the indenter tip, as follows:
 - Raise the testing head assembly (if necessary) with the up/down arrow button.
 - Remove the indenter tip by pulling straight down on the indenter tip (you don't need to loosen the knurled knob).
 - Locate the proper indenter. Indenters may be found in the containers on the left side of the tester.
 - Align the flat side of the new indenter tip to where the knob is and push in (do not turn the knurled knob).
5. Control the indenter tip location with the arrow buttons on the front of the instrument. When sample is aligned under indenter tip, press the green start button to begin testing.
6. Record your reading, find a new location, and repeat the testing procedure.

Helpful Hints

1. Your hardness reading should fall within the 20-100 range. If the measured hardness is out of this range, you should switch to a different scale.
2. When changing the scale the display shows which indenter tip should be in the machine, check to make sure the display matches the actual indenter.
3. If a certain scale must be used, as with thin samples, the machine can convert your readings to another scale. Press the arrow next to convert in the scale and select the desired scale.
4. For the most accurate results, take several measurements and average them.
5. Don't perform hardness tests too close to the edge of your specimen. Outer edges may deform and result in an incorrect "soft" reading. A general rule-of-thumb is to stay at least 2 indenter diameters away from edges.
6. Don't perform hardness tests too close to previous indentations. Most metals will harden when deformed at room temperature, and testing too close to previous indentations will provide an erroneously high reading.

Scale Selection

Rockwell Scale Application Guide			
Scale Symbol	Indenter	Major Load kgf	Typical Applications of Scales
HRA	Brale® Diamond	60	Cemented carbides, thin steel and shallow case hardened steel
HRB	1/16" ball	100	Copper alloys, soft steels, aluminum alloys, malleable iron
HRC	Brale® Diamond	150	Steel, hard cast irons, pearlitic malleable iron, titanium, deep case hardened steel and other materials harder than B100
HRD	Brale® Diamond	100	Thin steel and medium case hardened steel and pearlitic malleable iron
HRE	1/16" ball	100	Cast iron, aluminum and magnesium alloys, bearing metals
HRF	1/16" ball	60	Annealed copper alloys, thin soft sheet metals
HRG	1/16" ball	150	Phosphor bronze, beryllium copper, malleable irons. Upper limit G92 to avoid possible flattening of ball
HRH	1/8" ball	60	Aluminum, zinc, lead
HRK	1/8" ball	150	Bearing metals and other very soft or thin materials, including plastics (See ASTM D785). Use smallest ball and heaviest load that do not give anvil effect.
HRL	1/4" ball	60	
HRM	1/4" ball	100	
HRP	1/4" ball	150	
HRR	1/2" ball	60	
HRS	1/2" ball	100	
HRV	1/2" ball	150	
Rockwell superficial scales are used to test materials too thin for the regular scales. Generally Brale® Diamond Indenters are used for hard materials while Ball Indenters are used on soft materials. (All superficial scales use a 3 kgf minor load.)			
HR15N HR30N HR45N	Brale® Diamond	15 kg 30 kg 45 kg	<ul style="list-style-type: none"> Cemented carbides, thin steel and shallow case hardened steel Steel, hard cast irons, pearlitic malleable iron, titanium, deep case hardened steel and other materials harder than B100 Thin steel and medium case hardened steel and pearlitic malleable iron
HR15T HR30T HR45T	1/16" ball	15 kg 30 kg 45 kg	<ul style="list-style-type: none"> Copper alloys, soft steels, aluminum alloys, malleable iron Annealed copper alloys, thin soft sheet metals Phosphor bronze, beryllium copper, malleable irons. Upper limit G92 to avoid possible flattening of ball
HR15W HR30W HR45W	1/8" ball	15 kg 30 kg 45 kg	<ul style="list-style-type: none"> Cast iron, aluminum and magnesium alloys, bearing metals Aluminum, zinc, lead Steel, hard cast irons, pearlitic malleable
HR15X HR30X HR45X	1/4" ball	15 kg 30 kg 45 kg	

(All regular scales use a 10 kgf minor load)