Principle of Rockwell hardness testing

The Rockwell hardness test is one of several common indentation hardness tests used today, other examples being the Brinell hardness test and Vickers hardness test. Most indentation hardness tests are a measure of the deformation that occurs when the material under test is penetrated with a specific type of indenter . In the case of the Rockwell hardness test, two levels of force are applied to the indenter at specified rates and with specific dwell times. Unlike the Brinell and Vickers tests, where the size of the indentation is measured following the indentation process, the Rockwell hardness of the material is based on the difference in the depth of the indenter at two specific times during the testing cycle. The value of hardness is calculated using a formula that was derived to yield a number falling within an arbitrarily defined range of numbers known as a Rockwell hardness scale.

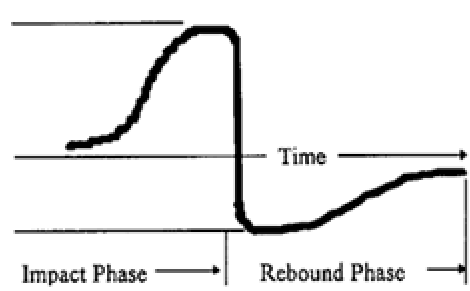
The general Rockwell test procedure is the same regardless of the Rockwell scale or indenter being used. The indenter is brought into contact with the material to be tested, and a preliminary force (formally referred to as the minor load) is applied to the indenter. The preliminary force is usually held constant for a set period of time (dwell time), after which the depth of indentation is measured. After the measurement is made, an additional amount of force is applied at a set rate to increase the applied force to the total force level (formally referred to as the major load). The total force is held constant for a set time period, after which the additional force is removed, returning to the preliminary force level. After holding the preliminary force constant for a set time period, the depth of indentation is measured a second time, followed by the removal of the indenter from the test material. The measured difference between the first and second indentation depth measurements, "h", is then used to calculate the Rockwell hardness number. For many older models of **Rockwell hardness machines** , the operator must manually control most or all of the steps of the test procedure. Many of today's newer machines automatically perform the entire Rockwell test.

PORTABLE HARDNESS TESTING

Why portable hardness testing? Portable hardness testers have come of age since the late 90’s, with a vast offering of high tech, digital instrumentation. Small, compact and menu driven, these instruments have never been easier to use for unlimited types of applications.

There are two basic methods of portable hardness testing that is accepted in the field today.
“Dynamic Impact” is based on the Leeb principle of hardness,developed by Dietmar Leeb in the 1970’s. A spring loaded impact body is thrust to the test surface, effecting rebound. The speed of both the initial thrust and the rebound is measured in a non-contact mode. This is calculated as a Leeb hardness value and then automatically converted to Rockwell C, B, Brinell, Vickers and Shore Values. It has effectually brought easy, fast and accurate results to portable hardness testing.

Figure 4: Voltage characteristic of output signal



“Ultrasonic Contact Impedance” is based on a 136 degree diamond at the end of a vibrating rod being depressed into the test surface at a fixed load. The difference in Ultrasonic vibration frequency is then calculated into a hardness value. The UCI test procedure is slower than the Dynamic Impact style, however the “UCI” method of hardness testing is portable, easy and accurate. It also has its own advantages when utilized for certain testing applications. UCI testers are not restricted to large mass items like dynamic type testers. These units can test metals as thin as 1mm and at a hardness value as low as 20HRC (75HB). They also excel at performing hardness tests on larger, harder metals as well. Another reason for the rise in popularity is due to the fact that the UCI method is categorized as "Non-Destructive". That translates into less scrap parts/ lower mfg costs due to necessary inspections.

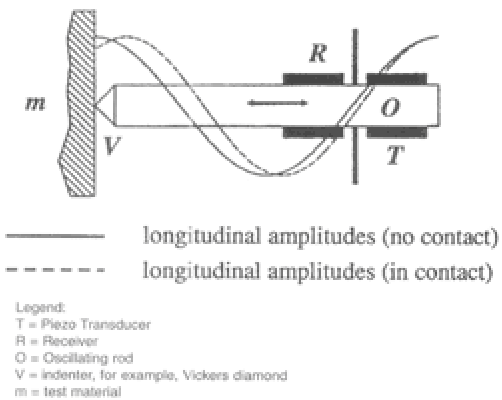


FIG. 1 Schematic Description of the UCI Probe

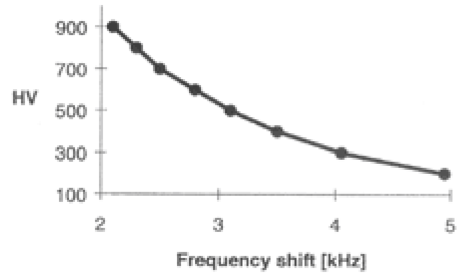


FIG. 2 Hardness Value versus Frequency Shift of the Oscillating Rod

Technical Data for Dynamic Impact Devices

Impact Devices →	**D/DC/DL**	**D+15**	**C**	**G**
Impact energy	11Nmm	11Nmm	3Nmm	90Nmm
Mass of the impact body	5. 5g	7. 8g	3. 0g	20g
	DL: 7.3g			
Test tip				
* Hardness	1600HV	1600HV	1600HV	1600HV
* Diameter	3mm	3mm	3mm	5mm
* Material		Tungsten	Tungsten	
*		carbide	carbide	
Impact device				
* Diameter	20mm	20mm	20mm	30mm
* Length	147/86mm	162mm	141mm	254mm
* Weight	75/50g	80g	75g	250g
Max. hardness of sample	940HV	940HV	1000HV	650HB
Preparation of surface				
* Roughness class ISO	N7	N7	N5	N9
* Max. roughness depth Rt	10 μ m	10 μ m	2.5 μ m	30 μ m
* Average roughness Ra	2 μ m	2 μ m	0. 4 μ m	7 μ m
Min. weight of sample				
* Of compact shape	5kg	5kg	1.5kg	15kg
* On solid support	2kg	2kg	0.5kg	5kg
* Coupled on plate	0. 1kg	0. 1kg	0. 02kg	0. 5kg
Min. thickness of sample				
* Coupled	3mm	3mm	1mm	10mm
* Min. thickness of layers	0. 8mm	0. 8mm	0. 2mm	-
Indentation of test tip				
With 300 HV				
* Diameter	0. 54mm	0. 54mm	0. 38mm	1.03mm
* Depth	24 μ m	24 μ m	12 μ m	53 μ m
with 600 HV				
* Diameter	0. 45mm	0. 45mm	0. 32mm	0. 90mm
* Depth	17 μ m	17 μ m	8 μ m	41 μ mC
with 800 HV				
* Diameter	0. 35mm	0. 35mm	0. 30mm	-
* Depth	10 μ m	10 μ m	7 μ m	-

Technical Data for UCI Hardness Tester

Test Device	**U1 (UCI)**
Length	160mm
Diameter	25mm
Indentation Depth	30µm
Pressure Force	14.7N
Transducer Test Life *(approx)*	200,000
Min. Thickness for test	1mm
Min. Radius for Test	5mm
Max Roughness of surface	Ra 2.5µm
Max Archive	100 Tests
Time of Test	4 sec.

Comparison of Hardness Testing Methods-Phase II Models shown below

Data	**Dynamic**	**Ultrasonic**	**Rockwell**
Requirements			
Surface Finish	Smooth	Smooth	Smooth-Semi Rough
Rigid Support of Sample	Yes	Yes	Yes
Test sample portability	Not required	Not required	Required
Procedures			
Structural Steel	Functional	Functional	Functional
Heat Treated Steel	Functional	Functional	Functional (HRC)
Case Hardened Material	Functional	Functional	Functional (HRC)
Non-Ferrous Metals	Functional	Functional	Functional (HRB)
Large Samples	Yes	Yes	Restricted
Small Samples	Restricted	Yes	Yes (w/proper scales)
Thin Samples	Restricted	Yes	Restricted
Curved/Round Surfaces	Yes	Yes	Restricted
Special Features			
Automatic Test Procedure	Yes	Yes	Yes
Direct Hardness Value	Yes	Yes	Yes
Required Time for Avg/5 Tests	Approx. 10 Sec.	Approx. 20 Sec.	Approx. 2 Minutes
Digital Display	Yes	Yes	Some Models
Scale Conversions	Yes	Yes	Some Models
Directional Testing	Yes	Yes	No
Standardized by:	ASTM	ASTM	NIST (HRC scale only)
Indentation Depth	20µm	30µm	160µm
Operator Requirements			
Skills Required	Minimal	Minimal	Minimal
Possible Reading Error	None	None	None
Instrument Features			
Portability	Yes	Yes	No
Power Supply	Battery	Battery	Manual/110v
Output to PC	Yes	Yes	Some Models

Type	**Model**	**Model**
Dynamic Testers	PHT-2000D	PHT-2500D
Ultrasonic (UCI)	MET-U1	MET-UD

Rockwell	900-331 & 900-340	900-360 & 900-370