FISON

Rock Well Hardness Tester

FM-RWHT-A100

www.fison.com | info@fison.com

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1. Safety Measures

For Rockwell hardness testers, except under normal testing, in any case, the diamond indenters should not be pressed against the anvil, extension and test piece. Otherwise, it can be damaged.
Indentations should not appear on the bearing surface of the hardness block or the work surface of the anvil.
During the test, the direction of the testing force must be vertical to the test piece's testing surface, and when applying the test force the piece should not move or slide on the anvil.
The process of applying force should be slow at an even pace. The dial pointer should rise smoothly. If the pointer is found to be uncontrollably dithering or sliding down, the following reasons may explain and relevant measures should be taken:

- Improper selection of the anvil.
- The support of the test piece is not stable.

2. Introduction

Rock Well Hardness Tester FM-RWHT-A100 applies an initial test force of 3 kgf ensuring precise surface contact before applying the total test load. It supports total test forces of 15 kgf 30 kgf and 45 kgf making it versatile for various hardness testing requirements. It is ISO 6508-compliant ensuring that all tests meet internationally recognized Rockwell hardness standards. It calibrates its test force using load cells ensuring precise and stable force application during testing.

3. Features

1. Superficial Metal Hardness Testing
2. Precision Testing for Delicate & Small-Surface Workpieces
3. Non-Destructive Hardness Testing
4. Certified Traceable Hardness Block
5. Indenter Verified with Standard Rockwell Hardness Tester

4. Specifications

Model No.	FM-RWHT-A100
Initial Test Force	3 kgf
Total Test Force	15 kgf, 30 kgf, 45 kgf (for PHR-1ST 15 kgf only)
Indenter	120° Diamond Indenter, 1/16
Accuracy	Complies with ISO 6508, ASTM E18
Resolution	0.5 HR
Testing Range	HRN, HRT, HRW, HRX, HRY, etc. (15 scales)
Specimen Size	50 X 50 mm
Dimension	220x150x240 mm
Net Weight	1.5 Kg
Gross Weight	1.8 Kg

5. Applications

Rock Well Hardness Tester is ideal for Manufacturing and Engineering, Metal Processing, Automotive and Aerospace, Construction and Infrastructure, Research and Development.

6. Installation

Inspection of Hardness Testers

6.1 Verification of Rockwell / superficial Rockwell hardness tester

1) Daily Inspection

If the tester is used every day, it should be inspected daily; otherwise, it should be inspected every time before use. Daily inspection could be applied to only one scale to be used with one standardized hardness block. Choose the standardized hardness block with its hardness most close to the hardness value of the test piece. When the daily inspection is carried out, test 5 times on the hardness block, neglect the first 2 data, and take the average of the rest 3 data. The difference between the average value and the standardized hardness block value should comply.

2) Regular Inspection

A periodic inspection should be made to this device in no more than 6 months at most. Regular inspections should be applied to each scale that could be used and the standard hardness blocks to be used in the inspection should have as many specifications as possible.

Only the front face could be used when testing the hardness blocks. After 2 times of "pretest", on the 5 evenly-distributed dots measure the hardness values H1, H2, H3, H4, and H5 arranged in increasing order by size.

Note: "H" is the hardness value of the standardized hardness block.

Mean Hardness: $$\bar{H} = \frac{H_1 + H_2 + H_3 + H_4 + H_5}{5} \quad \cdots\cdots\cdots\cdots\cdots (5)$$

Repeatability: $$H_5 - H_1 \quad \cdots\cdots\cdots\cdots\cdots (6)$$

Error: $$\bar{H} - H \quad \cdots\cdots\cdots\cdots\cdots (7)$$

6.2 Selection of Indenter, Test Force, and Anvil

To test the metallic materials of different qualities, hardness, and thickness, 3 different test forces are applied, resulting in 9 combinations corresponding to the 9 scales of rock well hardness. 2 kinds of indenters and 3 kinds of testing forces are applied in the superficial rock well hardness testing, resulting in 6 combinations corresponding to 6 scales of superficial rock well hardness.

1) Indenters Selection for Rockwell / Superficial Rockwell Hardness

The indenters should be selected according to the hardness range of testing materials. Select diamond indenters for tempered steel, quenched steel, surface hardening soft steel, and hard alloys; ball indenters for soft metals; small ball indenters for harder metals; big ball indenters for softer metals, and bigger ball indenters for even softer metals.

When the hardness of test samples cannot be estimated, a diamond indenter should be used first to test the HRC or HRN scale. When the hardness value is smaller than a certain relevant testing range, the ball indenter can be applied instead. The following requirements should also be considered:
Do not use the ball indenter to test quenched steel and hard alloys.
Choose suitable ball indenters based on the hardness of test pieces when testing soft metals to make the test results lie within the valid measuring range of relevant scales. Prevent the indenter from damaging the anvil when testing thin materials.
The diamond indenter and the diamond spot anvil are forbidden to be used.

2) Test Force Selection for Rockwell Hardness / Superficial Rockwell Hardness

The test force should be selected according to the thickness of the test piece. Apply big test force to thick test pieces, small test force to thin test pieces, and use a superficial Rockwell hardness tester to test thinner test pieces.
When different test forces are applicable for a certain test piece, choose the biggest test force among them, because a big test force can make deep indentations and the accuracy will be relatively higher.
When testing thin test pieces, no visible deformation trace should be observed on the back side of test pieces, otherwise, it means the test force is overloaded with measuring anvil effect. On this occasion, there would be a large measuring d aviation, so the test force should be reduced.
When testing the hard alloy, only the HRA scale is permitted to be applied. Do not use the HRC scale to test hard alloys in the big test force. Otherwise, the diamond indenter will be damaged.

3) Selection of Anvil

The anvil should be selected according to the shape of the test piece. Flat anvils are adopted by flat test pieces.
V-shape anvils are used to test the test pieces with a cylindrical surface thick wall pipes, round bars, and wires.
For tubing with inner diameter > 30mm, apply the regular Rockwell hardness tester and use the spot anvil by inserting its left side into the tube to test the external surface hardness, or by exchanging the positions of indenter and anvil to test its internal surface hardness.
For tubing with an inner diameter < 30mm, cut one piece from the test piece of tubing and use the flat anvil to test its internal surface.
For the soft metal thin-wall tubing with inner diameter >4.8mm, use the model PHR-1ST superficial Rockwell hardness tester.
The spot anvil can be applied to test small test pieces and those with uneven bottom surfaces. For small-size, deformed punching parts, the slender spot anvil can be selected.
For the bent sheets, use the flat anvil or the spot anvil and have the convex surface rest on the anvil.
For such thin and soft metal sheets as tin plates, cold-rolled thin steel sheets, and thin copper strips, the best choice is a diamond spot anvil together with superficial Rockwell Hardness Tester.

6.3 Factors Affecting Testing Accuracy

1) **Surface of test pieces:** The surface of the test piece should be smooth and flat without oxide coating, without decarburized layer or dirt. The rough surface of the test piece will cause the testing value to go on the low side and will increase the data dispersion.
   For forgings and castings without smooth surfaces, the surface of the test piece should be burnished smoothly by the portable grinding machine.

2) **Thickness of test pieces:** The test piece should be thick enough, otherwise the hardened and deformed area at the bottom of the indentation will be diffused to the interface with the anvil and the surface will be deformed which will result in accurate testing results. According to ISO6508, different scales or testing conditions should be applied to the test pieces with different thicknesses; after testing, the back side of the test piece should not be seen with naked eyes any trace of deformation. during Rockwell hardness testing, when the diamond indenter is used, the thickness of the test piece should not be smaller than 10 times the remnant indentation depth, for a steel ball indenter, it should be no less than 15 times; during the Brinell hardness testing, the thickness of the test piece should not be smaller than 8 times the indentation depth. The relationship between the minimum thickness of the test piece and Rockwell hardness is specified in ISO6508.

3) **Test piece with curved surface:** There will be a deviation in the hardness value obtained from the curved surface test piece compared with that of the flat surface test piece. Therefore, the test result should be added or subtracted by a correction value. A correction value should be added when the test is made on a convex cylindrical surface, while a correction value should be subtracted when the test is made on a concave cylindrical surface.

4) **Test piece position:** When choosing the anvil and placing the test piece, ensure that the test surface is vertical to the indenter axis. Avoid any displacement of the test piece, partial elastic deformation and tilted force direction.
   For the flat-surface test piece, to ensure applying the force vertically, there must be a certain parallelism between the bearing surface and the test surface. Otherwise, it will affect the test result, especially for HRC.
   Flat anvil should be used for warped plates. Its convex surface should lean against the anvil in order to avoid suspending bearing surface of the testing point which otherwise will result in elastic deformation under the test force.
   For tubing test pieces, proper anvils should be chosen as per the diameter and wall thickness of the tubing to avoid the moving and elastic deformation of the test piece. Thin-wall tubing materials may be affected by elastic deformation, which may result in errors caused by incorrect indentation depth during the test.

5) **Invalidation of hardness blocks:** The hardness block can only be used on its front surface. Infinite testing on the blocks is impossible, when the surface is full of indentations, a new block should be replaced. If the block is rusty and the test result is inaccurate, a new block should also be replaced.
   Different devices are equipped with different hardness blocks. Superficial Rockwell hardness testers are equipped with HRN, HRT superficial Rockwell hardness blocks, and Rockwell hardness testers with HRA, HRB, HRC Rockwell hardness blocks. The blocks should not be shared in common, otherwise the testing is invalid.

6) **Incorrectly applying force:** During the test, applying force should be slow and even to bring the indicator hand-aligned exactly with relevant scale marks. The accuracy will be affected by both not reaching up or beyond the scale marks.
   Different test forces should be applied to different testing conditions and different scales. The test force of Rockwell hardness is marked in black, the testing will be invalid if the wrong test force is chosen.

7) **Incorrect Reading:** During the Rockwell, superficial Rockwell hardness testing, when operating the instrument, the visual angle of the operator should be maintained unchanged. The position of reading should be consistent to that of the barrel dial adjustment. Otherwise it will cause error reading.

8) **Damage of Indenter:** The indenter can be damaged by wearing, impacting or testing very hard materials. When the tester has been used for a long time or its accuracy is going down, the indenter should be inspected with an 8-10x magnifier. When the diamond indenter has some cracks, cicatrices or defects and the ball indenter has been deformed, it should be replaced with a new one.

7. Working Principle

Principle of Rockwell Hardness Test

As illustrated in the figure indenter is pressed (diamond cone or hard alloy ball) into the test piece surface in two steps. After maintaining the pressure for a predetermined period, unload the major test force F1, and measure the remaining indentation depth h under initial test force F0.

Rockwell hardness value is:

$$HR = N - \frac{h}{s}$$

In this equation:

N — a constant related to scales; for A, C, D, N, and T scales, N=100; for B, E, F, G, H, and V scales, N=130.

S — unit indentation depth, for Rockwell hardness, it is 0.002mm, for superficial Rockwell hardness it is 0.001mm.

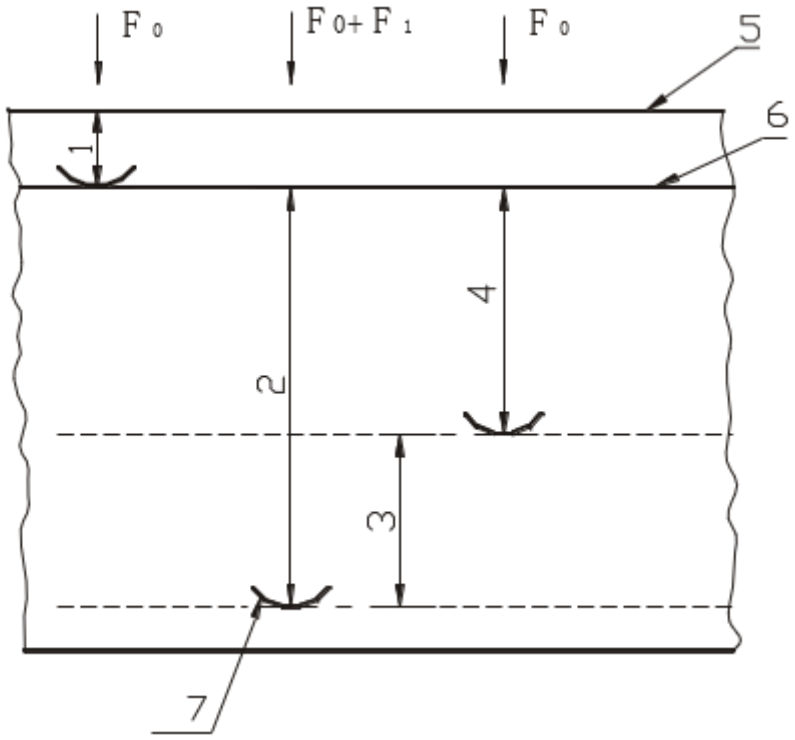


Figure-1 (Principle of Rockwell Hardness Testing)

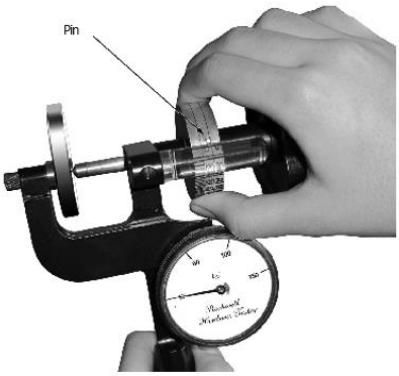
1—Indentation depth under initial test forces F0
2—Indentation depth under total test forces F0+F1
3—Elastic recovery depth when major test force F1 is removed
4—Remaining indentation depth h
5—Test piece surface
6—Datum plane
7—Position of indenter

Rockwell hardness testers are designed according to the basic principle of the Rockwell hardness test. The main differences from the bench type lie in: the test force is applied by a screw and a calibrated U-shape spring; two indicators are installed on the tester: one indicating dial indicates the test force value by measuring the deformation of the elastomer and one precision screw micrometer used for testing the indentation depth; one barrel dial installed on the micrometer shows the hardness values. The principle and structure of this device are by the American Standard ASTM E110.

8. Operations

Rockwell/Superficial Rockwell Hardness Tester

1) **Preparation:** Be sure to have chosen the proper indenter and anvil before testing. This device is equipped with the diamond indenter and flat anvil before leaving the factory. When changing the indenter and anvil, be sure to have the screws fastened tight. When using a hardness tester with an opening size >1 inch to test small test pieces, an extension should be adopted and also fixed tight. After the indenter and anvil are changed or the extension is installed, a pretest should be made before the formal test. The result of the pretest should be neglected.



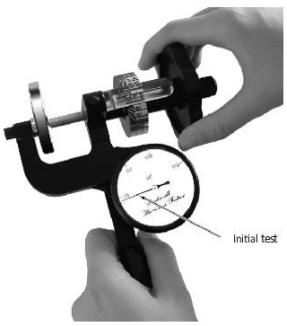
(Apply initial test force) **(Adjust the barrel dial)**

Figure-2

2) **Set the load dial to "0":** Check the indicator hand. It should rest exactly on the red dot "0" on the indicator dial. If it doesn't, adjust the dial by turning the bezel to locate the red dot under the pointer.

3) **Fix the test piece:** Put the test piece into the opening of the tester with its back side contacting the anvil tight, and be sure to keep its testing surface vertical to the principal axis of the indenter. Turn the hand wheel to make the main shaft of the tester move to the left, and the indenter is made to hit the test piece surface.

4) **Apply the initial test force:** Slowly turn the hand wheel clockwise to bring the indicator hand to the position of initial force F0 (for Rockwell Hardness Tester F0=10Kg, for superficial Rockwell hardness tester F0=3 Kg)



(Apply major test force) **(Take the reading)**

Figure-3

5) **Set the reading line in magnifier aligned with a full-scale line in barrel dial:** Rotate the barrel dial anticlockwise until its pin rests against the upper edge of the magnifier. Meanwhile, the operator should adjust the observing angle to make the full-scale benchmark line on the fixed drum dial (the red scale mark 130, black scale mark 100) exactly aligned beneath the reading scale mark of the magnifier. The operator should keep this viewing angle also known as the viewing angle for reading the hardness value until the test is finished.

6) **Load and unload major test force:** Rotate the hand wheel stably clockwise to bring the indicator hand to the position of total test force F=F0+F1 (e.g., for HRC scale, F=150kg). The indicator hand should be aligned exactly to the marked scale of the selected test force, refer to Fig. 9. If the pointer goes beyond the scale mark, the testing should be considered a failure. Then unload the test force and choose a new point on the test piece to make a new test.
   The time duration from loading the initial test force to loading the total test force should be no more than 8 seconds.
   After loading the total test force, the test force should be maintained for 3 to 5 seconds. Then completely unload the major test force within 2 seconds to bring the indicator hand back to the position of the initial test force F0.

7) **Take the reading:** Looking through the magnifier, determine the superposition of the reading line of the barrel dial aligned with that of the magnifier, the value of which represents the hardness value of this test. Each long-scale mark on the rotational drum dial represents 10 hardness units, and the value is shown above the mark. Between every two long scale marks, there are 5 (or 10) graduations, each of which indicates 2 (or 1) hardness units. The midpoint of every 2 short marks indicates 1 (or 0.5) hardness unit. The 1/4 point between 2 short marks indicates 0.5 (or 0.25) hardness unit. The reading value should be estimated to 0.5 hardness unit as shown in the figure below.

   For Rockwell hardness testers: Read the black numbers under C on the rotational drum dial for scales HRA, HRC, HRD with a diamond indenter; read the red numbers under B on the rotational drum dial for Scales HRB, HRE, HRF, HRG, HRH, HRK with a ball indenter.
   For superficial Rockwell hardness testers: Read the N-T graduations on the rotational drum.

9. Maintenance

Process of Maintenance

This tester is a precision instrument, the service life of which depends on correct usage and timely maintenance. This tester can be used for 20 years under proper maintenance and inspection conditions. Users must read carefully this instruction manual, and master the inspection rules and operating methods after receiving it. The tester should be inspected correctly, handled carefully, stored properly, and used by a special person. It should be put in the carrying case after use.

Pay special attention to the following points:

1) **Anti-rust**
   Though all the parts of this instrument have been treated anti-rust, some parts still can be rusted by improper storage or maintenance, especially in the coastal areas. The instrument has been fully lubricated before leaving the factory, so no lubricating should be made in use. It should be often wiped with a piece of soft cloth. Be careful to keep the anvil, indenter, extension, and hardness block dry and clean. The testing surface of the hardness block is not allowed to be touched by hand.

2) **Avoid falling off**
   This instrument is made up of many precision components, impact or falling off of it will result in permanent damage to some parts, and even worse the instrument can be discarded as useless. The magnifier of this instrument is made of synthetic glass, and it can be broken by impact. Disassemble and store the magnifier separately during transportation to protect it. The force indicator should be protected from impact in use and during transportation as an important part of the tester. For the instrument with an opening size of 1 inch, move away the hardness block nearest to the force indicator during transportation.

3) **Disassembly forbidden**
   The testing accuracy of this instrument is guaranteed by the good collaboration of some of the precision parts. This collaboration is not easy for non-professional people to master. Consequently, disassembly of the parts is not allowed except for parts, such as the indenter, anvil, and extension, otherwise, this will result in an inaccurate instrument or some parts damaged, and the warranty will be void.

10. Accessories

Standard Accessories

1. Tester
2. Bench Stand
3. Diamond Penetrator
4. Carbide Ball Penetrators Φ1.588mm
5. Test Block HR30T
6. Test Block HR30N
7. Flat Anvil ½"
8. "V" Anvil 1"
9. Magnifier
10. Extension Adaptor ½"
11. Extension Adaptor 1"
12. Carrying Case

Optional Accessories

1. 120° Diamond Indenter
2. Carbide Ball Indenter (1/16", 1/8")
3. Steel Ball Indenter (1/4", 1/2")
4. Standard Test Blocks (HR30N, HR30T)
5. Raised Spot Anvil
6. Slim Raised Spot Anvil (Flat Top: Φ1.5 mm, Φ2.5 mm, Φ3.5 mm)
7. Diamond Raised Spot Anvil
8. Ball Testing Anvil
9. Spare Magnifier