



650MA

**ELECTROMOTION ROCKWELL HARDNESS TESTING
MACHINE**

OPERATING INSTRUCTION

BAQ GMBH

GENERAL SAFETY PRECAUTIONS



Material testing systems are potentially hazardous.

Material testing involves inherent hazards from high forces, rapid motions and stored energy. You must be aware of all moving and operating components that are potentially hazardous, particularly the indenter.

Carefully read all relevant manuals and observe all Warnings and Cautions. The term *Warning* is used where a hazard may lead to injury or death. The term *Caution* is used where a hazard may lead to damage to equipment or to loss of data.

Ensure that the test set-up and the actual test you will be using on materials, assemblies or structures constitute no hazard to yourself or others. Make full use of all mechanical and electronic limits features. These are supplied to enable you to prevent movement of the system components beyond desired regions of operation. Limits provide protection for your specimen and machine and reduce potential hazard.

The following pages detail various general warnings that you must heed at all times while using materials testing equipment. You will find more specific Warnings and Cautions in the text whenever a potential hazard exists.

Your best safety precautions are to obtain training in the testing equipment that you are using and to read your Operating Instructions and Reference Manual(s) to gain a thorough understanding of that equipment.

Staff training on materials testing with appropriate training certificate can be obtained from:

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Warnings



Wear eye protection and use protective shields or screens whenever any possibility exists of a hazard from the failure of a specimen, assembly or structure under test.

Wear eye protection and use protective shields or screens whenever any possibility exists of a hazard from the failure of a test specimen or assembly, particularly where explosive disintegration may occur. Due to the wide range of specimen materials or assemblies that may be tested, any hazard resulting from the failure of a test specimen or assembly is entirely the responsibility of the owner and the user of the equipment.



Protect electrical cables from damage and inadvertent disconnection.

Protect all electrical cables from damage. Never route cables across the floor without protection, nor suspend cables overhead under excessive strain. Use padding to avoid chafing where cables are routed around corners or through wall openings.



Wear protective clothing when handling equipment at extremes of temperature.

Material testing is often carried out at non-ambient temperatures using ovens, furnaces or cryogenic chambers. Extreme temperature means an operating temperature exceeding 60°C (140°F) or below 0°C (32°F). You must use protective clothing, such as gloves, when handling equipment at these temperatures. Display a warning notice concerning low or high temperature operation whenever temperature control equipment is in use. You should note that the hazard from extreme temperature can extend beyond the immediate area of the test.



Take care when installing or removing a specimen, assembly or structure.

Installation or removal of a specimen, assembly or structure involves working inside the hazard area between the indenter and the specimen mounting stage. Keep clear of the hazard area between the indenter and the specimen mounting stage during system component movement. Ensure that all indenter and stage movements necessary for

installation or removal are slow and, where possible, at a low force setting.



Power supply should be well earthed, otherwise it could influence the test accuracy and even result in personnel injure or property damage!

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GENERAL DESCRIPTION

The **650MA** is a Rockwell hardness testing machine which is used to determine the material hardness. Hardness has typically been defined as the resistance of a material to permanent penetration by another harder material. The more resisting capacity is, the higher hardness is, vice versa, the lower hardness is. As one of the means to determine the quality of metal materials or work-pieces and to control the product quality in manufacturing process, the hardness test is the easiest and most convenient testing method among all the mechanical property tests. As there exists the mutual relationship between metal hardness and other mechanical properties such as strength, fatigue, creep, abrasion and internal defective etc., these other properties of most metal materials could be approximately obtained by testing the hardness.

Basic principle

The general principle of the Rockwell indentation hardness test is illustrated in **Figure 1-1**.

The test is divided into three steps of force application and removal.

Step 1 — the indenter is brought into contact with the test specimen, and the preliminary test force F_0 is applied. After holding the preliminary test force for a specified dwell time, the baseline depth of indentation is measured.

Step 2 — the force on the indenter is increased at a controlled rate by the additional test force F_1 to achieve the total test force F . The total test force is held for a specified dwell time.

Step 3 — the additional test force is removed, returning to the preliminary test force. After holding the preliminary test force for a specified dwell time, the final depth of indentation is measured. The Rockwell hardness value is derived from the difference h in the final and baseline indentation depths while under the preliminary test force. The preliminary test force is removed and the indenter is removed from the test specimen.

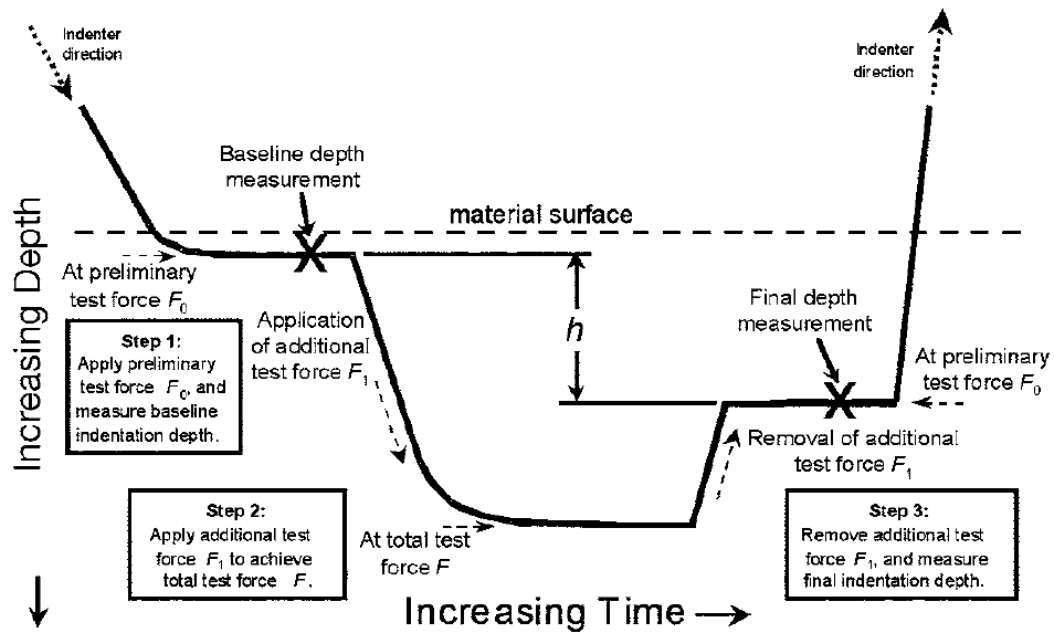


Figure 1-1 Test principle

Formulas for Rockwell hardness Test

$$\text{HRC.A} = 100 - \frac{n_1 - n_0}{0.002}$$

$$\text{HRB} = 130 - \frac{n_1 - n_0}{0.002}$$

Where:

n_0 = Indentation depth made by preliminary test force F_0

n_1 = Indentation depth made by total test force F ; however, at that time, additional test force F_1 is removed while preliminary test force F_0 maintained.

External and Internal Components

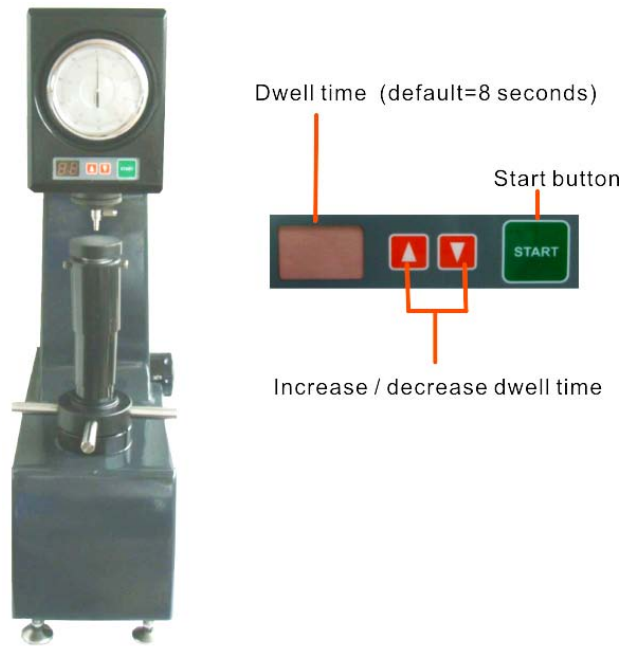


Figure 1-2 External Components

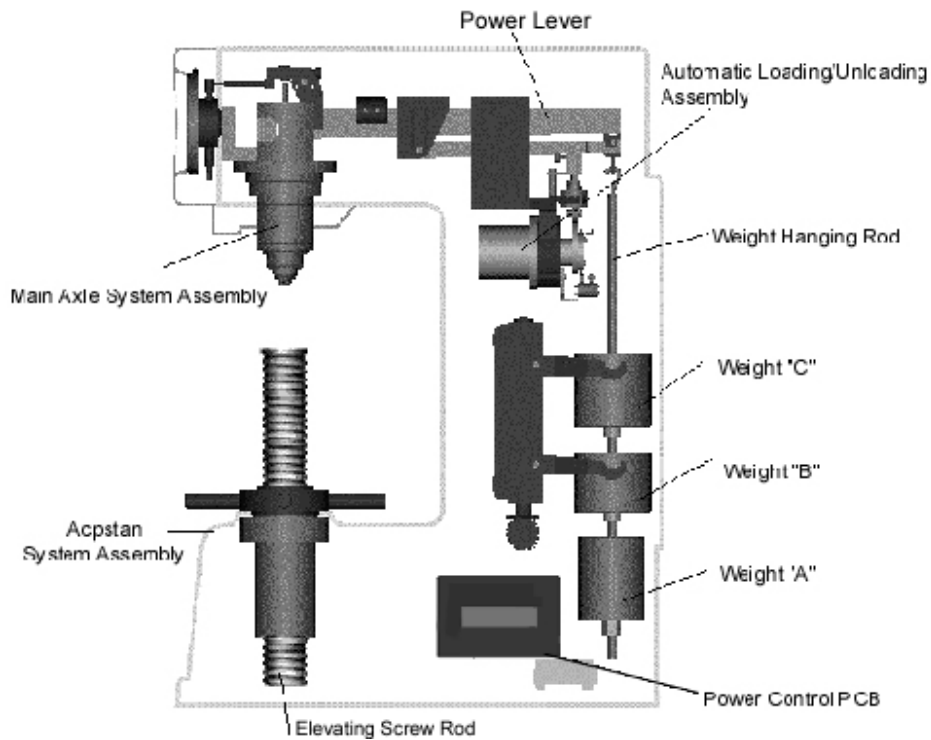


Figure 1-3 Internal Components

Elevating assembly

The elevating assembly is composed of hand wheel, screw spindle and spindle protection sleeve etc.

When you turn the hand wheel clockwise, the screw spindle will go upwards; when you turn the hand wheel counterclockwise, the screw spindle will go downwards until it travels through the hole on work-bench surface. Around the screw spindle there is a protection sleeve. On the top surface of the screw spindle there is a coupling hole for supporting the anvil or the special fixture.

Cover

Two covers can be removed, which provides access to the internal components. Six Philips screws are used to fix the upper cover so as to protect the power lever and the axle assembly. Two Philips screws are used to fix the back cover. You can access the deadweight stack after removal of the back cover.

Deadweight stack assembly

The deadweight stack assembly is composed of a deadweight hanger rod and three deadweights. A hook at the top end of the hanger rod attaches the ring at the end of the power lever. One weight is placed at the bottom of the rod, and the other two are placed on the middle of the rod.

Power Lever Assembly

The power lever assembly extends from the main axle to the rear of the testing machine. A pivot hangs from the rear of the lever and supports the weight stack. Mechanical linkage between the weight changer and dash pot assemblies controls the magnitude of the test force and the rate of force application.

Deadweight Changer

A pair of bevel gears drives the camshaft to rotate so as to move the forks up and down, so that the weights release from or apply on the hanging rod, then the test force is changed.

Automatic Loading/Unloading Assembly

Automatic loading/unloading assembly is composed of servomotor, loading/unloading cam, limit switch and screw spindle. Automatic loading/unloading assembly is electrically controlled.

Hardness Dial Gauge

A glass dial, on the front of the testing machine, contains scales and pointing needle which can indicate the preliminary force and the hardness value.

TECHNICAL SPECIFICATIONS

The testing machine dimensions and total weight are illustrated as **Figure 2-1**:



Figure 2-1 Dimensions

Table 2-1 Dimensions and Weight

Dimension	mm
Height	715 (approx.)
Width	227
Length	516
Test height (With protection sleeve) (Without protection sleeve)	84 170
Throat depth (from the centerline to machine wall)	165
Weight (kg)	85
Voltage	220V
Dwell time	5~99s

Table 2-2 Test force

Preliminary test force N (kgf)	Total test force N (kgf)
98 (10)	588 (60)
	980 (100)
	1471 (150)

Table 2-3 Scale, indenter and test force

Scale Symbol	Indenter mm (inch)	Pre-test force N (kgf)	Total test force N (kgf)	Dial figure
A	Diamond Cone	98 (10)	588 (60)	white
B	Ball ϕ 1.5875 (1/16)		980 (100)	red
C	Diamond cone		1471 (150)	white
D	Diamond cone		980 (100)	white
E	Ball ϕ 3.175 (1/8)		980 (100)	red
F	Ball ϕ 1.5875 (1/16)		588 (60)	red
G	Ball ϕ 1.5875 (1/16)		1471 (150)	red
H	Ball ϕ 3.175 (1/8)		588 (60)	red
K	Ball ϕ 3.175 (1/8)		1471 (150)	red
L	Ball ϕ 6.35 (1/4)		588 (60)	red
M	Ball ϕ 6.35 (1/4)		981 (100)	red
P	Ball ϕ 6.35 (1/4)		1471 (150)	red
R	Ball ϕ 12.7 (1/2)		588 (60)	red
S	Ball ϕ 12.7 (1/2)		980 (100)	red
V	Ball ϕ 12.7 (1/2)		1471 (150)	red

Table 2-4 Indicating error and repeatability

Scale Symbol	Range of Standardized Test Blocks	Indicating error δ	Maximum Repeatability b
A	20~75HRA	$\pm 2\text{HRA}$	$\leq 0.02(100 - \bar{H})$ or 0.8HR
	75~88HRA	$\pm 1.5\text{HRA}$	
B	20~45HRB	$\pm 4\text{HRA}$	$\leq 0.04 (130 - \bar{H})$
	45~80HRB	$\pm 3\text{HRB}$	
	80~100HRB	$\pm 2\text{HRAB}$	
C	20~70HRC	$\pm 1.5\text{HRC}$	$\leq 0.02(100 - \bar{H})$ or 0.8HR

D	40~70HRD	$\pm 2\text{HRD}$	$\leq 0.02(100 - \bar{H})$ or 0.8HR
	70~77HRD	$\pm 1.5\text{HRD}$	
E	70~90HRE	$\pm 2.5\text{HRE}$	$\leq 0.04 (130 - \bar{H})$
	90~100HRE	$\pm 2\text{HRE}$	
F	60~90HRF	$\pm 3\text{HRF}$	$\leq 0.04 (130 - \bar{H})$
	90~100HRF	$\pm 2\text{HRF}$	
G	30~50HRG	$\pm 6\text{HRG}$	$\leq 0.04(130 - \bar{H})$ or 1.2HR
	50~75HRG	$\pm 4.5\text{HRG}$	
	75~94HRG	$\pm 3\text{HRG}$	
H	80~100HRH	$\pm 2\text{HRH}$	$\leq 0.04 (130 - \bar{H})$
K	40~60HRK	$\pm 4\text{HRK}$	$\leq 0.04 (130 - \bar{H})$
	60~80HRK	$\pm 3\text{HRK}$	
	80~100HRK	$\pm 2\text{HRK}$	

INSTALLATION

Installing Procedure

1. Unpack the testing machine.
2. Lift the hardness testing machine onto the work-bench.
3. Assemble the leveling screws to the testing machine.
4. Assemble the deadweight stack to the testing machine.

Check the followings before installation

1. The workbench is solid enough to support the testing machine and accessories. The bench surface should have a hole on it for screw spindle to travel through. Refer to **Figure 3-1**.
2. The floor supporting the workbench is free from the mechanical vibrations.
3. There is an adequate clearance between the testing machine and adjacent walls for the convenience of routine service.

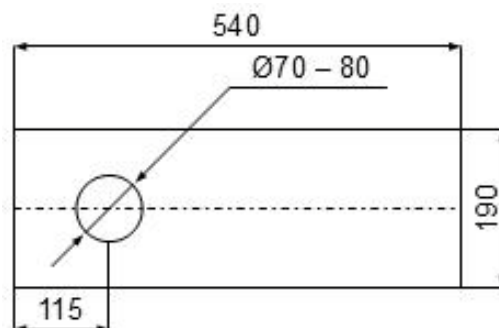


Figure 3-1 Workbench surface

Unpacking

1. Shear off the packing straps.
2. Use a wrench to remove four screw nuts and take the packing case upwards.
3. Take off the plastic protection bag from the testing machine.
4. Check all items against the packing list. Some accessories would probably be packed together with the testing machine and sometimes packed separately.

Lifting the testing machine on the workbench

1. Do not manually lift the testing machine, which will probably cause personal injury. It is not easy to manually move the testing machine due to its heavy weight and large dimensions. You have to lift the hardness testing machine with the help of a mechanical lifting device. According to the correct lifting method, only those who have rich experience in this field are allowed to move the testing machine.
2. Do not lift the testing machine by attaching the cover or the screw spindle, which will do harm to the testing machine's components and testing accuracy.
3. Prior to moving the testing machine, take off the deadweight stack. The movement of hanging weights inside testing machine will probably damage the testing machine.
4. When lifting or moving the testing machine, make sure the deadweight stack has been removed.
 - (a) Tie up the testing machine with a rope which is twice as much as the testing machine in rated bearing capacity, as **Figure 3-2** illustrates.
 - (b) Slowly lift the testing machine onto the workbench with the help of a mechanical lifting device and then remove the rope.



Figure 3-2 Lift the testing machine

Assembling the leveling screws

When the testing machine is moved onto the workbench, you can install the four leveling screws. Make sure that the deadweight stack is hung in the correct position and the testing machine does not move.

Tools

- Rope
- Mechanical lifting device
- Spirit level gauge
- Adjustable wrench
- Flat anvil (inside the accessory box)
- Four leveling screws (inside the accessory box)

Procedure

1. Before you start test, make sure that the workbench supporting the testing machine is stable.
2. Carefully tilt the testing machine up as **Figure 3-3** illustrates and hold the testing machine with a mechanical lifting device.
3. Turn the leveling screws into the holes on the pedestal.
4. Remove the foam pad.
5. Install a flat anvil.
6. As **Figure 3-4** illustrates, place the spirit level gauge on the anvil to level the testing machine from the front to the back.
7. Use the wrench to adjust the testing machine for leveling as **Figure 3-4** illustrates.
8. Rotate the spirit level 90°.
9. Use the wrench to level the testing machine from left to right.
10. Remove the rope.

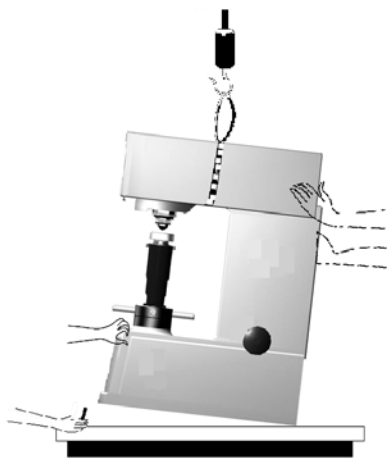


Figure 3-3 install the leveling screw



Figure 3-4 leveling the machine

Installing the deadweights

The deadweights are taken out from the testing machine prior to shipment. You must install the deadweights when the testing machine has been leveled.

Before you move the testing machine, you should also take out of the weight stack from the testing machine. The internal components could probably be damaged if you leave the deadweight stack inside the testing machine when moving.

Check the followings before you install the deadweight

- The testing machine is leveled.
- The screw spindle is in the lowest position.

Tools

- Philips screwdriver
- Slot screwdriver
- Shears

Procedure

1. Remove the six screws from top cover, as **Figure 3-5** illustrates.
2. Remove the top cover.
3. Remove the back cover, as **Figure 3-5** illustrates.
4. Remove the foam in the body.
5. Turn the test force selector to the 588N (60kgf).
6. Carefully take out of the deadweight hanger rod, put deadweight A at the bottom of hanger rod and secure it with two screws. Now you can attach the hanger rod on the ring at the end of the power lever as **Figure 3-6** illustrates. Finally, insert other two deadweights on the hanger rod carefully and use the studs to hang the deadweights onto the fork slots, as **Figure 3-7** illustrates.
7. Turn the test force selector to choose all of test force to make sure that the deadweights are centered on the rod and the studs securely seat in the deadweight forks.
8. Put on the top and back covers.

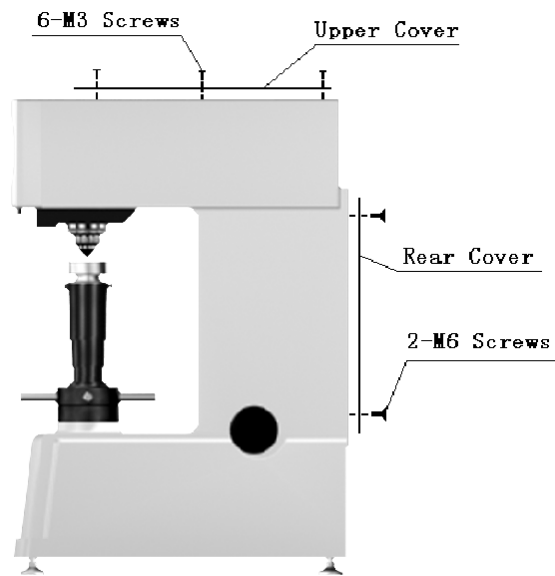


Figure 3-5 Remove top and back covers

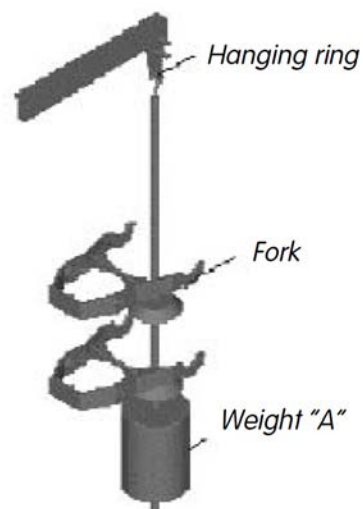


Figure 3-6 Installation of hanger rod and weight A

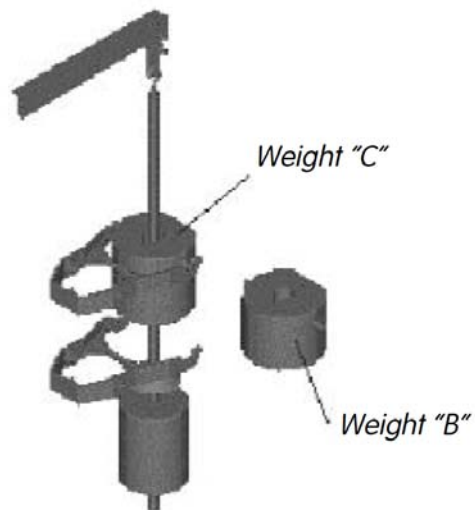


Figure 3-7 Installation of weights B and C

FUNCTION OF COMPONENTS

Dial Gauge

The dial gauge, located on the front of the testing machine, contains hardness scales and hardness scale needle and preliminary force needle, as **Figure 4-1** illustrates:

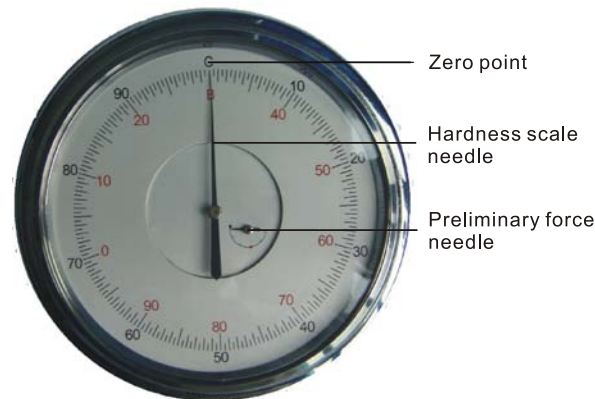


Figure 4-1 Dial Gauge

In the dial gauge, the black scale is hardness value.

The black number indicates the hardness value obtained by using the diamond indenter; the red number indicates the hardness value obtained by using the ball indenter. You can use the various combination of indenters and deadweights to test the specimen according to the Table 2-3 information.

- The small needle points to the preliminary test force. When the indenter tip touches the specimen, user rotates the hand wheel until hardness scale needle turns three circles. The preliminary test force needle moves from black mark to red mark. The red mark indicates that the preliminary test force has been fully applied and a shallow indent has been made on the specimen surface.
- The big needle points to the hardness value. When the preliminary test force is applied, user rotates the dial gauge to align the needle with the scale zero point. When the main test force is applied, the indent increases in depth. This increase causes the needle to move from the zero point to the number that represents the specimen's hardness.

Note: The letter B or C presents the hardness scale, and also it is zero point of hardness needle.


Test force selector

The test force selector is a ratcheting knob on the side of the testing machine as **Figure 4-2** illustrates.



N	kgf
1471	150
980	100
588	60

Figure 4-2 Test force selector

	<p>WARNING!</p>
	<p>Do not rotate the test force selector when the testing machine is applying the test force or in the period of dwell time, otherwise the force selector may fail to choose the correct test force.</p>

Hand wheel

The hand wheel is used to elevate the screw spindle, as **Figure 4-3** illustrates. By turning the hand wheel clockwise or counter clockwise, you raise or lower the screw spindle to install or remove the specimen, and then apply or remove the preliminary test force.

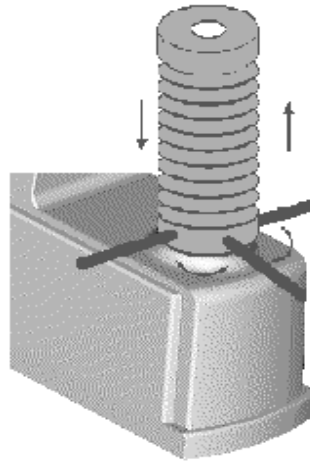



Figure 4-3 Screw spindle

	CAUTION!
	<p>Do not strike the indenter with the anvil. Striking the indenter with the hardened anvil could damage both components.</p> <p>Do not move the hand wheel while the testing machine is applying the total test force. Doing so will invalidate the test result.</p>

Start button

Start button is used to control the loading and unloading, as **Figure 4-4** illustrates

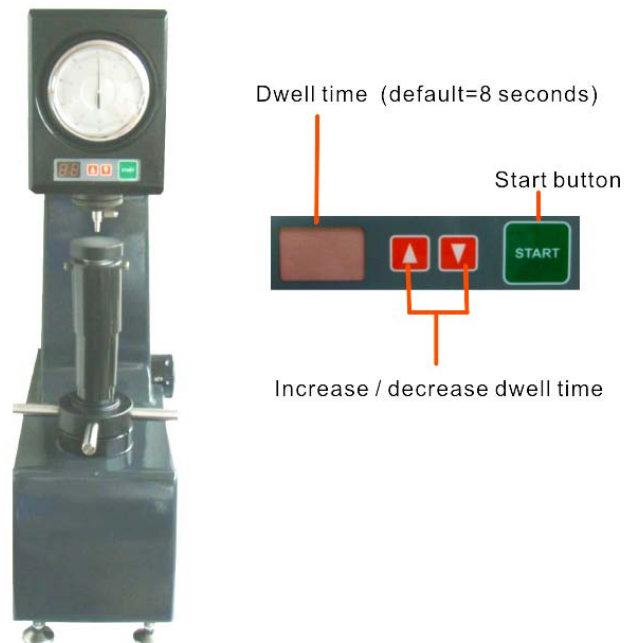









Figure 4-4 Start button

The start button is used to control the application and removal of the test force. The system controls the servo motor and cam to make the elevating spindle move upwards and downwards, and thus make the power lever move upwards and downwards.

Note: after you apply the preliminary test force, you can press the start button to apply the main test force. When the main test force is applied completely, after a period of dwell time, the testing machine automatically removes the main test force.

You can change the testing machine from the automatic loading/unloading mode to manual loading/unloading mode to verify if the test force is correct.

Turn off the testing machine. Simultaneously press    and then turn on the testing machine. If the screen displays “— —”, keep pressing these three keys until the screen displays the dwell time. Now you can release the buttons. The testing machine is in the manual mode. You can press  to increase the test force and press  to decrease the test force. The dwell time does not change.

To go back to automatic loading/unloading mode, you turn on the testing machine and simultaneously press  and .

PREPARATION FOR USE

Installing the anvil

You can install the anvil according to the illustration of **Figure 5-1**.

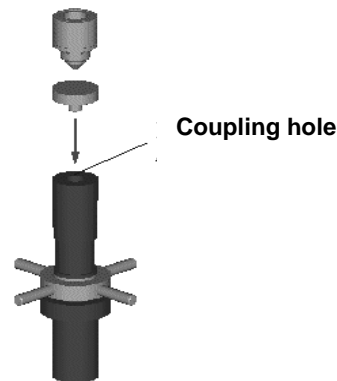


Figure 5-1 Install the anvil

1. Before installing, lower the screw spindle so that you will have enough room to install the anvil.
2. Select the proper anvil considering the dimensions and shape of the specimen.
3. Clean the installing hole in the screw spindle before installing the anvil (You should also clean the threads if there are).
4. After installing, you should perform a few hardness tests on this testing machine so that the anvil could be securely seated on the screw spindle.

Installing the indenter

1. To begin with, clean the indenter shank and the main axle hole, and then insert the shank into the hole. The shank surface must face the screw hole in the main axle when being inserted, as **Figure 5-2** illustrates.
2. The indenter tip should not hit the anvil; otherwise both parts could be damaged.
3. Insert the indenter shank into the main spindle hole. Then turn the screw tight through the main axle hole. After applying preliminary test force, loose the screw until applying the main test force. Then you turn the screw tight again so that the indenter could be fixed more securely.

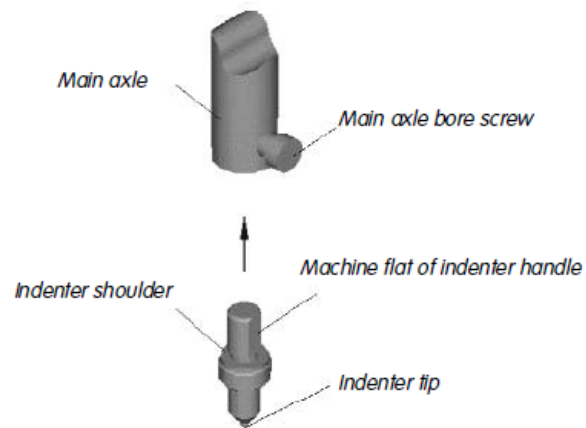




Figure 5-2 Installing the Indenter

Adjust the dwell time

Refer to **Figure 4-4**. Press  button to increase the dwell time and press  button to decrease the dwell time. The dwell time is displayed in the left side.

OPERATION

Check the followings before you start a test

- The proper anvil has been installed in the installing hole of the screw spindle.
- The proper indenter has been installed in the installing hole of the main axle.
- There is enough room between anvil and indenter to accommodate the specimen.

Note: Refer to Table 2-3 for the information about dial number and the combination of indenter and test force.

Test procedure

1. Place the specimen or test block on the anvil.
2. Adjust dial gauge until the hardness scale needle points to the “C”. Refer to *Figure 6-1*.



Figure 6-1 Zero the Scale

3. Turn the test force selector to choose the test force that meets the hardness scale.
4. Watch the dial gauge and turn the hand wheel clockwise until the hardness scale needle (big needle) goes three circles and the preliminary test force needle (small needle) points to the red mark, as *Figure 6-2* illustrates.




Figure 6-2 Small needle points to the red mark

5. If the big needle is not exactly in the “C” zero point after it moves three circles, you can rotate the dial gauge to make the big needle in the “C” position in case the deviation is within $\pm 5\text{HR}$.
6. Press the start button to start the test. The testing machine starts to apply the main test force, and the big needle begins to move, as **Figure 6-3** illustrates.



Figure 6-3 Applying main test force

	<p>WARNING!</p>
	<p>Do not move the hand wheel when the testing machine applies the test force.</p>

7. After the hardness scale needle stops moving, the test machine comes to the dwell time. When the dwell time is over, the testing machine removes the main test force.
8. You can read the Rockwell hardness value from the dial gauge, as **Figure 6-4** illustrates.



Figure 6-4 Read the Hardness Value

9. Turn the hand wheel counter-clockwise to lower the elevating screw spindle to remove the test force.

Indication value adjustment

The related engineer can make the appropriate adjustment after getting familiar with the structure and operating principle of the testing machine, as **Figure 6-5** illustrates.

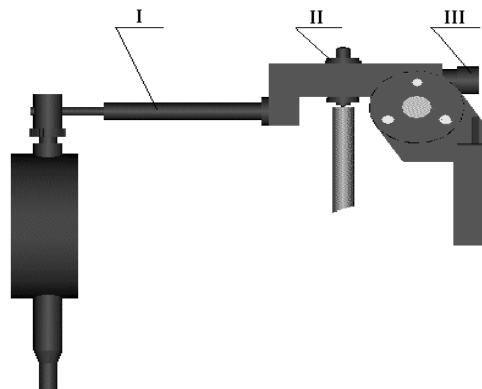



Figure 6-5 Indication value adjustment

Remove the upper cover. If the hardness value you get is lower than that on the standard block, you should loosen the screw-cap (II) and slightly turn screw (III) clockwise. After that, turn tightly the screw-cap (II). Repeat the above operation until you get the test value within the tolerance. If the hardness value you get is higher than that on the standard block, you can turn the screw (III) counterclockwise.

MAINTENANCE


Non-metallic Surfaces

Use a soft cloth to dip (not soak) some mild liquid detergent and gently wipe and clean the components.

	CAUTION!
	Do not use excessive detergent. It could seep into the testing machine and cause component damaged.

Metallic Surfaces

Use a soft cloth to dip (not soak) some light-weight oil and gently wipe and clean the components.

	CAUTION!
	Do not use excessive oil, which would attract dirt and other abrasive particles that would cause damage to the testing machine.

Clean the mating surfaces of the screw spindle and anvil, the indenter and the main axle surface as well, as **Figure 7-1** illustrates. Dirt, oil, metal chips or other debris on these surfaces could cause inaccurate results.

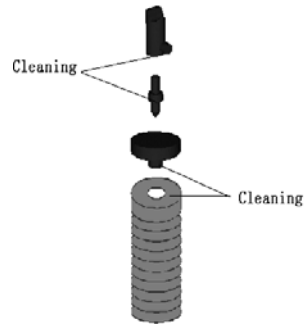


Figure 7-1 Cleaning

Lubricating the screw spindle

You should periodically lubricate the screw spindle to prevent it from being blocked

Before lubricating, check the following conditions:

- There is no specimen, anvil or indenter installed in the testing machine.
- The screw spindle is completely exposed.

Procedure

1. Remove the protective sleeve, as **Figure 7-2** illustrates.
2. Check if there is any dirt, fibers or other debris in the screw threads. If you find any, remove them with a cloth.
3. Apply appropriate oil to threads. Do not apply too much oil.
4. Use a cloth to clean excessive oil.
5. Remove any lint or fibers with a soft brush.
6. Put on the protection sleeve.
7. Turn the screw spindle up and down several times to distribute the oil equally.

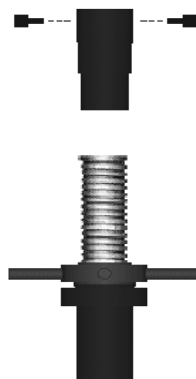



Figure 7-2 Remove the protection sleeve

	CAUTION!
	<p>The tiny and minute fibers or other debris will cause the screw spindle to get blocked. After lubricating the screw spindle, remove all of the left over oil on the screw thread with a soft brush.</p>

Care of Indenter

Figure 7-3 illustrates a diamond cone indenter and a ball indenter.

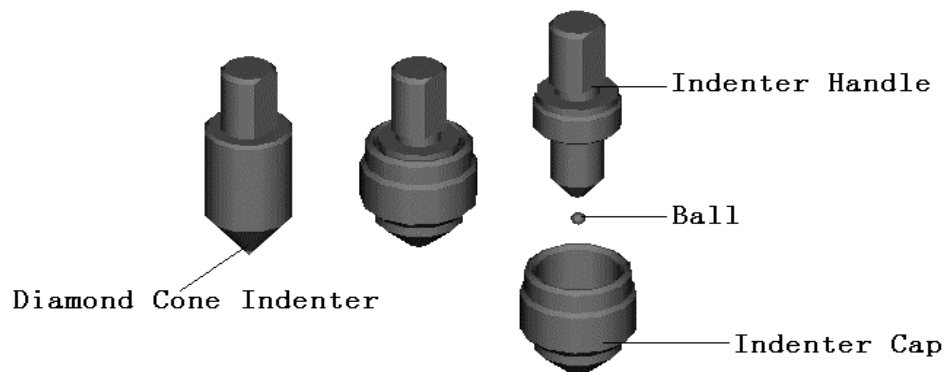



Figure 7-3 Diamond Cone Indenter (left) Ball (middle, right)

	CAUTION!
	<p>Do not use a worn or damaged indenter.</p>

- **Diamond Cone Indenter**

Inspect the diamond cone indenter every month. If the conical surface of the metal body has many dents, it means that the operator has probably struck the indenter against the hardened anvil. Inspect the indenter under a 10x power magnifier. If there is significant damage, replace the indenter. In order to avoid damaging the indenter, protect it with your finger when remove the anvil and specimen.

- **Ball Indenter**


Inspect the ball indenter daily. If there is the sign of wear or deformation, replace the ball.

Method of replacement: Unscrew the cap by turning it. Remove the old ball and install a good one. Screw on the cap and install the indenter.

Test block verification

Testing block verification is an easy and convenient way to verify the accuracy of the testing machine.

You can perform a hardness test on the standard test block and compare the resulting hardness value with that marked on the standard block. This comparison lets you know whether or not the testing machine needs calibration.

	<p>CAUTION!</p>
	<p>You should verify the testing machine accuracy every day if you use the testing machine frequently.</p>

Standard test block

Before you use the standard test block to perform verification, make sure:

1. Always use the top surface of the test block. The bottom and side surfaces will not yield the proper hardness values.
2. Always use a test block that is in good condition. Do not use a test block which has a ratio of diagonal length to indent depth less than 2.5.
3. Always use a test block that has its original surface finish. Grinding off old indents and machining the surface will invalidate the block's original hardness designation.
4. If you use the testing machine within the given scales, check the high, middle and low ranges of the scale. If you only use one or two ranges, you could choose test blocks with the hardness values above or below those ranges.

Note:

You must test at least five times on a standard test block (excluding the first point). The certified hardness value is marked on the standard block surface.

Compare the mean measured hardness value with the certified value on the standard block. If the difference is within the allowable tolerance, it is acceptably qualified.

If the average of five hardness values is out of the tolerance of Rockwell:

- Check the indenter and replace the ball or check the top of the diamond indenter with the help of a 10x magnifier. If there is significant damage, replace the diamond indenter.
- Check the mating surfaces of the indenter and the main axle to see if they are clean and free of dirt, chips and oil. These foreign matters would prevent the indenter from properly seating and thus cause inaccurate test results.

After replacing the indenter or anvil, you should conduct several tests for the purpose of making the components securely installed.

Troubleshooting

Table 7-1 offers you probable problem causes and their remedies. If the problem remains unsolved, please contact HDNS office.

Table 7-1 Troubleshooting Guide

Problem	Probable Cause	Solution
Screw spindle blocked	Rust or debris	Clean and lubricate the screw spindle
Total load is bouncy	Testing machine not leveled yet	Level the testing machine
Testing machine could not apply total load	Weights are not properly hung	Check if weights are properly hung.
Inaccurate hardness value	Unknown	Verify the testing machine with standard block
	Wrong test force	Check if you are using the proper test force.
	Wrong indenter	Check if you are using the proper indenter.
	Wrong indent distance	Check if the distance between indents is at least 2.5 times as much as the diameter of indent.
	Indenter damaged	Replace the damaged indenter.

	Anvil or indenter installs unsteadily	Check if the anvil and indenter are seated securely.
	Anvil not appropriate for specimen	Select the appropriate anvil.
	Vibrations	Isolate the testing machine from environmental vibrations.
	Specimen is too thin	The thickness of specimen should be 10 times as much as indent depth.
	Specimen angle	Adjust specimen surface to make it in 90° to the indenter.
	Specimen is non homogenous	Use an indenter with a larger area.

HARDNESS SCALE, INDENTER, ANVIL, CONVERSION, CORRECTION AND MINIMUM THICKNESS

Selecting Rockwell scale

Before testing a specimen, you should first of all determine the Rockwell scale. Each scale requires the appropriate test force and indenter.

In most cases, a hardness tolerance specification for a material is indicated on a technical drawing. If the material under test has no specification, or you have doubt on the scale for a particular specimen, you should consider the following facts:

- Specimen material
- Specimen thickness
- Scale limits

Specimen Material

Table 8-1 presents a list of common Rockwell scales and typical material for these scales. The table includes only the common Rockwell scales, which would be a help for your test.

Note: *As usual, you should use the large test force as much as possible.*

Table 8-1 Typical application of Rockwell

Scale symbol	Typical Applications of Scales
A	Cemented carbides, thin steel, and shallow case-hardened steel.
B	Copper alloys, soft steels, aluminum alloys, malleable iron, etc.
C	Steel, hard cast irons, pearlitic malleable iron, titanium, deep case hardened steel, and other materials harder than B100.
D	Thin steel and medium case hardened steel, and pearlitic malleable iron.

E	Cast iron, aluminum and magnesium alloys, bearing metals.
F	Annealed copper alloy, thin soft sheet metals.
G	Malleable irons, copper-nickel-zinc and cupro-nickel alloys. Upper limit G92 to avoid possible flattening of ball.
H	Aluminum, zinc, lead.
K	Bearing metals and other very soft or thin materials. Use smallest ball and heaviest load that does not give anvil effect.
L	
M	
P	
R	
S	
V	

Specimen thickness


In order to prevent from the interference of cold treatment, the material thickness should be 10 times as much as the depth of the indent.

Scale limits

- Readings below 20HRC when performing tests with diamond indenter

Do not use a diamond indenter when readings fall below 20HRC since there is the sensitivity loss. Diamond indenter has not been calibrated when reading is below 20HRC. When performing tests on the soft materials, try to use scale B.

Note: Do not use scale C to make hardness test on the hard alloy material. It may damage the indenter or reduce the indenter life.

	<p>WARNING!</p>
	<p>Do not use scale C to make hardness test on the hard alloy material. It may damage the indenter or reduce the indenter life.</p>

- Hard alloy

There is no special limitation on the material hardness, if you perform tests with the diamond indenter, the scale A is the commonly recommended in hard alloy industry.

- Readings above 100 when performing tests with ball indenter.

Although scale could be up to 130 when you perform tests with the ball indenter, it is highly recommended that the readings should not above 100 except in special condition. As for readings between 130 and 100, you should use the very tip of the ball indenter. Because the ball indenter has the blunt slope, most scales have the poor sensitivity in this region. If you perform a test with a smaller indenter in diameter, there would be a potential hazard of squeezing the ball under the high pressure. In order to get the consistent results, you should frequently change the balls.

Cylindrical specimens

When you perform a test on the cylindrical or curve surface, the test result requires a cylindrical correction factor. Correction factors are dependent on whether the indent is on the internal or external surface of the specimen, as **Figure 8-1** illustrates.

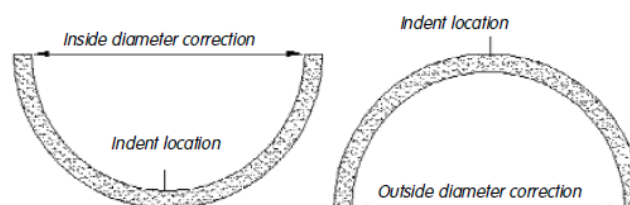


Figure 8-1 cylindrical specimens

Selecting an indenter

Depending on the material and scale, you may need either a cone-shaped diamond indenter or a steel ball indenter. *Table 8-2* details the choice of indenter and test force for common Rockwell test.

Table 8-2 Rockwell scale

Scale Symbol	Indenter mm (in.)	Load N (kgf)
A	Diamond Cone	588 (60)
B	Ball ϕ 1.588 (1/16)	980 (100)
C	Diamond Cone	1471 (150)
D	Diamond Cone	980 (100)
E	Ball ϕ 3.175 (1/8)	980 (100)
F	Ball ϕ 1.588 (1/16)	588 (60)
G	Ball ϕ 1.588 (1/16)	1471 (150)
H	Ball ϕ 3.175 (1/8)	580 (60)
K	Ball ϕ 3.175 (1/8)	1471 (150)
L	Ball ϕ 6.35 (1/4)	588 (60)
M	Ball ϕ 6.35 (1/4)	980 (100)
P	Ball ϕ 6.35 (1/4)	1471 (150)
R	Ball ϕ 12.7 (1/2)	588 (60)
S	Ball ϕ 12.7 (1/2)	980 (100)
V	Ball ϕ 12.7 (1/2)	1471 (150)

Selecting an Anvil

It is important for you to select an appropriate anvil to support the specimen. *Figure 8-2* illustrates the common types of anvil.

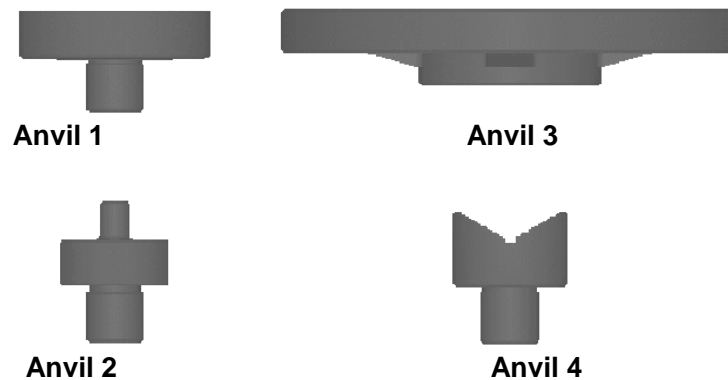


Figure 8-2 Anvils

Anvil 1	This anvil is suitable for middle or small specimen which has a flat and even bottom surface
Anvil 2	This anvil has a small elevated flat spot which will eliminates the errors in testing the specimen with irregular shapes. If the specimen surface is not flat and even, place it on the anvil with the convex surface downwards. This operation will make the specimen keep good contact with anvil.
Anvil 3	This anvil has a large flat and even surface. It is common to use this anvil to test large-sized specimens with flat and even surface.
Anvil 4	This anvil has a V groove which could hold the cylinder specimens. This anvil can be used in testing cylindrical specimens with a diameter of over 6 mm.

APPENDIX C

For tests on convex cylindrical surfaces, the corrections given in Table C-1, C-2, C-3 or C-4 shall be applied.

Table C-1 Test with diamond cone indenters (scale A, C, and D)

HRC	Curvature radius (mm)								
Hardness reading	3	5	6.5	8	9.5	11	12.5	16	19
20				2.5	2	1.5	1.5	1	1
25			3	2.5	2	1.5	1	1	1
30			2.5	2	1.5	1.5	1	1	0.5
35		3	2	1.5	1.5	1	1	0.5	0.5
40		2.5	2	1.5	1	1	1	0.5	0.5
45	3	2	1.5	1	1	1	0.5	0.5	0.5
50	2.5	2	1.5	1	1	0.5	0.5	0.5	0.5
55	2	1.5	1	1	0.5	0.5	0.5	0.5	0.5
60	1.5	1	1	0.5	0.5	0.5	0.5	0.5	0.5
65	1.5	1	1	0.5	0.5	0.5	0.5	0	0
70	1	1	0.5	0.5	0.5	0.5	0.5	0	0
75	1	0.5	0.5	0.5	0.5	0.5	0.5	0	0
80	0.5	0.5	0.5	0.5	0.5	0	0	0	0
85	0.5	0.5	0.5	0	0	0	0	0	0
90	0.5	0	0	0	0	0	0	0	0

Note: Corrections greater than 3HRA, HRC and HRD are not considered acceptable and are therefore not included in this table.

Table C-2 Test with $\phi 1.5875$ mm ball indenter tests (Scale B, F and G)

HRC	Curvature radius (mm)						
Hardness reading	3	5	6.5	8	9.5	11	12.5
20				4.5	4	3.5	3
30			5	4.5	3.5	3	2.5
40			4.5	4	3	2.5	2.5
50			4	3.5	3	2.5	2
60		5	3.5	3	2.5	2	2
70		4	3	2.5	2	2	1.5
80	4	3.5	2.5	2	1.5	1.5	1.5
90	4	3	2	1.5	1.5	1.5	1
100	3.5	2.5	1.5	1.5	1	1	0.5

Note: Corrections greater than 5HRB, HRF and HRG are not considered acceptable and are therefore not included in this table.

Table C-3 —Rockwell superficial test (Scale N) ^{a,b}

Hardness reading	Curvature radius (mm) ^C					
	1.6	3.2	5	6.5	9.5	12.5
20	(6) ^d	3	2	1.5	1.5	1.5
25	(5.5) ^d	3	2	1.5	1.5	1
30	(5.5) ^d	3	2	1.5	1	1
35	(5) ^d	2.5	2	1.5	1	1
40	(4.5) ^d	2.5	1.5	1.5	1	1
45	(4) ^d	2	1.5	1	1	1
50	(3.5) ^d	2	1.5	1	1	1
55	(3.5) ^d	2	1.5	1	0.5	0.5
60	3	1.5	1	1	0.5	0.5
65	2.5	1.5	1	0.5	0.5	0.5
70	2	1	1	0.5	0.5	0.5
75	1.5	1	0.5	0.5	0.5	0
80	1	0.5	0.5	0.5	0	0
85	0.5	0.5	0.5	0.5	0	0
90	0	0	0	0	0	0

a. These corrections are approximate only and represent the averages, to the nearest 0.5 Rockwell superficial hardness units, of numerous actual observations of the test surfaces having the curvatures given in this table.

b. When testing convex cylindrical surfaces, the accuracy of the test will be seriously affected by misalignment of elevating screw, V-anvil and indenter and imperfections in the surface finish and straightness of the cylinder.

c. For radii other than those given in this table, corrections may be derived by linear interpolation.

d. The corrections given in parentheses shall not be used, except by agreement.

Table C-4 — Rockwell superficial test (Scale T) ^{a,b}

HRC	Curvature radius (mm) ^c						
Hardness Reading	1.6	3.2	5	6.5	8	9.5	12.5
20	(13) ^d	(9) ^d	(6) ^d	(4.5) ^d	(3.5) ^d	3	2
30	(11.5) ^d	(7.5) ^d	(5) ^d	(4) ^d	(3.5) ^d	2.5	2
40	(10.5) ^d	(6.5) ^d	(4.5) ^d	(3.5) ^d	3	2.5	2
50	(8.5) ^d	(5.5) ^d	(4) ^d	3	2.5	2	1.5
60	(6.5) ^d	(4.5) ^d	3	2.5	2	1.5	1.5
70	(5) ^d	(3.5) ^d	2.5	2	1.5	1	1
80	3	2	1.5	1.5	1	1	0.5
90	1.5	1	1	0.5	0.5	0.5	0.5

a. These corrections are approximate only and represent the averages, to the nearest 0.5 Rockwell superficial hardness units, of numerous actual observations of the test surfaces having the curvatures given in this table.

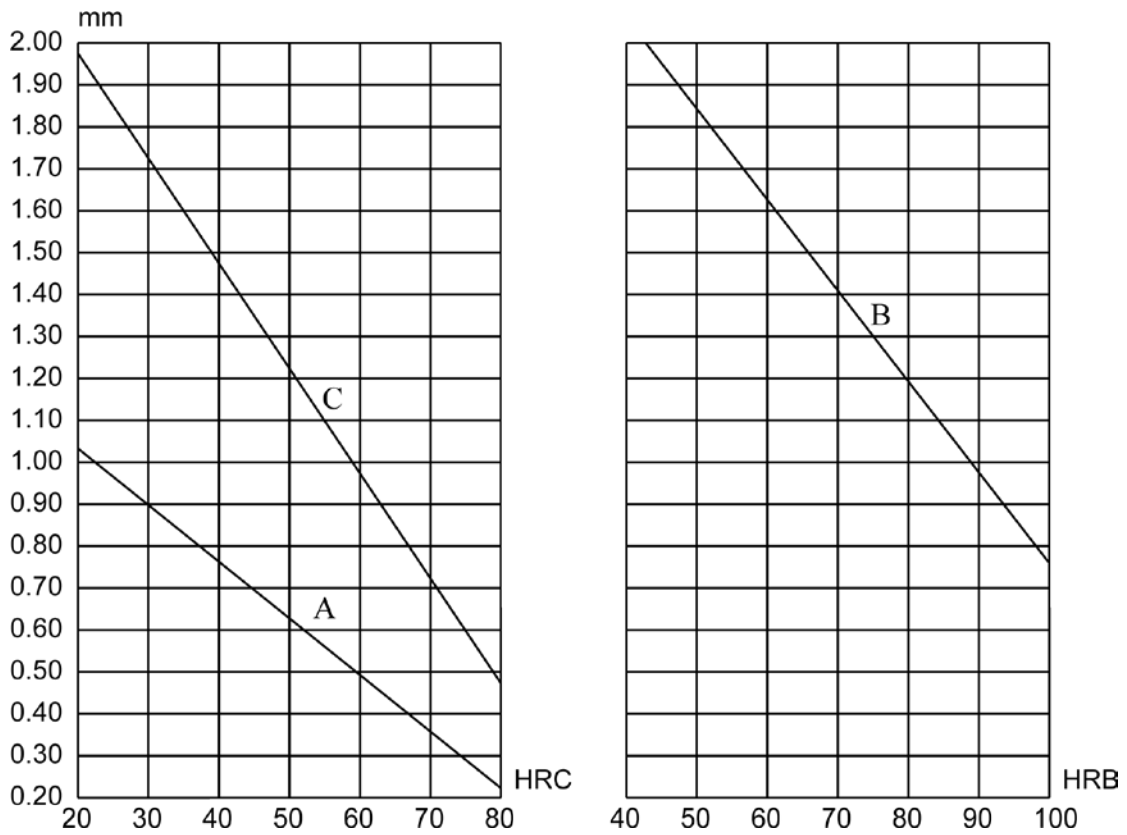
b. When testing convex cylindrical surfaces, the accuracy of the test will be seriously affected by misalignment of elevating screw, V-anvil and indenter and imperfections in the surface finish and straightness of the cylinder.

c. For radii other than those given in this table, corrections may be derived by linear interpolation.

d. The corrections given in parentheses shall not be used except by agreement.

Minimum thickness of the test piece in relation to the Rockwell hardness

HRC,HRB.



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