Automatisierung und Qualitätssicherung

650D

DIGITAL ROCKWELL HARDNESS TESTER

650DS

DIGITAL SUPERFICIAL ROCKWELL HARDNESS TESTER

OPERATING INSTRUCTION

BAQ GMBH

Inhaltsverzeichnis

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.

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℃ (140℉) or below 0℃ (32℉). 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!**

GENERAL DESCRIPTION

The **650D / 650DS** is a Rockwell/Superficial Rockwellhardness testing machine which is used to determine the material hardness. The hardness means that in certain condition the capacity of material of resisting indent pressed by another object, which is without remnant deformation. The more resisting capacity is, the higher hardness is, and conversely, 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 and economical 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.

The 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.

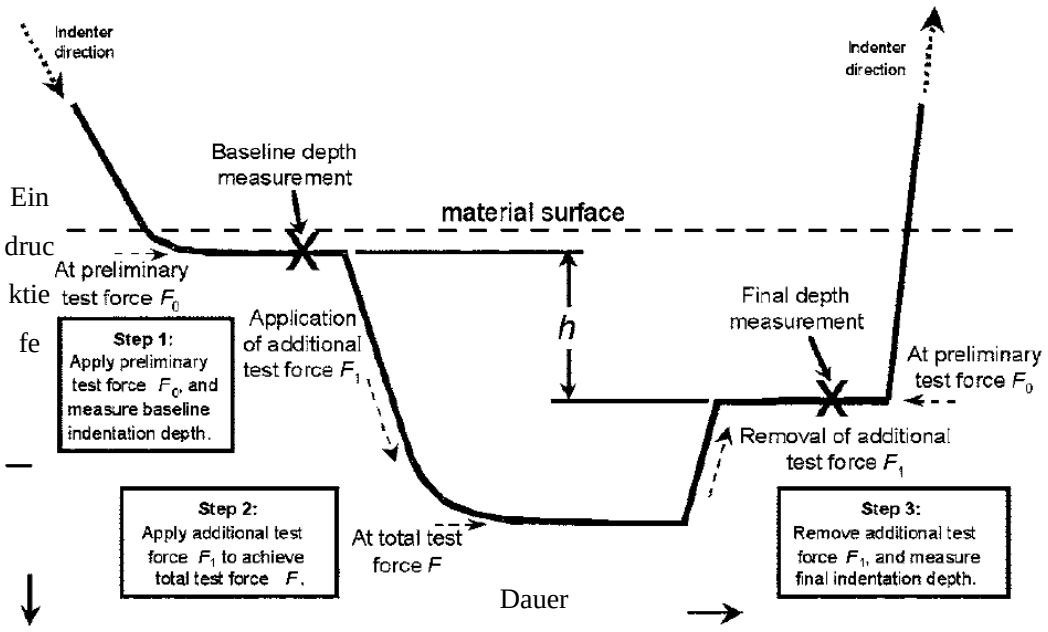


Figure 1-1 Test principle

Formulas for Rockwell hardness Test

HRC.A=100－**Δn/0.002**

HRB=130－**Δn/0.002**

Where:

$\Delta n=n_1-n_0$

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.

Formeln der Super-Rockwell- Härte

HR＝100－**Δn/0.001**

Where:

$\Delta n=n_1-n_0$

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 Externel 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 removable covers provide access to the internal components. Six Philips screws are used to fix the upper cover so as to protect the main lever and the main 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 weight stack assembly is composed of a weight hanger rod and three deadweights. A hook at the top end of the hanger rod attaches the ring at the end of the main lever. One weight is placed at the bottom of the rod while the other two are placed on the middle of the rod.

Main lever

The main lever extends from the main axle assembly to the rear of the testing machine. At the end of the main lever exists a ring for hanging the weight rod..

load varing mechanism

A permanent magnetic synchronous motor is used to drive the cam to make the fork move upwards and downwards. In this case, the deadweights could be released from or applied on the hanger rod so as to change the test force.

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.

Touch screen

The touch screen is on the front of the testing machine which displays preliminary test force, test scale, hardness value, dwell time and number of tests etc.

TECHNICAL SPECIFICATIONS

Figure 2-1 illustrates the **650D/650DS** dimensions and total weight

Figure 2-1Dimension and weight

Tabele 2-1 Rockwell/Superficial Rockwellhardness testing machine dimension and weight

Dimension	mm
Height	760
Width	210
Length	540
Testing height (With protection sleeve) (Without protection sleeve)	 84 170
Throat depth	175
Weight (kg)	85
Power supply	AC 220V / 110V 50Hz/60Hz
Dwell time	4～99s

Tabele 2-2 Test force of Rockwell hardness testing machine

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 of Rockwell hardness testing machine

Hardness scale	Indenter Mm (in.)	Pre-test force N (KGF)	Total test force N (KGF)
A	Diamond Cone	98（10）	588（60）
B	Ball ϕ 1.5875 (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 1.5875 (1/16)		588 (60)
G	Ball ϕ 1.5875 (1/16)		1471 (150)
H	Ball ϕ 3.175 (1/8)		588 (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)		981 (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)

Table 2-4 Test force of Superficial Rockwellhardness testing machine

Preliminary test force N (KGF)	Total test force N (KGF)
29.4（3）	147.1（15）
	294.2（30）
	441.3（45）

Table 2-5 Scale, indenter and test force of Superficial Rockwellhardness testing machine

Hardness scale	Pre-test force N (KGF)	Total test force N (KGF)	Indenter
HR-15N	29.4 (3)	147.1 (15)	120^0 diamond cone
HR-30N		294.2 (30)	
HR-45N		441.3 (45)	
HR-15T		147.1 (15)	Steel ball ϕ 1.588 (1/16)
HR-30T		294.2 (30)	
HR-45T		441.3 (45)	
HR-15W		147.1 (15)	Steel ball ϕ 3.175 (1/8)
HR-30W		294.2 (30)	
HR-45W		441.3 (45)	
HR-15X		147.1 (15)	Steel ball ϕ 6.35 (1/4)
HR-30X		294.2 (30)	
HR-45X		441.3 (45)	
HR-15Y		147.1 (15)	Steel ball ϕ 12.7 (1/2)
HR-30Y		294.2 (30)	
HR-45Y		441.3 (45)	

INSTALLATION

InstallationProcedure

1. Unpack the testing machine.
2. Lift the hardness testing machine onto the workbench.
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 other 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 other mechanical vibrations.
3. There is an adequate clearance between the testing machine and adjacent walls for the convenience of routine service.

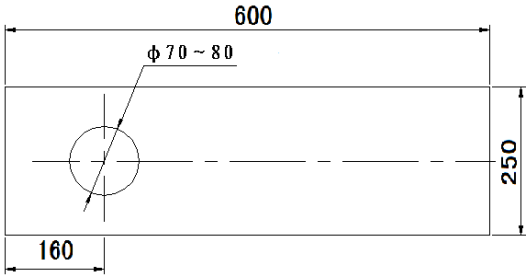


Figure 3-1 Workbench

Unpacking

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

Lifting the testing maschine 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 has 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 leveling screws

After the testing machine is moved onto the workbench, you can install the four leveling screws. Make sure that the deadweight stack is hung correctly 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 base.
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***.
8. Rotate the spirit level 90°.
9. 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 will have to install the deadweights after 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 follwoings before you start testing:

1. The testing machine is leveled.
2. 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. Choose the HRA scale (HR15N for Rockwell Superficial).
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 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. Choose scale HRA, HRB and HRC (Rockwell Superficial: HR15N, HR30N and HR45N) to make sure that the deadweights are centered on the rod and the studs seat in the deadweight forks.
8. Put on the top and back covers.

Figure 3-5 Remove top and back covers

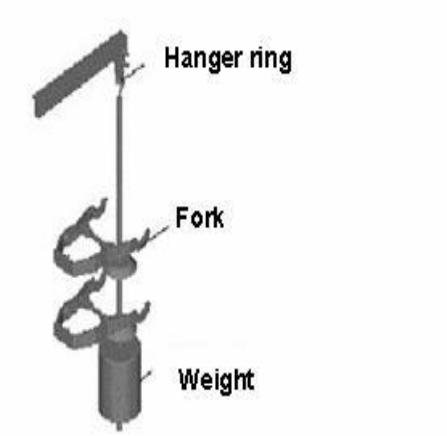


Figure 3-6Installation of hanger rod and weight A

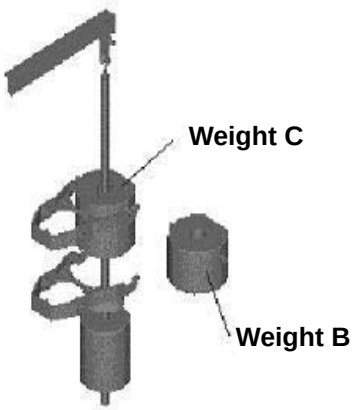


Figure 3-7Installation of weights B and C

Components Function

Main screen

After turning on the testing machine, the company logo will be displayed for about 3 seconds.

Next you will see the main screen, which displays the test information, test steps, test result and statistics etc, as ***Figure 4-1*** illustrates.

Figure 4-1 Rockwell main screen

What is Main Screen?

In Figure 4-1, the menu on touch screen is the Main Screen. It contains (from top to bottom, left to right) force application indication beam, hardness value, test scale, scale conversion, limit(upper and lower), test force, dwell time, indenter type, printer, delete, menu, statistics etc.

The main screen would be mentioned many times in the latter chapters. Keep it in mind that it always refers to the screen here when main screen is mentioned.

How to return to the main screen?

By touching **<RETURN>** in the submenu, you can return to the main menu from any submenu, and touching **<RETURN>** in the main menu you can return to the main screen.

<PRINT>

By touching **<PRINT>** in the main screen, you can output the data according the settings in the main menu (Printer, RS232).

<DELETE>

By touching **<DELETE>** in the main screen, you access the deletion screen and choose any item to delete.

There are 2 options for choice: - as ***Figure 4-2*** illustrates

- DELETE THE LAST DATA
- DELETE ALL THE DATA

Touch **<RETURN>** after you make the choice.

Figure 4-2 Delete screen

<CLEAR>

In order to ensure the testing accuracy, you should touch **<CLEAR>** in the main screen to make the test force application indication beam return to zero before hardness test begins. Refer to Figure 4-1.

<MENU>

By touching **<MENU>** in main screen, you can access the setup menu as Figure 4-3 illustrates. There are totally 6 items available.

- **SHAPE CORRECTION**
- **DATA OUTPUT**
- **DATA/CLOCK**
- **LANGUAGE**
- **SPEAKER**
- **RETURN**

If you don't want to change the current setting, you can touch **<RETURN>** to return to the main screen.

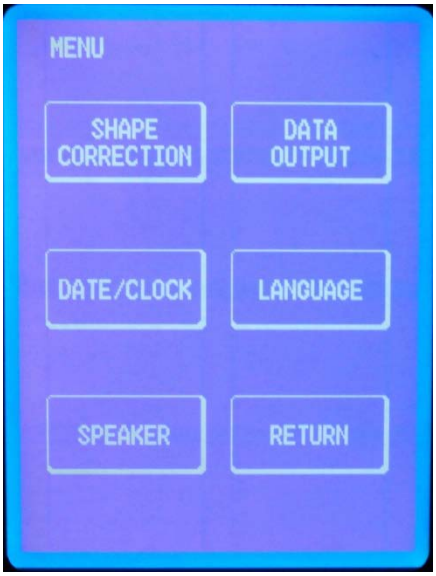


Figure 4-3 Menu screen

1. SHAPE CORRECTION

You can touch **<SHAPE CORRECTION>** to access the shape correction screen. Refer to *Figure 4-4*. If "**<NONE>**" is white highlighted, you should first press **<GB>** or **<ASTM>** to activate the menu. Touch **<OK>** for confirmation and return to the previous menu. Touch **<RETURN>** to return to the previous menu without saving current change.

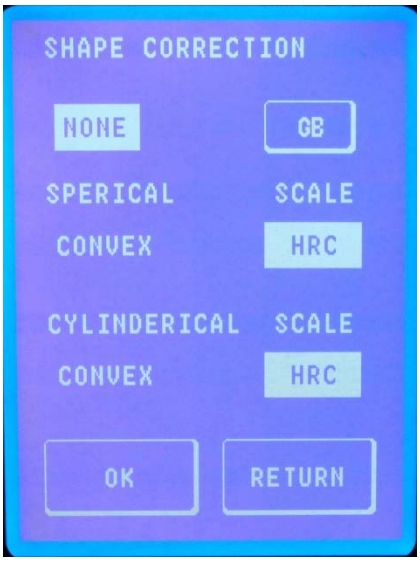


Figure 4-4 Shape Correction screen

In the Shape Correction screen, you can make correction on the radius of SPHERICAL CONVEX and CYLINDRICAL CONVEX. If you want to make correction on the radius of CYLINDRICAL CONVEX, you can touch the white block on its right side and then touch **<OK>** for confirmation. Refer to Figure 4-5. Touch **< ↑ INC>** or **< ↓ DEC>** to adjust the radius.

The shape correction on spherical convex is same as that of cylindrical convex.

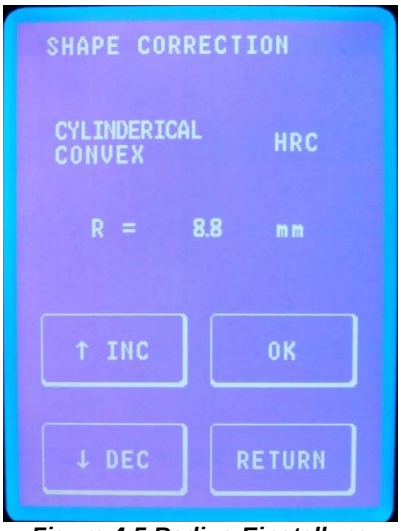


Figure 4-5 Radius-Einstellung

Touch **<OK>** for confirmation and return to the previous menu. Touch **<RETURN>** to return to the previous menu without saving your current setting.

If you set SHAPE CORRECTION function, an icon will appear in the main screen as Figure 4-6 illustrates.

Figure 4-6 Shape Correction Icon screen

The system will automatically save the setting when you power off the testing machine.

2. DATA OUTPUT

There are three options available for the data output:

- **INTERNAL PRINTER**
- **TO RS232C NO STATS**
- **TO RS 232C WITH STATS**

Touch **<OK>** for confirmation and return to the previous menu. Touch **<RETURN>** to return to the previous menu without saving your current setting. Refer to Figure 4-7.

The system will automatically save the setting when you power off the testing machine.

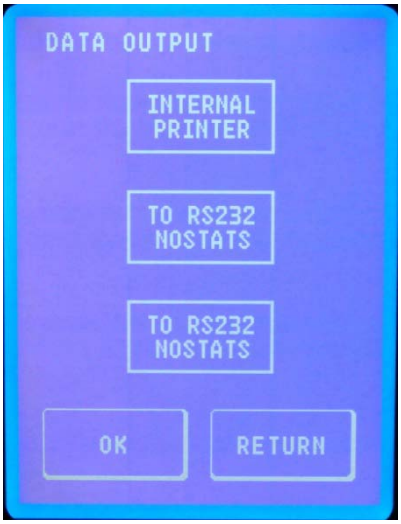


Figure 4-7 Data Output screen

3. DATE/CLOCK

You can touch **DATE/CLOCK** to access the setting menu as ***Figure 4-8*** illustrates. You can touch the respective white block and then touch **< ↑ INC>** or **< ↓ DEC>** to adjust the time.

Touch **<OK>** for confirmation and return to the previous menu. Touch **<RETURN>** to return to the previous menu without saving your current setting.

The system will automatically save the setting when you power off the testing machine.

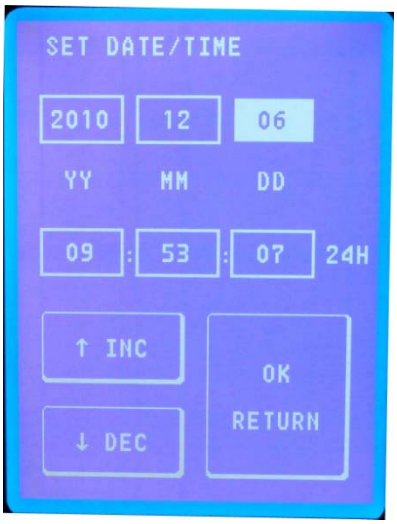


Figure 4-8 **Date/Clock** ***screen***

4. LANGUAGE

You can touch **LANGUAGE** to choose the language. Refer to Figure 4-9.
There are 2 languages for choice:

- GERMAN
- ENGLISH

Touch **<OK>** for confirmation and return to the previous menu. Touch **<RETURN>** to return to the previous menu without saving your current setting.

The system will automatically save the setting when you power off the testing machine.

Figure 4-9 Language screen

5. SPEAKER

You can touch **SPEAKER** to access the speaker screen. Refer to *Figure 4-10.*

Touch **<OK>** for confirmation and return to the previous menu. Touch **<RETURN>** to return to previous menu without saving the current setting.

The system will automatically save the setting when you power off the testing machine.

Figure 4-10 Speaker screen

6. RETURN

You can touch **<RETURN >** to return to the main screen. Refer to Figure 4-1.

SCALE

You can touch the icon 

in main screen to access the scale screen. Refer to *Figure 4-11*. There are 15 scales available for your choice.

Touch **<OK>** for confirmation and return to the previous menu. Touch **<RETURN>** to return to previous menu without saving the current setting.

Figure 4-11 Scale screen

HARDNESS CONVERSION

You can touch the icon 

in the main screen to access the scale conversion screen. Refer to 4-12.

There are 2 standards: **<GB>** and **< ASTM >**.

Figure 4-12 Scale conversion screen

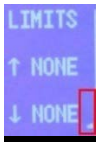
You can choose the standard you need and then access the scale conversion screen. There are 25 scales in ASTM and 26 scales in GB. Refer to Figure 4-13.

Touch **<OK>** for confirmation and return to the previous menu. Touch **<RETURN>** to return to the previous menu without saving the current setting.

The system will automatically save the setting when you power off the testing machine.

Figure 4-13a Conversion (GB) screen ***Figure 4-13b Conversion (ASTM) screen***

LIMITS

You can touch 

in the main screen to access the limits screen. Refer to Figure 4-*14*.

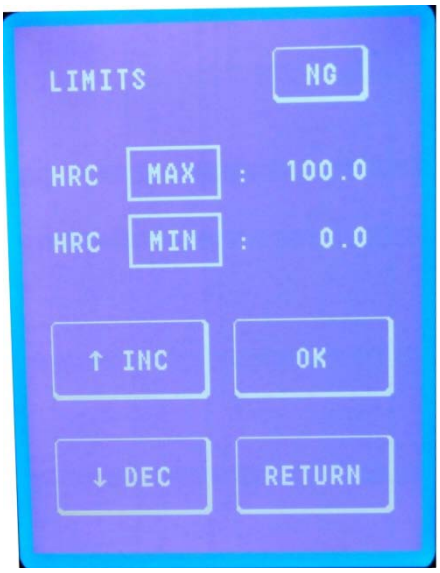


Figure 4-14 Limit screen

You can touch **<NG>** to change it to **<GO>** in the limit screen.

Touch **<MAX>** or **<MIN>** and then touch **< ↑ INC>** or **< ↓ DEC>** to adjust the value.

Touch **<OK>** for confirmation and return to the previous menu. Touch **<RETURN>** to return to previous menu without saving the current setting.

Note:

If you activate the limit function, the testing machine will automatically make comparsion between the test result and limit value. If the test result is within the limit range, the buzzer will give out short beep; if the the test result is out of the limit range, the buzzer will give out long beep.

The system will automatically save the setting when you power off the testing machine.

FORCE UNIT

You can touch 

in the main screen to change the force unit between KGF and N. Refer to ***Figure 4-1*****.**

TEST FORCE

As soon as you select the scale, the system will automatically recognize the scale and choose the responding test force.

HALTEZEIT

You can touch 

in the main screen to access the DWELL TIME screen. Refer to Figure 4-15. Touch **<↑INC>** or **<↓DEC>** to increase/decrease dwell time. The time can be set between 4-99 second.

Touch **<OK>** for confirmation and return to the previous menu. Touch **<RETURN>** to return to previous menu without saving the current setting.

The system will automatically save the setting when you power off the testing machine.

Figure 4-15 Dwell time screen

INDENTER

After you choose the test scale, the system will remind you of using the correct indenter. Refer to Figure 4-1.

HAND WHEEL

The hand wheel is used to elevate the screw spindle as ***Figure 4-16*** illustrates. By turning the hand wheel clockwise or counterclockwise, you can raise or lower the screw spindle for the convenience of placing or removing the specimen and for the purpose of applying or removing the preliminary test force.

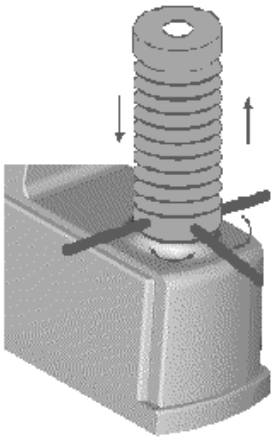


Figure 4-17 Screw spindle

	**WARNING!**
	The indenter should not hit the anvil. Otherwise both could be damaged. **Do not turn the hand wheel while the testing machine is applying or already applied the total test force. Otherwise you might not get the accurate test results.**

PREPARATION FOR USE

Installing the anvil

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

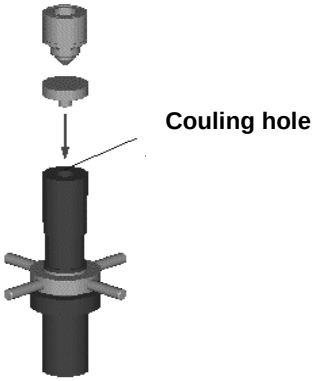


Figure 5-1 Install the anvil

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.

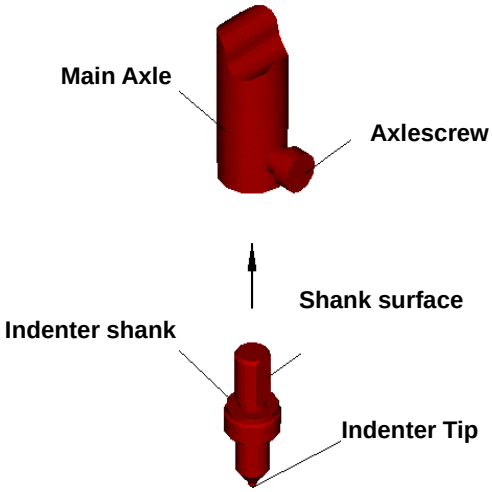


Figure 5-2 Installing the Indenter

OPERATION

Check the followings before you start a test:

1. The proper anvil has been installed in the installing hole of the screw spindle.
2. The proper indenter has been installed in the installing hole of the main axle.
3. The proper test force has been selected via the load selection knob.
4. The dwell time has been set
5. The conversion scale has been set. (It is allowed not to set conversion scale if no need)
6. The power supply is already on (The power supply should have the earthing cable).
7. You should have enough room between anvil and indenter to place the specimen.
8. You should wear an ESD protective wrist strap to protect the equipment from electrostatic discharge.

Procedure

1. Turn on the power.
2. When the test number is 0, you can choose the test scale.
3. When the test number is 0, you can set the dwell time. If necessary, you can set the scale conversion.
4. When you turn on the testing machine, test results last time you made will be displayed. You should touch **<CLEAR>** in the main screen before a new round of test. You can make no more than 99 tests each round.
5. Place the specimen or test block on the anvil. Make sure that the specimen surface is flat, clean and free from smudge, oxidization layers, crevices and pits. Both the bottom surface of the specimen and the test anvil should keep clean so that they could achieve good and fine mating. The specimen thickness should be 10 times as much as the indentation depth.
6. Turn the hand wheel clockwise to move the screw spindle up. When the indenter touches the specimen, you should turn the hand wheel slowly and steadily. At that moment, the light beam on the LCD screen will extend from the **PRELOAD** area to the **OK** area, which indicates that 98N (superficial Rockwell: 29.4N) preliminary test force has been applied. Refer to Figure 6-1. You have to stop turning the hand wheel at that time. If you fail to stop, the light beam will go to **OVER** area, and the buzzer will beep. In this case, this test is invalid. You should turn the

hand wheel counterclockwise to move the screw spindle downwards until the light beam disappears on the screen. You have to start a new test. At the same time, automatically the motor will apply the main load, control the dwell time and remove the main load. The system will start the test and information about test force, dwell time (count back), unload and hardness value etc will appear on the screen. When the LIMITS is activated and the hardness value is within the limit range, the buzzer will beep shortly and icon GO appears on the screen. While, when the hardness value is out of the set range, the buzzer will beep longer and icon NG appears on the screen. When LIMITS isn't activated, the buzzer would only beep and icons GO and NG will not appear on the screen.

7. Turn the hand wheel counterclockwise to move the screw spindle downwards and release the preliminary test force 98N (29.4N). At this time, the light beam disappears. This is the end of the first test. The test result will be displayed on the screen until the next test is performed.
8. If you want to start a new test, repeat the step 5-7.
9. Data output:

- INTERNAL PRINTER
- TO RS232C NO STATS
- TO RS232C WITH STATS

You should perform at least two tests (The first hardness value should be deleted).

1. *INTERNAL PRINTER*

Turn on the power of the printer and select the INTERNAL PRINTER mode. Touch **<PRINT>** to output the test result.

$\bar{X}$: 63.0HRC
NO : 06
S.DEV : 0.2
MAX : 63.2
MIN : 62.8
R : 0.4
$\bar{X}$CONV :
1. 62.8HRC
2. 62.9HRC
3. 63.0HRC
4. 62.9HRC
5. 63.2HRC
6. 63.2HRC

Following is the print contents:

$\bar{X}$: Mean hardness value
No: Number of test
S.DEV: Standard deviation
MAX: Maximum hardness value
MIN: Minimum hardness value
R: Repeatability
$\bar{X}$CONV: Mean hardness value of conversion scale

2. *ZU RS232C OHNE STATISTIKEN:*

You can select this option and then touch **<PRINT>** to initiate simple information output. In this mode, only the test data could be output.

3. *TO RS232C WITH STATS:*

You can select this option and then touch **<PRINT>** to initiate complete information output. In this mode, both the test data and the statistic data could be output.

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 6-1*** illustrates.

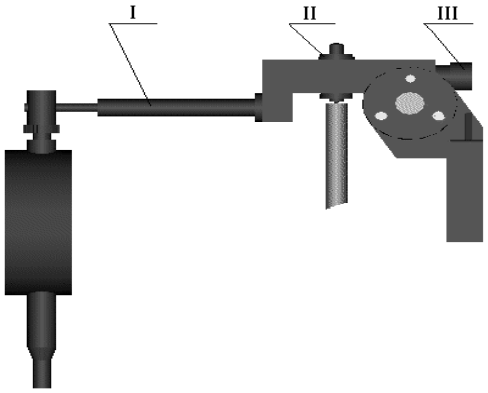


Figure 6-1 Indication value adjustment

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

The testing machine is a precision instrument which needs routine cleaning. How often you clean the testing machine depends on the working environment.

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 mild liquid detergent 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.

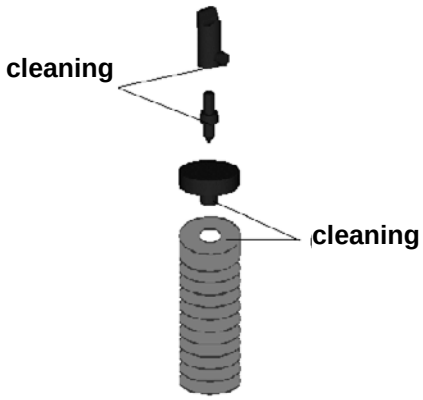


Figure 7-1 Cleaning

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.

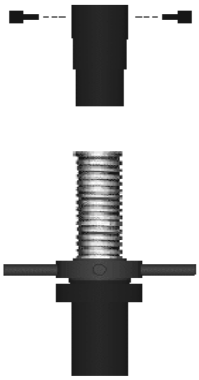


Figure 7-2 Remove the protection sleeve

	**CAUTION!**
	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.

Care of Indenter

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

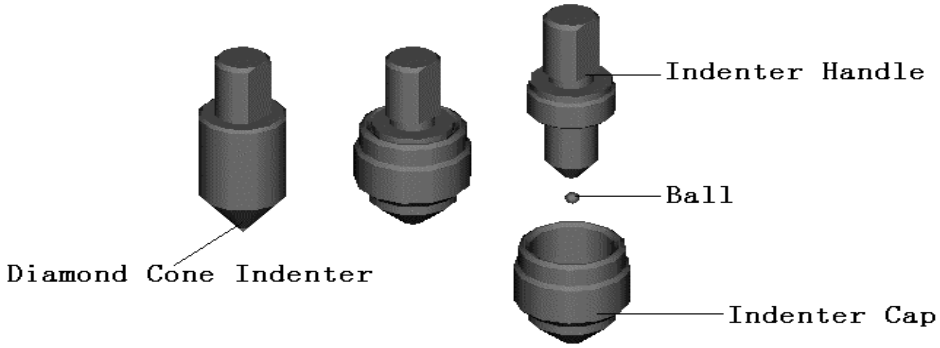


Figure 7-3 Diamond Cone Indenter (left) Ball (middle, right)

Note:

Do not use a worn or damaged indenter.

- Diamond Cone Indenter

  Inspect the Diamond cone indenter for damage 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 for damage daily. If there is 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 could perform a hardness test on the standard test block and compare the resulting hardness value with that marked on the standard block. This comparison let you know whether or not the testing machine needs calibration.

	**CAUTION!**
	You should verify the testing machine accuracy every day if you use the testing machine frequently.

- **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 **BAQ GmbH**.

Table7-1 Troubleshooting

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.
Light could not turn on.	1. power supply problem 2. Fuse is broken	1. Check if the power supply line is conducted. 2. Change the fuse.
Motor could not stop	1. Interfered by the external circuit. 2. Mal operation	Turn off the power, lower the screw spindle. Wait for a while and turn on.
Hardness value is error.	1. Testing machine is not leveled, weight rubs body. 2. Weights are not properly installed.	Install the weight in a correct way.

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	

Table 8-2 Typical application of Superficial Rockwell

Scale	Preliminary test force N	Total test force N	Indenter Mm(in.)	Typical Applications of Scales
HR-15N	29.4	147.1	120^0 Diamond Cone-shaped	Cementite, nitriding, chrome plated and other disposal thin material surface hardness
HR-30N		294.2		
HR-45N		441.3		
HR-15T		147.1	Ball ϕ 1.5875	Steel, brass, bronze and other untreated thin material
HR-30T		294.2		
HR-45T		441.3		
HR-15W		147.1	Ball ϕ 3.175	Aluminum, lead alloy and other soft material
HR-30W		294.2		
HR-45W		441.3		
HR-15X		147.1	Ball ϕ 6.35	Aluminum, lead alloy and other soft material
HR-30X		294.2		
HR-45X		441.3		
HR-15Y		147.1	Ball ϕ 12.7	Aluminum, lead alloy and other soft material
HR-30Y		294.2 (30)		
HR-45Y		441.3 (45)		

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 a loss of sensitivity. Diamond indenters are not calibrated when reading is below 20HRC. When performing tests on soft materials, try to use the scale B.

Note:

Do not test hard alloy in the scale C condition. The hard alloy could damage the indenter and shorten the service life of the indenter.

- Hard alloy

  Although there is no limitation on the material hardness, if you perform tests with the diamond indenter, the scale A is the commonly accepted 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.

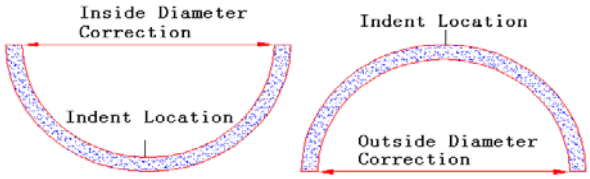


Figure 8-1 cylindrical specimens

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 8-3 Rockwell scale

Rockwell hardness scale	Hardness symbol	Type of indenter	Preliminary test force F_0	Additional test force F_1	Total test force F	Field of application (Rockwell hardness test)
A[a]	HRA	Diamond cone	98,07 N	490,3 N	588,4 N	20 HRA to 88 HRA
B[b]	HRB	Ball 1,587 5 mm	98,07 N	882,6 N	980,7 N	20 HRB to 100 HRB
C[c]	HRC	Diamond cone	98,07 N	1,373 kN	1,471 kN	20 HRC to 70 HRC
D	HRD	Diamond cone	98,07 N	882,6 N	980,7 N	40 HRD to 77 HRD
E	HRE	Ball 3,175 mm	98,07 N	882,6 N	980,7 N	70 HRE to 100 HRE
F	HRF	Ball 1,587 5 mm	98,07 N	490,3 N	588,4 N	60 HRF to 100 HRF
G	HRG	Ball 1,587 5 mm	98,07 N	1,373 kN	1,471 kN	30 HRG to 94 HRG
H	HRH	Ball 3,175 mm	98,07 N	490,3 N	588,4 N	80 HRH to 100 HRH
K	HRK	Ball 3,175 mm	98,07 N	1,373 kN	1,471 kN	40 HRK to 100 HRK
15N	HR15N	Diamond cone	29,42 N	117,7 N	147,1 N	70 HR15N to 94 HR15N
30N	HR30N	Diamond cone	29,42 N	264,8 N	294,2 N	42 HR30N to 86 HR30N
45N	HR45N	Diamond cone	29,42 N	411,9 N	441,3 N	20 HR45N to 77 HR45N
15T	HR15T	Ball 1,587 5 mm	29,42 N	117,7 N	147,1 N	67 HR15T to 93 HR15T
30T	HR30T	Ball 1,587 5 mm	29,42 N	264,8 N	294,2 N	29 HR30T to 82 HR30T
45T	HR45T	Ball 1,587 5 mm	29,42 N	411,9 N	441,3 N	10 HR45T to 72 HR45T

[a] The field of application can be extended to 94 HRA for testing carbides.

[b] The field of application can be extended to 10 HRBW if specified in the product specification or by special agreement.

[c] The field of application can be extended to 10 HRC if the indenter possesses the appropriate dimensions.

NOTE Indenter balls with diameter 6,350 mm and 12,70 mm may also be used, if specified in the product specification or by special agreement.

Table 8-4 Superficial Rockwell scale

Scale	Indenter mm (in.)	Test force N (kgf)
HR—15N	120^0 diamond cone	147.1（10）
HR—30N		294.2（30）
HR—45N		441.3（45）
HR—15T	φ1.588 ball steel(1/16)	147.1（10）
HR—30T		294.2（30）
HR—45T		441.3（45）
HR—15W	φ3.175 ball steel (1/8)	147.1（10）
HR—30W		294.2（30）
HR—45W		441.3（45）
HR—15X	φ6.35 ball steel (1/4)	147.1（10）
HR—30X		294.2（30）
HR—45X		441.3（45）
HR—15Y	φ12.7 ball steel (1/ 2)	147.1（10）
HR—30Y		294.2（30）
HR—45Y		441.3（45）

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:

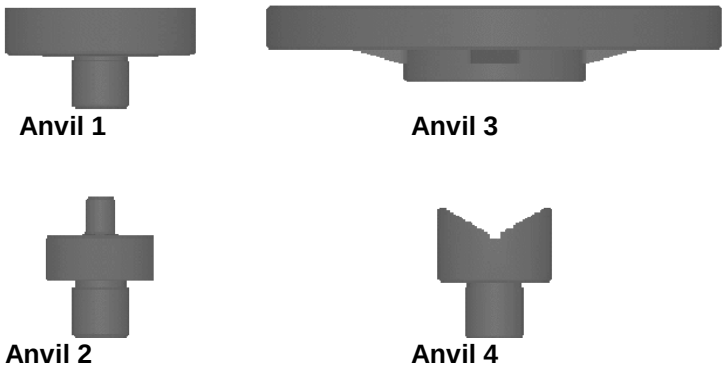


Figure 8-2 Anvils

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

Standard

Rockwell Hardness Correction Factors for cylindrical specimen.

Table C-1, C-2, C-3 and C-4 details the correction factors for convex cylindrical specimen

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.

HRC	Curvature radius (mm)							HRC
Hardness reading	3	5	6.5	8	9.5	11	12.5	Härtewe
20				4.5	4	3.5	3	20
30			5	4.5	3.5	3	2.5	30
40			4.5	4	3	2.5	2.5	40
50			4	3.5	3	2.5	2	50
60		5	3.5	3	2.5	2	2	60
70		4	3	2.5	2	2	1.5	70
80	4	3.5	2.5	2	1.5	1.5	1.5	80
90	4	3	2	1.5	1.5	1.5	1	90
100	3.5	2.5	1.5	1.5	1	1	0.5	100
Note: Corrections greater than 5HRB, HRF and HRG are not considered acceptable and are therefore nc included in this table.								

Table C-2 Test with ϕ1.5875 mm ball indenter tests (Scale B, F and G)

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 Superficial Rockwellhardness 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

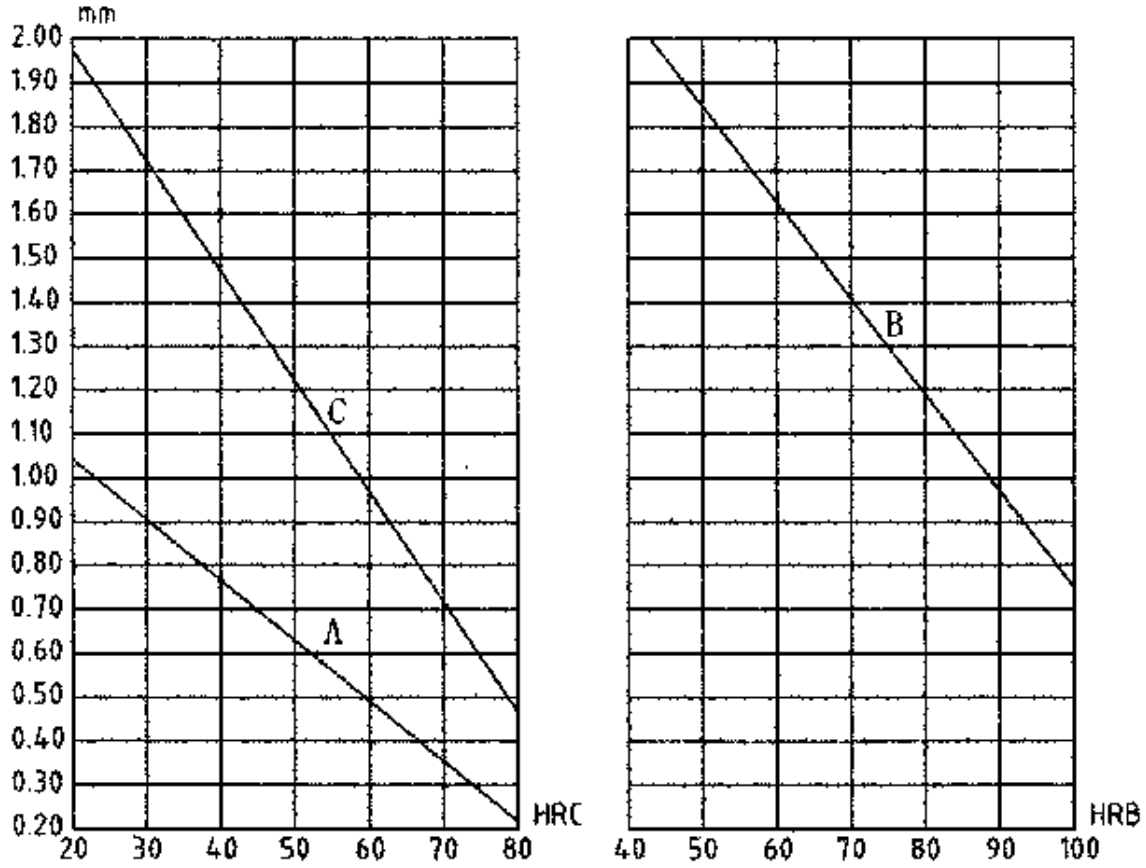
a. These corrections are approximate only and represent the averages, to the nearest 0.5 Superficial Rockwellhardness units, of numerous actual observations of the test surfaces having the curvatures given in this table.

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.



Minimum thickness of the test piece in relation to the Superficial Rockwell ardness N, T.

Thickness		Superficial Rockwell scale					
		15T		30T		45T	
in	mm	Reading	Approximate hardness scale B[A)]	Reading	Approximate hardness scale B[A)]	Reading	Approximate hardness scale B[A)]
0.010	0.25	91	93	--	--	--	--
0.012	0.30	86	78	--	--	--	--
0.014	0.36	81	62	80	96	--	--
0.016	0.41	75	44	72	84	71	99
0.018	0.46	68	24	64	71	62	90
0.020	0.51	--	--	55	58	53	80
0.022	0.56	--	--	45	43	43	70
0.024	0.61	--	--	34	28	31	58
0.026	0.66	--	--	--	--	18	45
0.028	0.71	--	--	--	--	4	32
0.030	0.76	--	--	--	--	--	--

Note: for the specified thickness, the hardness greater than this thickness test is allowed.

For the specified hardness, the thickness greater than this hardness is allowed.

A) These approximate values are only suited for the selected scale and not for the conversion scales. If it is necessary to convert the reading to the readings in other scale, you can refer to ASTM E140.

Thickness		Superficial Rockwells cale					
		15N		30N		45N	
in	mm	Reading	Approximate hardness scale B[A)]	Reading	Approximate hardness scale B[A)]	Reading	Approximate hardness scale B[A)]
0.006	0.15	92	65	--	--	--	--
0.008	0.20	90	60	--	--	--	--
0.010	0.25	88	55	--	--	--	--
0.012	0.30	83	45	82	65	77	69.5
0.014	0.36	76	32	78.5	61	74	67
0.016	0.41	68	18	74	56	72	65
0.018	0.46	--	--	66	47	68	61
0.020	0.51	--	--	57	37	63	57
0.022	0.56	--	--	47	26	58	52.5
0.024	0.61	--	--	--	--	51	47
0.026	0.66	--	--	--	--	37	35
0.028	0.71	--	--	--	--	20	20.5
0.030	0.76	--	--	--	--	--	--

Note: for the specified thickness, the hardness greater than this thickness test is allowed. For the specified hardness, the thickness greater than this hardness is allowed.

A) Minimum thickness of the test piece in relation to the Rockwell superficial, if it is necessary to convert the reading to the readings in other scale, you can refer to ASTM E140.

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