PACE® TECHNOLOGIES
www.metallographic.com

# OMEGA-HB Brinell Hardness Tester

INSTRUCTION MANUAL

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## *VERSION 1.0*

| | |
|---|---|
| Equipment type | Brinell Hardness Tester |
| Model | ***OMEGA-HB*** |
| Electrical Requirements | 110 Volts (Single-phase) |
| Frequency | 50/60 Hz |
| Manual Revision Date | April 24, 2022 |

## WARNINGS

- ⚠ Please read the instructions carefully before turning on the machine.
- ⚠ Supplying the wrong voltage will cause severe damage to the electrical system.
- ⚠ Do not disassemble.

# CONTENTS

# SECTION 1: WARRANTY

**Terms and Conditions applying to all PACE Technologies Products**

**1. LIMITED WARRANTY AND DISCLAIMER:**

PACE Technologies microscopes and hardness testers are warranted for one year from the purchase date to be free from defects in material and workmanship under correct use, normal operating conditions, and proper application. PACE Technologies obligation under this warranty shall be limited to the repair or exchange, at PACE Technologies option, of any PACE Technologies Product or part which proves to be defective as provided herein. PACE Technologies reserves the right to either inspect the product at Buyer's location or require it to be returned to the factory for inspection. Buyer is responsible for freight to and from factory on all warranty claims. The above warranty does not extend to goods damaged or subjected to accident, abuse or misuse after release from PACE Technologies warehouse, nor goods altered or repaired by anyone other than specifically authorized PACE Technologies representatives. PACE Technologies shall not in any way be responsible for the consequences of any alteration, modification or misuse unless previously approved in writing by an officer of PACE Technologies. Note: Corrosion is considered a maintenance issue and not a warranty issue.

PACE TECHNOLOGIES MAKES NO EXPRESS WARRANTIES OTHER THAN THOSE WHICH ARE SPECIFICALLY DESCRIBED HEREIN. Any description of the goods sold hereunder, including any reference to Buyer's specifications and any description in catalogs, circulars and other written material published by PACE Technologies, is the sole purpose of identifying such goods and shall not create an express warranty that the goods shall conform to such description.

THIS WARRANTY IS EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED. THERE ARE NO IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR PARTICULAR PURPOSE. THIS WARRANTY STATES PACE TECHNOLOGIES ENTIRE AND EXCLUSIVE LIABILITY AND BUYER'S EXCLUSIVE REMEDY FOR ANY CLAIM FOR DAMAGES IN CONNECTIONS WITH PACE TECHNOLOGIES PRODUCTS. PACE TECHNOLOGIES WILL IN NO EVENT BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES WHATSOEVER, NOR FOR ANY SUM IN EXCESS OF THE PURCHASE PRICE.

**2. LIABILITY CAP:**

PACE Technologies maximum aggregate liability for loss and damage arising under, resulting from or in connection with the supply or use of the Equipment and Consumables provided under this purchase, or from the performance or breach of any obligation (s) imposed hereunder, whether such liability arises from any one or more claims or actions for breach of contract, tort, (including negligence), delayed completion, warranty, indemnity, strict liability or otherwise, unless otherwise limited by the terms hereof, shall be limited to one hundred percent (100%) of the purchase price.

**3. DELIVERY:**

Customer assumes and shall bear the risk of all loss or damage to the Products from every cause whatsoever, whether or not insured, and title to such Products shall pass to Customer upon PACE Technologies delivery of the Products to the common carrier of Pace Technologies choice, or the carrier specified in writing by Customer, for shipment to Customer. Any claims for breakage, loss, delay, or damage shall be made to the carrier by the Customer and Pace Technologies will render customer reasonable assistance in prosecuting such claims.

**4. ACCEPTANCE:**

Customer shall inspect the Products promptly upon receipt of delivery. Unless customer objects in writing within thirty (30) business days thereafter, customer shall be deemed to have accepted the Products. All claims for damages, errors, or shortage in Products delivered shall be made by Customer in writing within such five (5) business day period. Failure to make any claim timely shall constitute acceptance of the Products.

**5. PAYMENT:**

Customer agrees to provide timely payment for the Products in accordance with the terms of payment set forth on the reverse side hereof or in any proposal submitted herewith. If any payment is not paid on or before its due date, Customer shall pay interest on such late payment from the due date until paid at the lesser of 12% per annum or the maximum rate allowed by law.

**6. DEFAULT:**

If Buyer is in default (including, but not limited to, the failure by Buyer to pay all amounts due and payable to Seller) under the work or purchase order or any other agreement between Buyer and Seller, Buyer ’s rights under the warranty shall be suspended during any period of such default and the original warranty period will not be extended beyond its original expiration date despite such suspension of warranty rights.

**7. MISCELLANEOUS PROVISIONS:**

This agreement has been made in and shall be governed by the laws of the State of Arizona. All disputes arising under or relating to the purchase of the equipment shall be brought and resolved solely and exclusively in the State of Arizona, Pima County. These terms and conditions and the description of the Products on the reverse side hereof or in any proposal submitted herewith constitute the entire agreement and understanding of the parties with respect to this sale and supersede all prior and contemporaneous agreements or understandings, inducements or representations, expressed or implied, written or oral, between the parties with respect hereto. Any term or provision of this Agreement may be amended, and any observance of any term of this Agreement may be waived, only by a writing signed by the party to be bounds. The waiver by a party of any breach shall not be deemed to constitute a waiver of any other breach. Should suit be brought on this Agreement, the prevailing party shall be entitled to recover its reasonable attorneys’ fees and other costs of suit including costs and attorneys’ fees incurred on appeal or in collection of any judgment., errors, or shortage in Products delivered shall be made by Customer in writing within such five (5) business day period. Failure to make any claim timely shall constitute acceptance of the Products.

**8. RESTOCKING FEE:**

All Returns are subject to a restocking charge equal to 15% (fifteen percent) of the Invoice, unless the Goods are proved to be non-conformed by PACE Technologies.

# SECTION 2: TECHNICAL SPECIFICATIONS

The **OMEGA-HB Brinell hardness tester** is a ball indenter designed to evaluate metallographic specimen hardness.

The **OMEGA-HB Brinell hardness tester** uses a load-cell to apply loads ranging from 62.5 kg to 3000 kg.

| | |
|---|---|
| Electrical Specifications: | 110V/220V Single Phase |
| Test forces | 62.5 kg (612.9 N)<br>100 kg (980 N)<br>125 kg (1226 N)<br>187.5 kg (1839 N)<br>250 kg (2452 N)<br>500 kg (4900 N)<br>750 kg (7335 N)<br>1000 kg (9800 N)<br>1500 kg (14700 N)<br>3000 kg (29400 N) |
| Hardness Range (HBW) | 8~650 HBW |
| Dwell time of test force | 5-60 seconds |
| Max. Height of Specimen | 8.7-inches (220 mm) |
| Max. Width of Specimen | 5.3-inch (135 mm) |
| Minimum Division on micrometer drum wheel | 0.005 mm |
| Weight | 275 lbs (125 kg) |
| Dimensions (W x D x H) | 9.25 x 21.5 x 29.7-inches<br>(235 x 545 x 755 mm) |
| Working temperature | 70-85° F (23-28° C) |
| Storage Temperature: | 32 – 100° F (0 – 40° C) |
| Power | 110V (50/60 Hz) |

Determining the Correct Force: To determine the correct for Brinell testing the indentation diamond should be in the range of 0.25 to 0.6 times the ball diameter (see chart below). The maximum accuracy of the measurement is achieved when the diameter of the indent is 0.37 times the diameter of the ball indenter.

| Indenter Ball diameter (mm) | Min. size of indent = (0.25xD) mm | Max. size of indent = (0.6xD) mm | Most accurate size of indent = (0.37xD) mm |
|---|---|---|---|
| 2.5 | 0.63 | 1.50 | 0.93 |
| 5 | 1.25 | 3.00 | 1.85 |
| 10 | 2.50 | 6.00 | 3.70 |

The following table also help determine the correct Brinell hardness ranges, based on the materials being tested:

| **Material** | **Brinell hardness** | **$F/D^2$** |
|---|---|---|
| Steel, nickel alloy, titanium alloy | — | 30 |
| Cast iron | ＜140 | 10 |
| | ≥140 | 30 |
| Copper & copper alloy | ＜35 | 5 |
| | 35~130 | 10 |
| | ＞130 | 30 |
| Light metal & its alloy | 35 | 2.5 |
| | 35~80 | 5,10 |
| | ＞80 | 10 |
| F—test force (kg) ; D—ball diameter (mm) | | |

Repetition and tolerance of displayed value for the hardness tester:

| **Standard hardness test block** | **Tolerance of displayed value%** | **Repetition of displayed value%** |
|---|---|---|
| ≤125 | ±3 | 3 |
| 125<HBW≤225 | ±2.5 | 2.5 |
| ＞225 | ±2 | 2 |

Correspondent relations among scale, indenter and test force:

| **Hardness symbol** | **Diameter of Indenter mm** | **$F/D^2$** | **Test Force N(kg)** |
|---|---|---|---|
| HBW 10/3000 | 10 | 30 | 29420(3000) |
| HBW 10/1500 | 10 | 15 | 14710(1500) |
| HBW 10/1000 | 10 | 10 | 9807(1000) |
| HBW 10/500 | 10 | 5 | 4903(500) |
| HBW 10/250 | 10 | 2.5 | 2452(250) |
| HBW 10/100 | 10 | 1 | 980.7(100) |
| HBW 5/750 | 5 | 30 | 7355(750) |
| HBW 5/125 | 5 | 5 | 1226(125) |
| HBW 2.5/187.5 | 2.5 | 30 | 1839(187.5) |
| HBW 2.5/62.5 | 2.5 | 10 | 612.9(62.5) |

# SECTION 3: UNPACKING, SHIPPING, AND INSTALLATION

## 3.1 Operational Conditions

3.1.1 Room temperature within 10~30 ℃ (50-85 °F);

3.1.2 Relative room humidity inferior to 65%;

3.1.3 The environment should have minimal shock and vibration;

3.1.4 Do not place Brinell tester in an corrosive atmosphere.

## 3.1 Unpacking

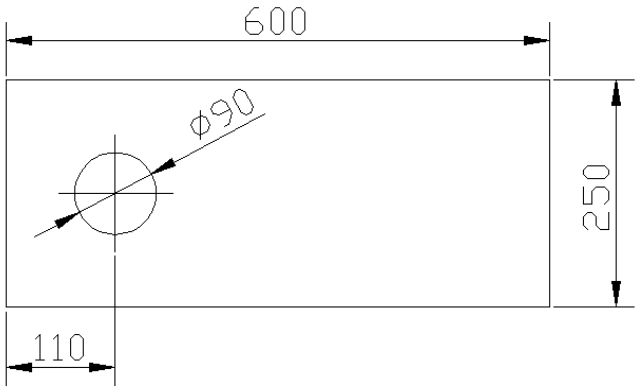
When moving the box, lift from the bottom using appropriate lifting techniques**.**

⚠ **The OMEGA-HB Brinell hardness tester is constructed of sensitive electronic and mechanical components. Do not drop.**

⚠ **Use caution when unloading to prevent injury.**

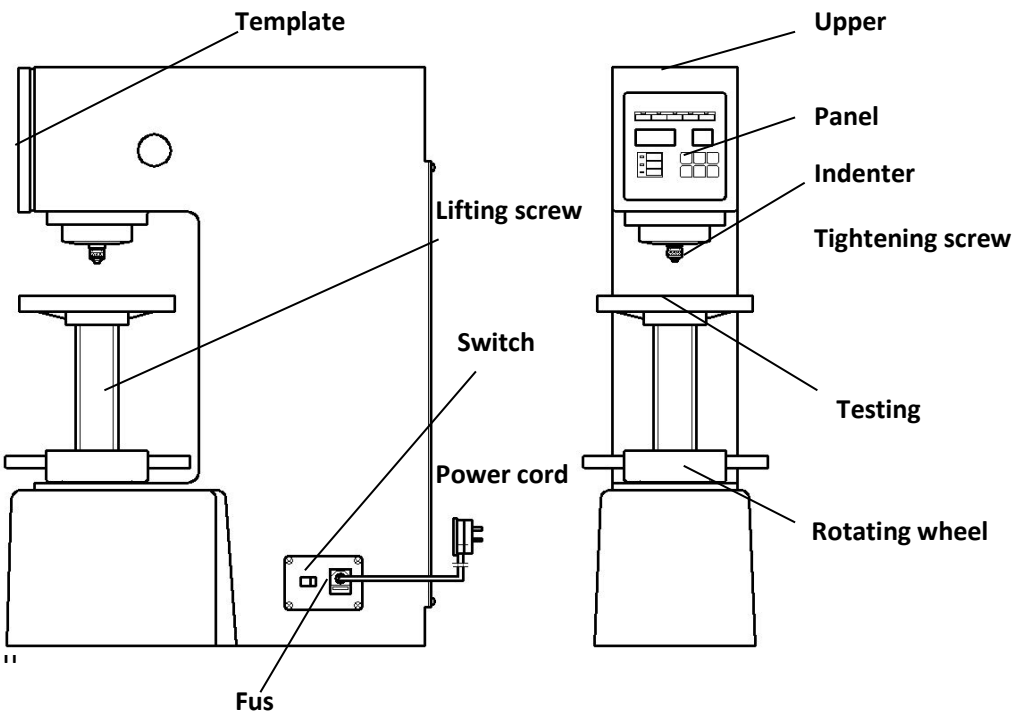
## 3.3 Installation

⚠ **Install unit carefully! Improper installation voids warranty.**




### 3.3.1 TABLE LOCATION

Installation of the ***OMEGA-HB*** should be on a flat sturdy surface, with easy access to electrical connections. For maximum height adjustment it is recommended that a 90 mm hole be drilled in the supporting table as per the above diagram.



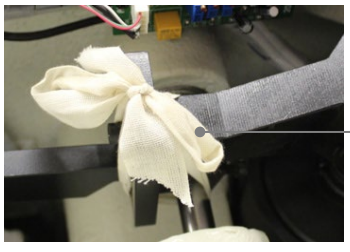

### 3.3.2 INSTALL LEVELING FEET

Attach four leveling feet and use bubble level on anvil to level unit

### 3.3.3 LEVELING UNIT

Place bubble level on stage and adjust feet height to level the unit.

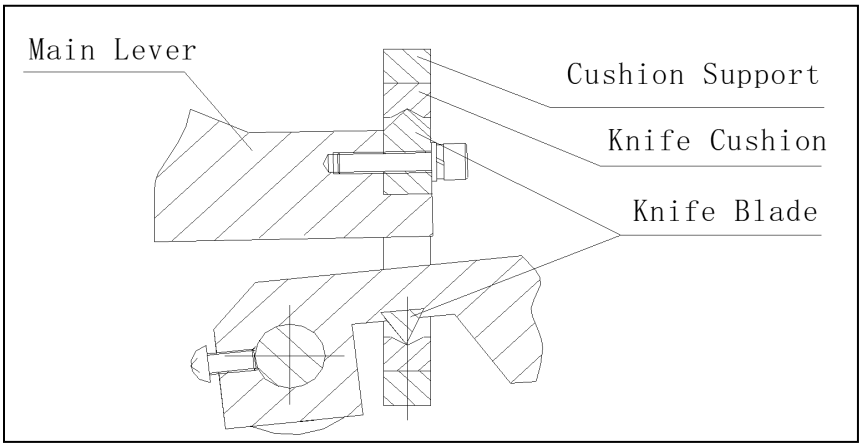
### 3.3.4 REMOVE SHIPPING TIE DOWNS



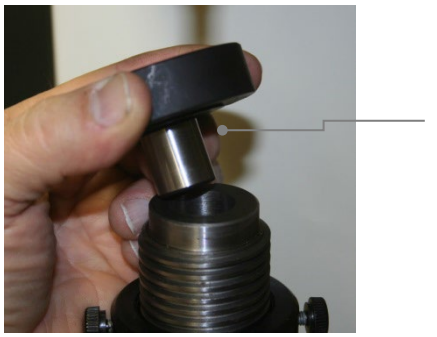
Open the upper cover. Remove the tie string

## 3.3.5 LEVER POSITIONING

Check the knife support to ensure that knife blade or “V” is positioned so it is resting in the groove of the support bar. If the blade is not being supported on the cushion (caused by severe shaking and vibration during transport), push down the main lever by hand and slide the blade into the groove (see image below). Replace upper cover.



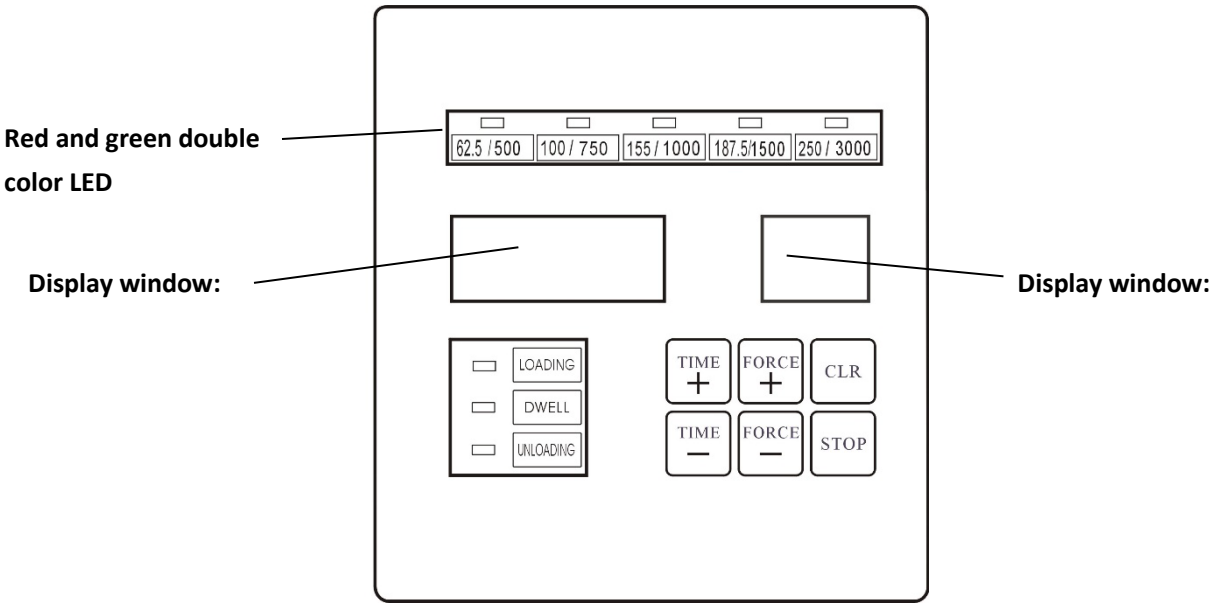

## 3.3.6 INSTALLING ANVIL STAGE




## 3.3.7 INSTALLING INDENTER

Install the indenter so that the flat end of the shank is facing the screw. Lift the indenter all the way into the guide and tighten the screw. It is good practice to set the indenter in place by doing an indent on the sample and then discarding this indent from any analysis.

# Section 4: Control Board and Its Functions




4.1 The panel board function includes six input keys and displays loading, dwell and unloading three statuses (see Fig.5).

4.2 An LED shows the present state of operation, such as “LOADING”, “DWELL” and “UNLOADING” during the operation of the machine.

| | | |
|---|---|---|
| **TIME +** | **TIME -** | Dwell time keys. Adjusts in 5 second increments, with a range from 5~60 seconds. (Initial “dwell time” is set to 15 seconds) |
| **FORCE +** | **FORCE -** | Test force selection key. There are 10 force settings. The red indicator LED is red for 62.5, 100, 125, 187.5, 250 (kg) forces and the green LED is for 500,750, 1000, 1500, 3000 (kg) forces. |
| **STOP** | | Stop key. It is necessary to stop the operation press “STOP”. The hardness tester will go back to the starting position. To continue, press the “CLR” key. |
| **CLR** | | Zero setting key. When the test force is completely unloaded (the specimen and the indenter is separated), press this key if the display window “dwell time” still has time remaining. |

# SECTION 5. SAFETY GUIDELINES

## 5. 1 Warning Sign

⚠ This symbol represents special safety precautions and warnings for the machine.

## 5.2 Safety Precautions

⚠ Pay careful attention to this instruction manual and the recommended safety guidelines. This is essential for the safe operation of the ***OMEGA-HB Brinell hardness tester***

⚠ Turning on the machine when the voltage switch direction does not match the voltage being supplied, will cause **severe damage** to the electrical system

⚠ Proper operator training is required for operation of the ***OMEGA-HB Brinell hardness tester***. Unauthorized mechanical and electrical changes, as well as improper operation, voids all warranty claims. All service issues need to be reported to the manufacturer / supplier.

⚠ Operate unit as specified in this manual.

⚠ Disconnect power before opening unit

⚠ Lower stage to avoid damaging indenter when not in use.

⚠ Cover unit with dust cover when not in use to eliminate dust contamination

## 5.3 Emergency Statement

Always follow proper operational guidelines and avoid contact with lubricants and abrasives.

# 6. START-UP AND OPERATION

## 6.1 Preparatory work

6.1.1 The surface of the specimen must be clean. Remove dirt, corrosion or oxide coatings and avoid making the indent into any imperfections such as pits or porosity in the surface.

6.1.2 The minimum thickness of the specimen should be >10 times the depth of the indentation. If there is visual deformation on the back of specimen after testing the load is too high.

6.1.3 The specimen should be stable on the testing table and should be stationary during the testing procedure. The test force must also be vertically applied on the specimen.

## 6.2 Usage of the instrument

6.2.1 Install the indenter into main shaft hole and align the flat edge towards the screw and then tighten.

6.2.2 Turn on the power switch, the panel display window will count down. When the display window shows “test force” of zero, the instrument automatically adjusts to the starting position.

6.2.3 When starting up, the default test force is set to 2452N (250kg), the dwell time is set to 15 seconds. If you want to change the test force or dwell time, refer to Section 4.

6.2.4 When preparatory work is finished, place the specimen evenly on the testing table. Press “CLR” to set zero and rotate the wheel to raise the anvil table. Continue rotating the wheel until the specimen touches the indenter, and the window begins to display test force.

**NOTE: For 62.5kg~250kg forces (red LED lights), rotate the wheel to make the window display about 30kg;**

**For 500kg~3000kg (green LED lights), rotate the wheel to make the window display about 90kg.**

6.2.5 When the instrument makes an audible beep, stop rotating the wheel and the instrument will automatically apply the test force. If the initial manual force applied is too high, the instrument will continuously beep and will not proceed. In this case, lower the anvil table and select a new location for the hardness test point and repeat the preloading procedure.

6.2.6 When loading, dwell and unloading is completed, lower the table to automatically reset the instrument.

6.2.7 The recommended Dwell times are 10~15 seconds for ferrous metal, 30 seconds for nonferrous metal, 60 seconds for those hardness value is less than 35HBW.

| **Average diameter of indentation (d)** | **Minimum thickness of specimen** | | | |
|---|---|---|---|---|
| | **Diameter of steel ball** | | | |
| | **D=1** | **D=2.5** | **D=5** | **D=10** |
| 0.2 | 0.08 | | | |
| 0.3 | 0.18 | | | |
| 0.4 | 0.33 | | | |
| 0.5 | 0.54 | | | |
| 0.6 | 0.8 | 0.29 | | |
| 0.7 | | 0.4 | | |
| 0.8 | | 0.53 | | |
| 0.9 | | 0.67 | | |
| 1 | | 0.83 | | |
| 1.1 | | 1.02 | | |
| 1.2 | | 1.23 | 0.58 | |
| 1.3 | | 1.46 | 0.69 | |
| 1.4 | | 1.72 | 0.8 | |
| 1.5 | | 2 | 0.92 | |
| 1.6 | | | 1.05 | |
| 1.7 | | | 1.19 | |
| 1.8 | | | 1.34 | |
| 1.9 | | | 1.5 | |

| | | | | |
|---|---|---|---|---|
| 2 | | | 1.67 | |
| 2.2 | | | 2.04 | |
| 2.4 | | | 2.46 | 1.17 |
| 2.6 | | | 2.92 | 1.38 |
| 2.8 | | | 3.43 | 1.6 |
| 3 | | | 4 | 1.84 |
| 3.2 | | | | 2.1 |
| 3.4 | | | | 2.38 |
| 3.6 | | | | 2.68 |
| 3.8 | | | | 3 |
| 4 | | | | 3.34 |
| 4.2 | | | | 3.7 |
| 4.4 | | | | 4.08 |
| 4.6 | | | | 4.48 |
| 4.8 | | | | 4.91 |
| 5 | | | | 5.36 |
| 5.2 | | | | 5.83 |
| 5.4 | | | | 6.33 |
| 5.6 | | | | 6.86 |
| 5.8 | | | | 7.42 |
| 6 | | | | 8 |

6.2.8 The hardness test should be uniformly distributed on the specimen. The distance between two adjacent indentation's centers should be not less than 3 times the diameter of the indentation; the distance between the indentation center and the edge of the specimen should be not less than 2.5 times the diameter of the indentation. Failure to comply can result in asymmetric indents resulting in incorrect hardness values.

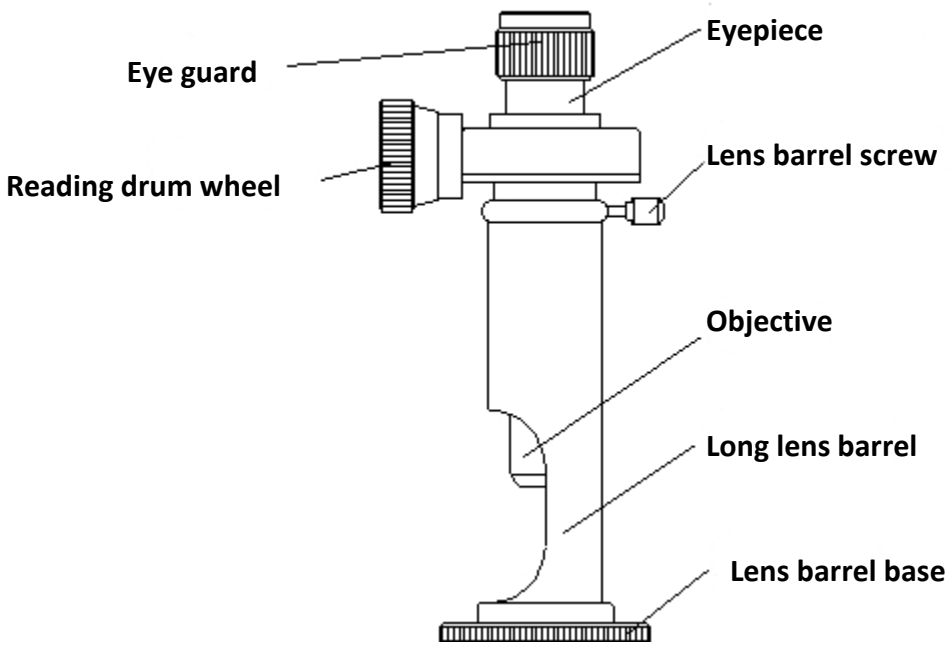
6.2.9 Each indentation diameter is measured on two vertical directions. The ratio of the diameter difference on two vertical directions and the shorter diameter should not be greater than 1%.

6.2.10 The instrument uses and electronic loop control system; it can dynamically reflect the real changes of the test force. During the dwell time cycle, the display window “test force” constantly shows the instantaneous force value. When the indenter gradually presses into the specimen the force value decreases. Once the value is reduced to the prescribed error range, the instrument will automatically adjust and the test force will be maintained within the specified range.

# SECTION 7: OPTICAL MANUAL MICROSCOPE

## 7.1 Eyepiece Components

For manual Brinell testers a small 20X reading microscope is used to measure the size of the indent.




## 7.2 TECHNICAL SPECIFICATIONS MICROSCOPE

7.2.1 Magnification of the reading microscope: 20X

7.2.2 Minimum division value of the drum wheel: 0.005mm

7.2.3 The effective measuring range of the field of view: 6mm

# 7.3 Usage of the reading microscope

7.3.1 There are 100 grid lines and numbers around the reading drum wheel, each grid for 0.005 mm.

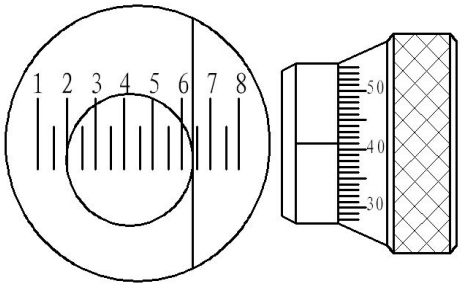
7.3.2 The eyepiece has two blocks of glass, one with 0~8 digits, digital interval for 1 mm and the other with a movable line.

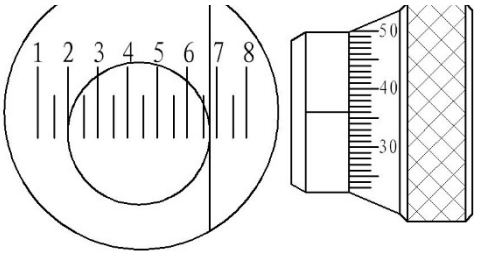
7.3.3 Example: Brinell hardness test with ϕ10mm ball indenter under 29420N (3000kg) test force

7.3.3a Put the hardness block or specimen which has Brinell hardness indentation on a stable table and place the reading microscope on the hardness block or specimen, with the long lens barrel faced to natural light or illuminated with light. Rotate the eye guard on the eyepiece and make the indentation edge clear.

7.3.3b Use any digit on the fixed glass of the eyepiece as the starting line (case grid 2), hold the reading microscope in position and then rotate the drum wheel so the filar aligns with the other side of the indent.

7.3.3c Read from the eyepiece, the integer value is 6, 6-2 = 4mm, and accumulate the remaining fraction from the dial. For this example, the method is as follows: read from the drum wheel, it's 41 grids, and each grid for 0.005mm, then 41×0.005mm = 0.205mm, the indentation diameter is 4mm+0.205mm = 4.205mm. Check the "Brinell hardness control table": 205HBW10 / 3000




7.3.3d If the right tangent edge of Brinell indentation diameter is more than half grid and the drum wheel is 36 grid, then plus 0.5mm when calculating the indentation diameter and the Brinell hardness indentation diameter is:

4mm + 0.5mm + (36×0.005) mm = 4.68mm.

## 7.4 Maintenance of the reading microscope

7.4.1 The precision of the reading microscope has been adjusted at the factory. Do not disassemble and reassemble.

7.4.2 The reading microscope should be stored in a dust free, dry and noncorrosive environment.

7.4.3 If the surface of the reading microscope lens is dirty, it can be wiped by soft cotton and lens paper; if it has an oil film, it can be wiped with a cotton swab and IPA or ether.

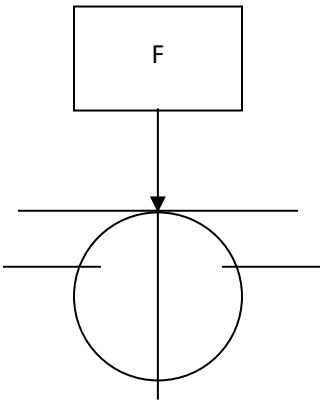
# SECTION 8. BRINELL TESTING BASICS

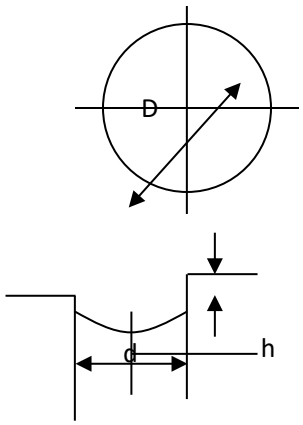
Hardness Testing provides useful information, which can be correlated to tensile strength, wear resistance, ductility, and other physical characteristics of the material. Hardness testing is therefore useful for monitoring quality control and for aiding in the materials selection process.

**BRINELL HARDNESS (ASTM E10, ISO 6506)**

To determine a Brinell hardness number (BHN), a 10 mm diameter steel ball is typically used as an indenter with a 3,000 kgf (29 kN) force. For softer materials, a smaller force is used; for harder materials, a tungsten carbide ball is used. The BHN can also be converted into the ultimate tensile strength (UTS), although the relationship is dependent on the material, and therefore is only an empirically based value.

Hardness testing is accomplished with a ball of specified diameter (D) being pressed by a specified force (F) into surface of the object to be tested (see figure below). The test force is removed after holding for a specific period of time (dwell time). The indent diameter (d) is measured with an optical manual microscope and the average pressure (N/mm2) acted on spherical surface can be calculated as a hardness value.




where:

HB – HBW (kgf/mm2)

P = applied force (kgf)

D = diameter of indenter (mm)

d = diameter of indentation (mm)

The indentation is measured and hardness calculated as:

$$\mathrm{BHN} = \frac{2P}{\pi D\left(D - \sqrt{D^2 - d^2}\right)}$$

The BHN can be converted into the ultimate tensile strength (UTS), although the relationship is dependent on the material, and therefore determined empirically. The relationship is based on Meyer's index (n) from Meyer's law. If Meyer's index is less than 2.2 then the ratio of UTS to BHN is 0.36. If Meyer's index is greater than 2.2, then the ratio increases.

BHN is designated by the most commonly used test standards (ASTM E10-08[2] and ISO 6506–1:2005[3]) as HBW (H for hardness, B for Brinell and W for the material of the indenter, tungsten carbide. In former standards HB or HBS were used to refer to measurements made with steel indenters. HBW is calculated in both standards using the SI units as

$$\mathrm{HBW} = 0.102 \frac{2F}{\pi D \left(D - \sqrt{D^2 - d^2}\right)}$$

# 8. 1 Technical Data for Hardness Evaluation

8.1.1 The degree of loading $1.02F/D^2$ is important because different results can be obtained depending on which degree of loading was used.

For example: a Brinell hardness value determined with a 10 mm ball and 9,807N (degree of loading 10) for a material is different from the hardness value determined with a 10 mm ball and 4,903N (degree of loading 5).

However, if the same material is measured with a 2.5 mm ball and a total test load of 612,9N (degree of loading 10) the resulting hardness value is the same as in the first measurement because the degree of loading is the same (provided that the material is homogeneous and has no layers of different hardness').

**0.24D＜d＜0.6D** (d - dent diameter, D – ball diameter)

**Table for Selection Value $0.102F/D^2$**

| Material | Ball Hardness | $0.102F/D^2$ |
|---|---|---|
| Steel and Cast Iron | <140 | 10 |
| | ≥ 140 | 30 |
| Copper and Cupric Alloys | <35 | 5 |
| | 35~130 | 10 |
| | >130 | 30 |
| Light Metals and Their Alloys | 35 | 2.5 |
| | 35~80 | 5, 10 |
| | >80 | 10 |

8.1.2 **For the following materials there are standard Brinell tests:**

**Steel:** Typically HBW x | 3000 (x=ball diameter).
For steel, the Brinell method is very important because there is a constant, accurate relation between the Brinell hardness and the tensile strength (with a ratio of 3.53 for carbon steel, chromium steel and chromium-manganese steel; for chromium-nickel steel it is 3.33).

Example: 225 HBW x | 3000 e.g. 225 x 3.53 = 794.3 N/mm² (see DIN 50150)

This is the only acceptable method for determining the tensile strength of steel non-destructively.

However, the Brinell method cannot be used for hardened steel. As there is no diamond penetrator intended for the Brinell procedure. Tests on treated steel with hardness greater than 1765 N/mm² is not acceptable.

Soft iron is usually tested with HB x | 3000, although the indentation diameter exceeds 0.6 of the ball diameter.

**Cast iron:** HBW x | 3000. Due to the smaller homogeneity, it is recommended to use the highest total test load of 29,420 N.

**Soft metals:** Typically HBW x | 10 or HBW x | 5; for very soft alloys, however, it is also possible to use HBW x | 2.5. The fact that it is possible to use different degrees of loading for medium hardness values might easily cause confusion. Thus, it is important to indicate the test used.

**Copper alloys:** For bronze use HBW x | 10 (if it is very hard, use HBW x | 30), and HBW x | 10 or HBW x | 5 for brass. Apart from that, also consider the principles mentioned for soft metals above. For the following materials there are standard Brinell tests:

8.1.3 Nomenclature

When quoting a Brinell hardness number (BHN or more commonly HB), the conditions of the test used to obtain the number must be specified. The standard format for specifying tests can be seen in the example "HBW 10/3000".

HBW - tungsten carbide ball indenter

HB or HBS - hardened steel ball.

10 is the ball diameter in millimeters.

3000 is the force in kilograms force.

The hardness may also be shown as XXX HB YYD2. The XXX is the force to apply (in kgf) on a material of type YY (5 for aluminum alloys, 10 for copper alloys, 30 for steels). Thus a typical steel hardness could be written: 250 HB 30D2.

8.1.4 Multiple Scales of test load are available for this tester, and they shall be properly selected as the nominal values specified below.

| Hardness | Ball Diameter (mm) | 0.102 $F/D^2$ ($F/D^2$) | Test Load F N (kgf) |
|---|---|---|---|
| HBW 10/3000 | 10 | 30 | 29400 (3000) |
| HBW 10/1500 | 10 | 15 | 14700 (1500) |
| HBW 10/1000 | 10 | 10 | 9800 (1000) |
| HBW 10/500 | 10 | 5 | 4900(500) |
| HBW 10/250 | 10 | 2.5 | 2450 (250) |
| HBW 10/100 | 10 | 1 | 980(100) |
| HBW 5/750 | 5 | 30 | 7350 (750) |
| HBW 5/125 | 5 | 5 | 1225 (125) |
| HBW 2.5/187.5 | 2.5 | 30 | 1837.5 (187.5) |
| HBW 2.5/62.5 | 2.5 | 10 | 612.5 (62.5) |

8.1.5 Dwell times

Ferrous (steel) metals: 10-15 seconds

Non-ferrous metals: 30 seconds (60 seconds for <35 HBW)

8.1.6 Distance from sample edge and in-between indents

At least 2.5X indent diameter

3X the indent size in-between indent

### 8.1.7 Surface preparation

More consistent results are obtained with better surface finishes, however, as a minimum, 600 grit finish is recommended.

Also, it is suggested that any surface scale, rust, contamination of other debris should be removed from the surface before testing.

### 8.1.8 Minimum specimen thickness

In general, the specimen thickness should be >8-10 X the depth of the indent. (see following table)

| Average Dent Diameter, d | Minimum Specimen Thickness | | | |
|---|---|---|---|---|
| | Ball Diameter | | | |
| | D=1 | D=2.5 | D=3 | D=10 |
| 0.2 | 0.10 | | | |
| 0.3 | 0.23 | | | |
| 0.4 | 0.41 | | | |
| 0.5 | 0.68 | | | |
| 0.6 | 0.8 | 0.36 | | |
| 0.7 | | 0.50 | | |
| 0.8 | | 0.66 | | |
| 0.9 | | 0.84 | | |
| 1 | | 1.04 | | |
| 1.1 | | 1.28 | | |
| 1.2 | | 1.54 | 0.73 | |
| 1.3 | | 1.83 | 0.86 | |
| 1.4 | | 2.15 | 1.00 | |
| 1.5 | | 2.5 | 1.15 | |
| 1.6 | | | 1.31 | |
| 1.7 | | | 1.49 | |
| 1.8 | | | 1.68 | |
| 1.8 | | | 1.88 | |
| 2 | | | 2.09 | |
| 2.2 | | | 2.55 | |
| 2.4 | | | 3.08 | 1.47 |
| 2.6 | | | 3.65 | 1.73 |
| 2.8 | | | 4.29 | 2.00 |
| 3 | | | 5.00 | 2.30 |
| 3.2 | | | | 2.62 |
| 3.4 | | | | 2.98 |
| 3.6 | | | | 3.35 |
| 3.8 | | | | 3.75 |
| 4 | | | | 4.18 |
| 4.2 | | | | 4.63 |
| 4.4 | | | | 5.10 |

| | | | | |
|---|---|---|---|---|
| 4.6 | | | | 5.60 |
| 4.8 | | | | 6.14 |
| 5 | | | | 6.70 |
| 5.2 | | | | 7.29 |
| 5.4 | | | | 7.91 |
| 5.6 | | | | 8.58 |
| 5.8 | | | | 9.28 |
| 6 | | | | 10.00 |

# SECTION 9: MAINTENANCE

## 9.1 General

9.1.1 Apply alight costing of oil to the lifting screw, anvil and other moving surfaces of the tester.

9.1.2 Turn off power after finishing.

9.1.3 Turn the hand-wheel in counter-clockwise direction to lower it away from indenter.

9.1.4 When the tester is not in use cover with a dust cover.

9.1.5 If the tester has not been used for a long period, allow the unit to warm up several minute to ensure the apparatus accuracy.

## 9.2 Adjustment of the Tester

The instrument has been comprehensively tested at the factory to conform to all technical requirements and standards. However, some variation may be caused by transportation, disassembly or voltage difference etc., therefore the user may need to make the following adjustments:

9.2.1 The surface of specimen and the indenter may need to be cleaned of any oil or dust. Use IPA or ethanol to clean specimen and indenter.

9.2.2 If the tester has been moved or not used for some time, make several indents at a test load of 29400N(3000kgf) to eliminate gaps between different parts and to insure proper function of electronic components.

9.2.3 Electrostatic interference can affect the Loading/unloading sensor. Place tester in an area that is free from strong electromagnetic interferences. If the unit needs to be reset after the load has been applied and a reading cannot be obtained:

## 9.3 Special Attentions

9.3.1 Do not tamper with the installation position of electronic components, switches and sockets etc. This may void the warranty.

9.3.2 The turntable (anvil) should never be rotated during the test cycle, otherwise the apparatus may be damaged. Only rotate the turntable after the beep sounds indicating the end of test cycle.

9.3.3 When measuring the indent, reflected light or shadowing may be observed in the indent. This is a normal physical phenomenon and will not impact the measurement accuracy.

9.3.4 Test load should not be applied when the tester is in the measurement mode. If a wrong key is depressed (other than EXIT key) the beeper will sound and other pages may appear on display. In such case just press OK/ESC key to return Home Page and the tested data will not be affected. If EXIT key is pressed by mistake, the tester will be shut down and unsaved data are lost.

9.3.5 When cursor is flashing at Dwell, Light, Change or Time on the Home Page, the tester is not in ready state to start test. Press OK/ESC key and wait for disappearance of the cursor, then the apparatus is ready for normal test operation.

9.3.6 Some slight clicking sound may be heard during loading/unloading. This is a normal phenomenon caused by the self adjustment for the loading mechanism.

9.3.7 The two graduation lines in filar lens should be calibrated before the first measurement. During the sequential tests no more calibration will be needed even if the test load or indenter is changed.

# 9.4. Working Principle of the Electric Parts

The OMEGA-HB Ball Hardness Tester employs a new loading procedure other than the conventional pendulum loading. The new loading system uses a closed loop control system, which is controlled by CPU. A sensor controls the signal and step motor for loading. PHILIPS P89C51RD2 is used as the CPU. AD 574 chip is used as AD converter, with a typical conversion time of 25μs and non-linearity of ±1/2LSB. BB company's INA114AP is used as the algorithm amplifier.

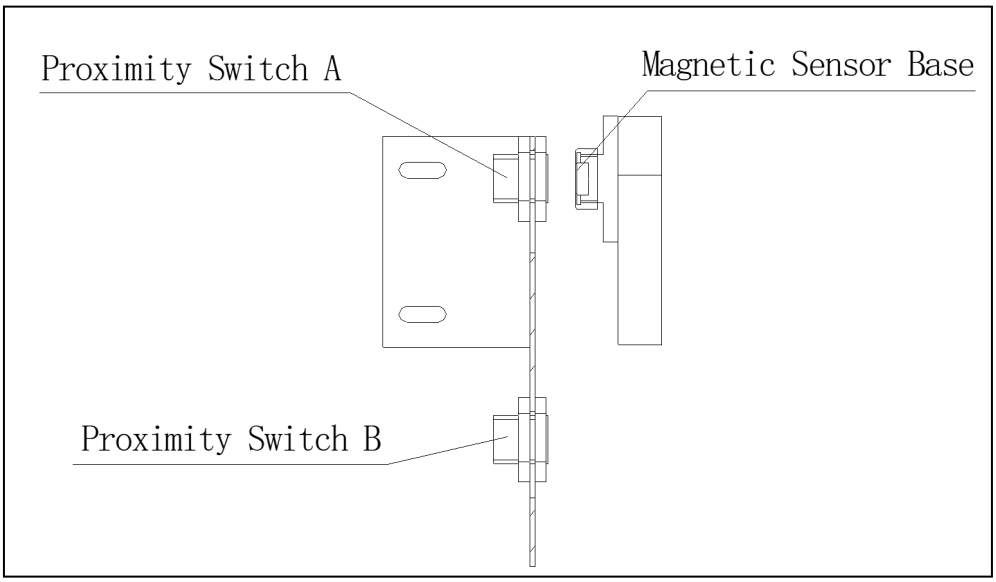
The electric working principle can be described as following: Electronic signals are collected by LF-3T spoke type sensor and, after being amplified by INA114, output to AD574 for AD conversion. Then the analogue voltage signals are changed into the 12-digit signals and sent to CPU for computation processing and finally used to control the motor's loading, dwell and unloading actions.

There are 10 test loads (62.5, 100, 125, 87.5, 250, 500, 750, 1000, 1500, and 3000 kgf) available for use on OMEGA-HB Digital Ball Hardness Tester, the lower 5 load (62.5～250 kgf) have a resolution of 0.1kgf, and the upper 5 loads (500～3000 kgf) have a resolution of 1 kgf, to ensure the test loading force is more stable and reliable,

The tester uses a Japan made DMF-50081 320×240 LCD as display, user may choose desirable test load and indenter on the display after start-up of the tester. Other data including D1 and D2 (indent diameter), HBW hardness and corresponding converted value are also shown on the display. After completion of the test cycle, the data may be output through RS232 serial interface into a PC's Hypertrm terminal for display or printing out, or directly saved into CPU's internal memory for permanent storage.

There are two limit switches for the ascending and descending movement of lifting screw respectively. A magnetic sensor base is installed at rear of the main lever (see figure). Two proximity switches are installed on the right side near to the rear cover to control the initial position of main lever and the total stroke. Both proximity switches (A and B) are placed in adjacent positions near the switch A. After powering on the tester the motor lifts the lever whereby the switch A will receive signal from magnetic sensor and is feed to the CPU. Thereafter the motor will stop at first and then rotate in counter direction for several turns to return the lever back to its original position. DO NOT change the position of proximity switches. Switch B is the lower limit switch for lever's movement, i.e. when the lever moves approaching

to B switch during the loading period, .the switch will stop the motor and cause it to rotate in the counter direction, thus providing the automatic unloading and return of the lever to its original position



# 10. TROUBLESHOOTING

| Phenomenon | Possible Causes | Method Used |
|---|---|---|
| Screen does not turn on | 1. No power<br>2. The fuse is blown. | 1. Check the power cable.<br>2. Change the fuse. |
| When the tester is on, the keys do not work | The instrument is not in working state. | When the tester is turned on, wait until the instrument returns to the working state. |
| The Up / Down Lead Screw is hard to move | The space between the Up /Down Lead Screws are blocked by the thread ends or dirt | Remove the protecting cover for the Up / Down Lead Screw and clean the screw threads |